PRoF Award abstract – Call 2015

FSO: Fractal Social Organizations

1. Research Outline

Acronym	FSO
Project name in English	Fractal Social Organizations
Pitch (1 sentence)	Moving from Caregivers & Care receivers to a Community of Care Participants
Executive summary (max. 10 lines)	
FSO is a novel paradigm for healthcare organizations. FSO removes the distinction between caregivers and care receivers, which become peer-level members in a hierarchy of communities of assistance. No role is predefined: any member may either provide or receive service depending on the context. This provides 3 main advantages: 1) Shortage of caregivers characterizing "traditional" organizations is solved by exploiting the potential inherent to our societies. 2) People's dignity is preserved by eliminating a distinction between active / passive parts of society. 3) The client-server model of traditional healthcare services is turned into a service-oriented e-referral scheme in which optimal responses to requests are orchestrated on the fly.	

2. Cause and context of the research

The overwhelming increase in the human population and in particular of the elderly; the dissipation of valuable resources such as water, energy, and clean air; the ill-considered management of waste are but a few examples that show how the current social organizations are proving to be ineffective and unable to scale to the sizes of our new "big world" [1,2].

Assistance of the elderly population is a typical case in point: The share of the total population older than 65 is constantly increasing worldwide [3,4], while the current organizations still provide assistance in an inefficient and inflexible way. Though effective when the context was different and a large amount of resources were available to manage a smaller demand, this approach is now becoming too expensive and thus unacceptable. Merely expanding the current organizations without properly restructuring them is simply not working anymore.

Promising solutions to this problem come from the domain of control systems. Such systems have been traditionally crafted by using paradigms such as the centralized, the hierarchical, or the heterarchical [5]. More recently additional classes of distributed control mechanisms have been introduced so as to enhance efficiency and reduce the bottlenecks that characterize the classical paradigms. The terms used in literature to refer to these classes is bionic, holonic, and fractal organizations [6] [7]. Such solutions have been successfully applied in several domains so as to achieve "smarter organizations", i.e. systems characterized by greater scalability, robustness, and manageability with respect to their traditional counterparts.

Aim of this proof of concepts is bringing quantitative evidence that the above distributed mechanisms provide us with promising new paradigms for the design of social ecosystems able to make full use of the potential inherent in our societies so as to turn them into abundant sources of valuable assets; complex behaviors; and massive redundancy.

3. Innovation results achieved

A major innovation result of this project has been the introduction of a novel model for the organization and the management of massively distributed open socio-technical healthcare systems based on the paradigms mentioned in Section 2. Said model is called Fractal Social Organization (FSO) [10].

FSO substitutes the classic client-server approach with *service orientation*. Clients and servers are replaced by members of so-called Service-oriented Communities [19, 9].

