Trusted Communities – Social Metaphors for Technical Systems*

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The complexity of technical systems – especially in the area of embedded systems – has increased dramatically. Reasons for the increase are the higher integration of circuits, shorter clock periods and lower power consumption leading to a miniaturization of microprocessors, microcontrollers and Systems on Chip. A result is the development and marketing of ubiquitous devices like small PCs, handhelds, cell or smart phones. In addition, several of these systems and devices are interconnected by busses or via the Internet. An example is a modern car, which contains up to 100 microcontrollers running crucial tasks like ABS, ESP, engine control, and the navigation system. It is obvious that programming them and their interactions is highly complex, especially if real-time aspects have to be considered. It is a grand challenge to develop and maintain such highly integrated and often distributed systems.

As a response, the Organic Computing (OC) Initiative was founded in 2002. It deals with theoretical and practical foundations to handle the complexity of technical systems described above, inspired by mechanisms found in nature and biology. Several research projects in the scope of the initiative were initiated in the last years. The work presented in [1] gives a good overview.

A typical property of OC systems is that they consist of interacting autonomous entities (e.g. the microcontrollers in the car). In the following, we call such autonomous entities *agents*. The interactions of the agents depend strongly on several conditions: Do the agents belong to the same owner (like in the car) or do they belong to different owners (like bidding agents of different eBay users)? If the agents belong to the same owner we can assume that they will cooperate. But if they belong to different owners, cooperation between them is not self- evident: The bidding agents of different eBay users will try to win the auction and to minimize the price for their owner. Agents in such open systems are at least self-interested, but could also act selfishly or outright maliciously.

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Therefore, it is necessary that agents in OC systems become social agents, i.e. they must be aware not only of their environment but also of other agents. We define awareness of an agent as its ability to collect, store, aggregate, and use information about itself, about other agents and the environment. Awareness in a technical system can be classified into different types of observations and derived knowledge about ”the world”. We distinguish five classes of knowledge:

1. Self-knowledge: The knowledge of the agent about itself, its internal state and its abilities.

2. Knowledge about interaction partners: In order to interact properly the agent wants to be able to predict the future behaviour of its partners. The usual social concept for this is trust. A certain trust value is derived from past experience with this partner. Was he reliable? Did he ever try to cheat? Did he deliver correct results? What are his goals, and do they match or oppose my own objectives?

3. Knowledge about the community: A community is a set of agents, which belong together in some sense (e.g. because they serve the same user or they work on the same task). Therefore it is useful if the agents know about the number of agents and the individual capabilities of the community's agents even if they do not interact. This makes sense because if an agent is failing another agent of the community can replace it. More information about the community, which might be useful for making decisions, would be: the average workload of other agents, their reputation (i.e. what others think about an agent) or an impending system shutdown.

4. Knowledge about the institution: Human societies have invented institutions which (i) have a wider view than a single individual and (ii) are able to support or modify the interactions of the individuals. Examples are the government or a court of justice. In order to achieve this vertical interaction individual agents need specific knowledge like: What are the rules (the laws) I have to obey? What are the sanctions if I break the rules? And, on a meta-level: How can I change these rules?

5. Knowledge about the environment: The agents need to know or to learn important properties of their environment. Is it static or dynamic? Are there obstacles to be avoided?

We call the knowledge types (2)–(4) social awareness because they comprise knowledge describing the relations of the different agents. An agent that is able to collect and use such social information is a social agent. Viewing technical systems as autonomous entities interacting with their environment and with other similar entities opens a whole range of new possibilities how to build such agents: Social agents mimic human societies. Should we then set out and study the mechanisms of natural (human) societies and simply transfer them into technical systems? Since this cannot be an end in itself we have to ask critically why we are doing this.

We are concerned with building complex technical systems consisting of (semi-) autonomous subsystems, which we model in terms of agents. This approach is not to be confused with sociotechnical systems where the focus is on the interaction of people and systems[1]. The benefit of transferring social behaviour into technical systems is to optimise the interactions between different agents: Agents know with which other agents they can cooperate (thus accelerating task execution) and which agents have different goals (which leads to competition).

It is not our goal to mimic or simulate human social systems in order to gain a deeper insight into their mechanisms. While this is a worthwhile endeavour, all we want to achieve is an improvement of the technical system. We adopt (human) social mechanisms only if they help us. And we change them whenever this is beneficial.

In this talk we discuss the reasons why it is beneficial for agents to go beyond the purely "rational" agent behaviour, using the prisoner's dilemma. Then we discuss the requirements for social agents to organize themselves into sustainable – or enduring – institutions. We will use Elinor Ostrom's template for such an "Enduring Institution" [3] who has shown that social awareness is necessary whenever a group of agents competes for limited resources. In the following we will have a closer look at Trusted Communities – our implementation of a society of social agents – and the individual technical agents who constitute such a community. We show that self-organization of social systems is possible but it will also become clear that we need more institutional mechanisms in order to drive an agent community into a desirable direction. Therefore, we will analyse in how far we can transfer additional social mechanisms from Ostrom's eight principles to our technical societies.

In conclusion we reflect on our methodology used in this research: The transfer of social mechanisms into technical systems. We conclude that doing so we use (natural) societies as *metaphors* rather than modelling them.

References

[1] Müller-Schloer, C., H. Schmeck & T. Ungerer eds. 2011: Organic Computing – A Paradigm Shift for Complex Systems. Birkhäuser.

[2] Churchman, C. 1968: The systems approach. Number Parts 1–4 in Delta book. Delacorte Press.

[3] Ostrom, E. 1990: Governing the Commons: The Evolution of Institutions for Collective Action. Political Economy of Institutions and Decisions. Cambridge University Press.

[1] Sociotechnical systems (STS) in organizational development [2] is an approach to complex organizational work design that recognizes the interaction between people and technology in workplaces. The term also refers to the interaction between society's complex infrastructures and human behaviour. In this sense, society itself, and most of its substructures, are complex sociotechnical systems.