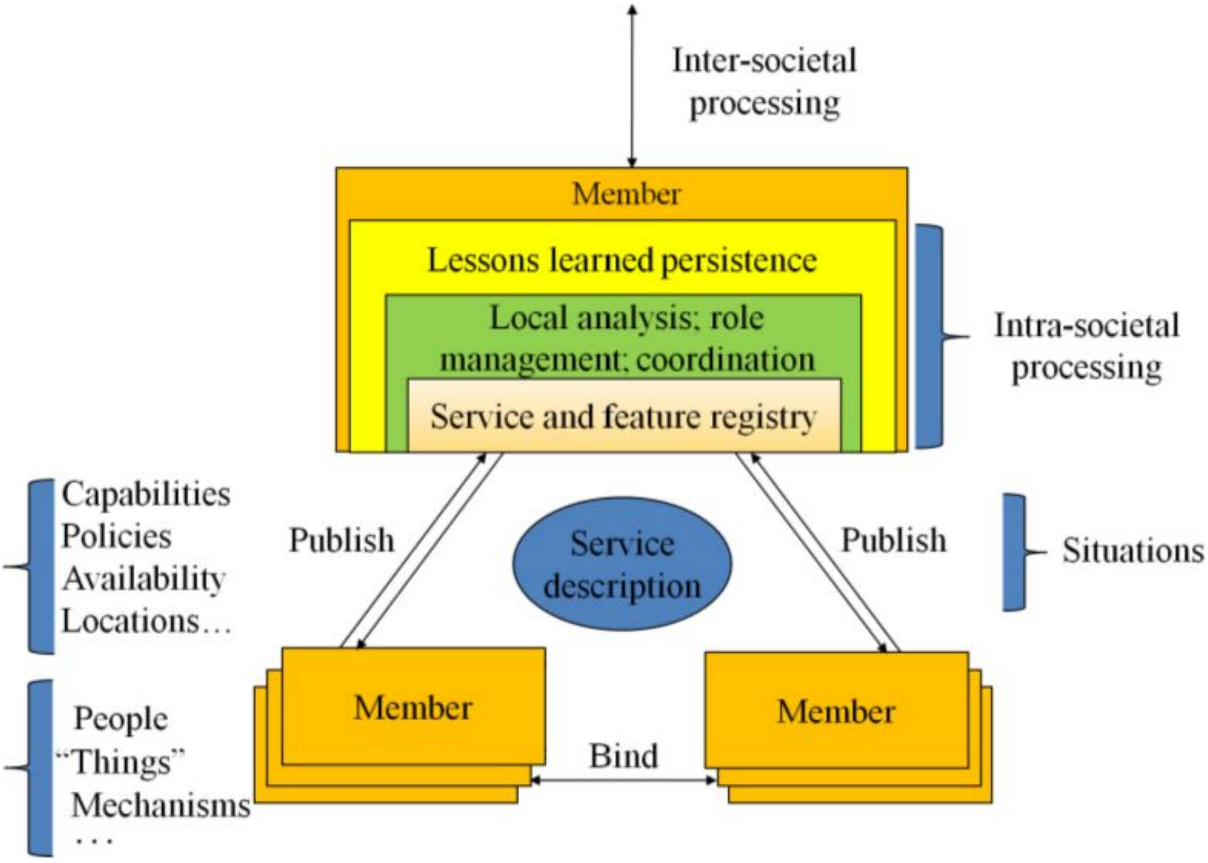

Figure 1. Scheme of a Service-oriented Community.

A Service-oriented Community (SoC) is a collective socio-technical system coupling services provided by smart cyber-physical "things" with services supplied by human beings. Actants that agree to join a SoC become their *members*. Members of a SoC are diverse, which translates into a rich variety of services. By focusing for instance on human members only, diversity implies

- different know-hows (e.g. those of a general practitioner, or those of a gardener);
- different policies for providing services (e.g. well-defined time schedules and fares, or dynamically varying availability to provide free-of-charge services as occasional informal carers);
- different location, in that members may be mobile, thus able to get dynamically closer to or farther from other members;

- different value systems,

and so on. Such attributes are called in what follows *features*. Finally, members may have different *goals*—for instance being able to reach a given location within a certain amount of time with a certain budget of traveling costs and with at least a given quality of experience. We call *viewpoints* any well-defined and agreed representation of a member's features and goals.

The operational model of the SoC is represented in Fig. 1, in which members publish their viewpoints to other members in logical or physical proximity. Viewpoints may be issued, e.g., by an elderly member in need of assistance, by a bystander posting their tweets to describe an accident, by a monitoring device notifying the occurrence of some critical event, by the acceptance service of a hospital, and so forth. Control and adaptation are achieved by sharing viewpoints, unraveling semantic analogies among them and creating transient "networks of relations" among members. More description about said semantic processes is in [18].

One or more members of a SoC are given the responsibility to host a viewpoint registry and act as temporary coordinator. The coordinators then become *collective members*, namely members representing a whole community of other societal actants. Among their duties, the coordinators are to identify whether the viewpoints currently stored in the registry correspond to a known situation (for instance a fall, or a transition of biological parameters beyond a safe region). Analyses are performed by semantically matching new viewpoints with those already stored in the registry [9]. Analogies between viewpoints are identified as shown in [18] by making use of ontologies associated with the reference domains. Once a similarity is discovered the coordinator notifies the corresponding members. The shared knowledge enables the creation of *bindings*, which may be spontaneous or mandatory depending on the context and the policies in use. A practical way to implement said bindings in a flat (that is, non-hierarchical) community was the so-called "Participant mode" described in [18].

Through bindings, members create a new temporary community that represents a team of members able to respond to the insurgence of the detected situation.

An example of a Service-oriented Community targeting Ambient Assistance Living services is given by the Mutual Assistance Community [18]. Dr. Hong Sun, now in AGFA HealthCare, was awarded an IBM Fellowship and received his PhD at the University of Antwerp with his work on Mutual Assistance Communities. We refer the reader to the cited references for more information on the technical design of a SoC.

Such communities themselves can become members of other communities. By allowing SoC's to become members of other SoC's we come up with an architecture with the "matryoshka doll" structure — the Fractal Social Organization. A FSO may be then concisely described as a fractal organization of SoC's.

An important difference between SoC's and FSO is in the construction of the teams to respond to the detected situations. While in SoC this is done locally, in FSO we introduced the concept of exceptions. Exceptions are events that are triggered when one or more roles are missing in the construction of a response team. This propagates the event to the next level upward in the hierarchy of SoC's. This goes on until all missing members are found or some threshold is met. This creates *a team whose members reside everywhere in the hierarchy*. We call this new team a *social overlay network* (SON). SON extends the concept of e-referrals to all the layers of an organization. More information on this is in [10].

An exemplary, static implementation of the FSO has been developed in the framework of Little Sister (https://www.iminds.be/en/projects/2014/03/04/littlesister), an ICON project financed by iMinds and the Flemish Government Agency for Innovation by Science and Technology (IWT). Its structure is shown in the following picture:

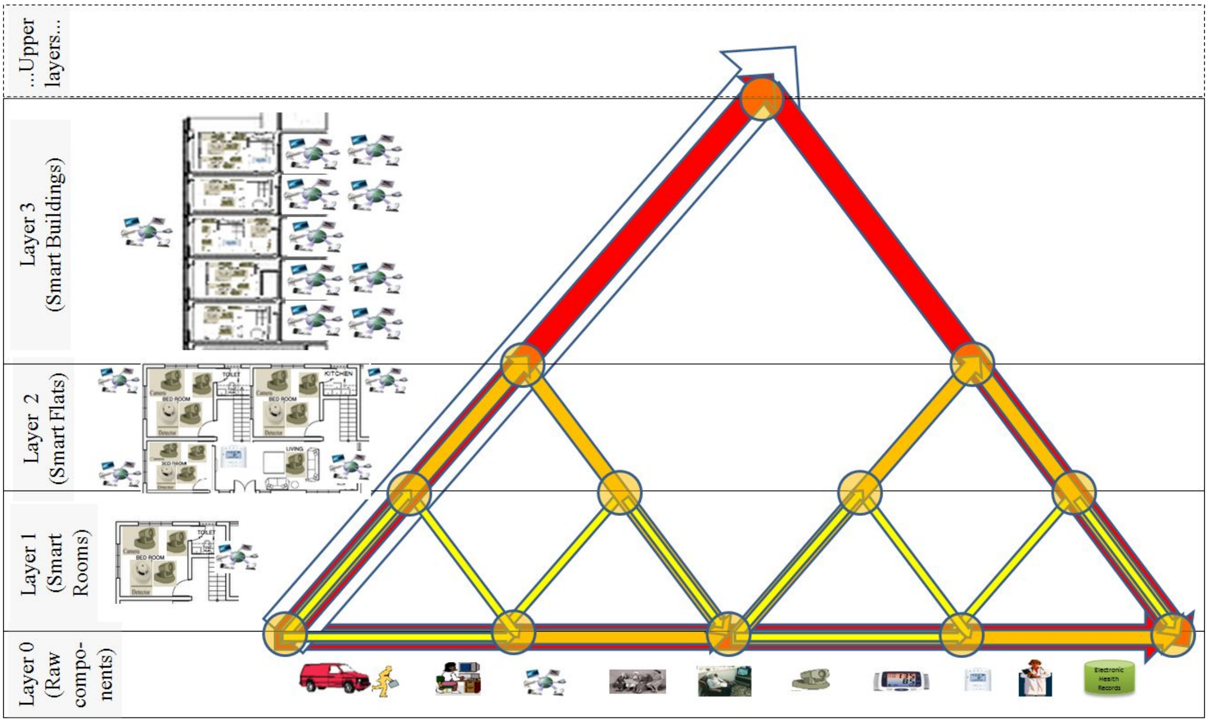

Figure 2: The Little Sister software architecture: a three-layer FSO.

As can be seen in Fig. 2, the Little Sister FSO may be described as a multi-tier, distributed systems architecture, in which specially designed low-resolution sensors and RFID readers are individually wrapped and exposed as manageable web services. These services are then structured within a hierarchical federation reflecting the architectural structure of the building in which they are deployed. More specifically, the system maintains dedicated, manageable service groups for each room in the building, each of which contains references to the web service endpoint of the underlying sensors (as depicted in layers 0 and 1 in Fig. 2). These "room groups" are then aggregated into service groups representative of individual housing units. Finally, at the highest level of the federation, all units pertaining to a specific building are again exposed as a single resource (layer 3). All services and devices situated at layers 0–3 are deployed and placed within the building and its housing units; all services are exposed as manageable web services and allow for remote reconfiguration. The system was designed to seamlessly integrate with external applications developed and offered by the Little Sister industrial project partners (layer 4). Information between different web services in the architecture is exchanged by means of a standardized, asynchronous publish-and-subscribe mechanism; subscriptions are automatically setup while the service group federation is initialized. Events are raised by the sensors (proxy software) at the lower tier, and can only "flow" upward. A dedicated software module is available within each resource to 1) accept events, 2) verify if actuation logic is available for the event to be dealt internally by some module contained within the resource logic, or 3) to propagate the event to the next level. Each event is annotated with a topic identifier when it is published, such that the system can decide on whether to trigger local actuation logic or propagate the event to the next tier.

Thanks to its compliance to Web Service standards, the Little Sister software can be easily reapplied to new contexts — for instance, crisis and disaster management.

Dr. Vincenzo De Florio was awarded an IBM Faculty Award in 2013 for his work on this project.

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4. Link to the PRoF values

The FSO approach introduces a number of new “organizational axioms”, some of which have a direct impact on PRoF values.

4.1) FSO eliminates the distinction between “clients” and “servers”, namely between service providers and service receivers. Its notions of “member” and “community” eliminate the artificial classification into “primary users” (professional care-givers), “secondary users” (informal care-givers), and “tertiary users” (the patients, the elderly, etc), introduced by traditional healthcare approaches. It is therefore a **NON STIGMATISING SOLUTION**, in that a unique, peer-level entity — the member — may operate as provider or receiver of services depending on the context.

4.2) The concept of service and that of the exchange of services is managed semantically, trying to uncover mutualistic (e.g., symbiotic) service relationships. An example is shown in Fig. 3: a person in need to talk with someone, and one in need to have a walk outside her smart home may fulfill each other’s requests: the former would find a person to talk to, the latter would be able to leave her house with a “living alarm” nearby. Exploiting this “social energy” — the intrinsic self-servicing potential of our societies — promotes **ANTI-LONELINESS**.

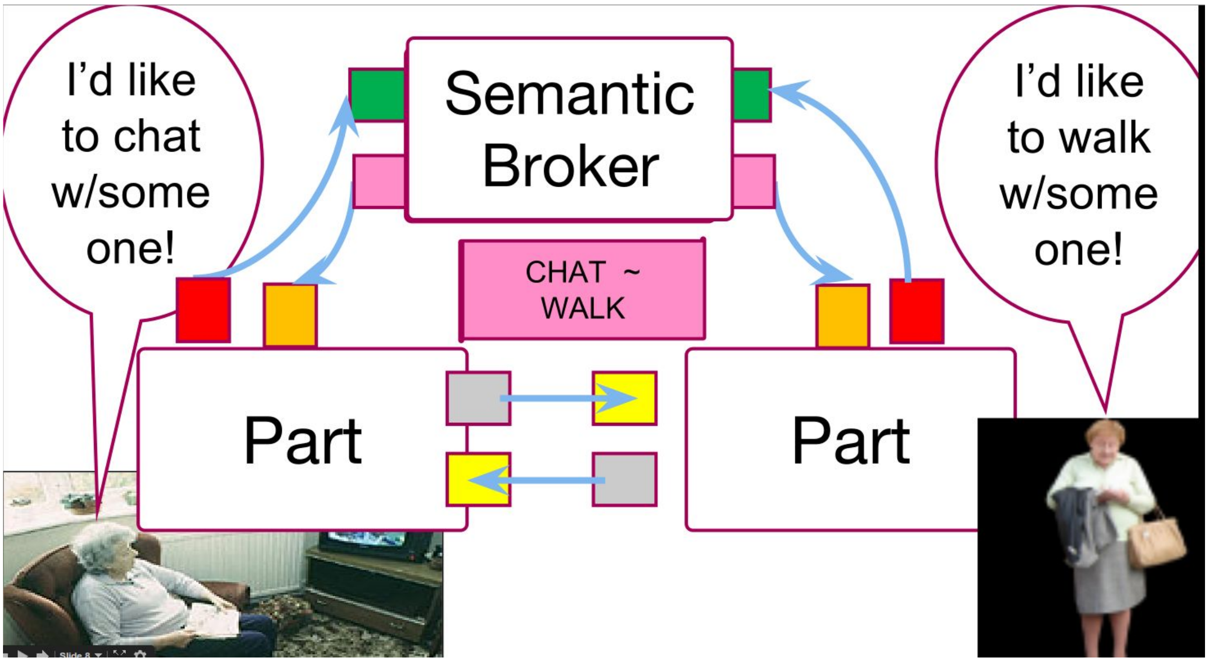

Figure 3: Example of symbiotic relationship. Two requests for service fulfill each other. Two “parts” become a temporary new “whole”.

4.3) For the reasons highlighted in 4.1) and 4.2), members may find mutually satisfactory requests regardless of the participating members' age. As an example, an elderly person feeling lonely, who was formerly a teacher of mathematics, may at the same time provide service to and receive service from a young student by offering him/her after-school support. It is just one example that shows the FSO potential as a tool to steer **INTER GENERATIONAL** value and **RESPECT**.

Rather than having fixed roles, the FSO appoints roles to members through dynamic enrollment that aims at improving quality at individual and social scale. In particular, mutualistic relationships are sought across the scales of FSOs so as to hook into the vast self-serve potential of our societies and exploit inter-organizational collaboration. This has a positive impact on **SUSTAINABILITY** and **FLEXIBILITY**.

PRIVACY is guaranteed by allowing participation to the FSO only through a registration scheme. No disclosure of the identity of participants becomes possible because transactions are managed through identifiers. Encryption and secure communication are used to guarantee **SECURITY**.

COMFORT is sought by creating usability metaphors that allow users not accustomed to technology to interact with the system in an easy and natural way. As an example, a TV channel metaphor is used to express a variety of user needs. As an example we could have special channels associated with typical requests: e.g.

channel 21 as the Chat Channel, channel 22 as the Walk Channel, and so on. An interactive TV would allow to catch tuning events and translate it in web services events.

5. Applicable IPR rules

None

6. Information on the partners

University of Antwerp conceived, designed, developed, simulated, and evaluated the current implementation of FSO as the sole partner of this project.

Addendum: Contact information

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