

Organic Computing Initiative

The 1980ies and 1990ies have been characterized by the convergence of computer and communication. In addition and fairly independently the application field of embedded systems has developed with far reaching impact for Europe's automotive, telecommunication and factory automation industry. The computerization of our environment opens fascinating application areas but, at the same time, bears the problem of its controllability. This means we have to construct these systems - which we increasingly depend on - as robust, safe, flexible und trustworthy as possible. In particular, a strong orientation of these systems towards the human needs as opposed to a pure implementation of the technologically possible seems absolutely central. In order to reach these goals, our technical systems will have to act more independently, flexible and autonomously, i.e. they will have to be life-like. We call those systems "organic". Hence, an "Organic Computing system is a technical system which adapts dynamically to the current conditions of its environment. It is self-organizing, self-configuring, self-optimizing, self-healing, self-protecting, self-explaining, and context-aware".

Organic Computing (OC) systems have been inspired by ideas from biology. However, they are based so far on well known silicon technology. Their life-like properties become apparent on the level of the total system and through the properties and cooperation of their components. By Organic Computing systems we mean neither DNA-based computers nor neurocomputers – although we wouldn't exclude such technologies in the long run.

First steps towards adaptive and self-organizing computer systems are being already undertaken. Adaptivity, reconfigurability, emergence of new properties and self-organisation are topics in a variety of research projects. The aims of OC have become strategic goals of prominent IT companies like IBM, Sun, DaimlerChrysler or Siemens-Fujitsu. In other networked systems such as traffic control, self-organization and strictly decentralized control have become a research goal. The research program which is proposed here by the Organic Computing Initiative goes – on the one hand – beyond the pure reconfigurability of circuits (SoC) or software since it includes the reconfiguration agent itself inside the technical system. But – on the other hand – it wants to differentiate itself from other more generally oriented research projects in the area of emergence and self-organisation, e.g. in the field of biological or social systems. *The objective of Organic Computing is the technical usage of principles observed in natural systems.*

The *advantages* of self-organizing systems are obvious: They behave rather like intelligent assistants than like rigidly programmed robots. They are flexible, robust in the presence of (partial) failures and able to self-optimize their behaviour. The design effort is reduced since not every conceivable variant has to be programmed explicitly in advance. But there are disadvantages and considerable risks, too. Learning systems can make errors which must not be tolerated in safety-critical systems. Learning means some unproductive effort in the first place which has to be amortized. Finally, adaptivity opens the potential for illegal manipulations of technical systems from the outside. Hence there is considerable need for research.

The OCI research program proposes three working areas (fig. 1). (1) It is necessary to investigate, model, understand, and quantify the principles of self-organization and emergence as observed in natural and technical systems. (2) The insights gained from this basic research are to be made available for technical systems, e.g. in terms of tools, algorithms or methods. (3) Finally the results are to be used in practically relevant application areas such as automotive, telecom or factory automation.

The emphasis of the proposed program, however, is in the area of the technical exploitation. We propose a three phase program with two years per phase. Each of the three working areas should be covered in each of three phases, however, with different emphasis and proportions of the devoted resources. Fig. 2 gives a rough estimate of these three phases.

The Organic Computing Initiative constitutes a unique opportunity to establish a long-term research cooperation between industry and academia within the European high tech community. The time horizon for the practical usage of OC systems is, according to renowned car manufacturers, at 10 to 15 years from now (2004). At the same time it is, according to the same source, a must, not an option, in order to manage the upcoming complexity of future technical systems. Self-organization is already a fact (as can be seen from the internet); it is our task to understand it and to keep it under control.

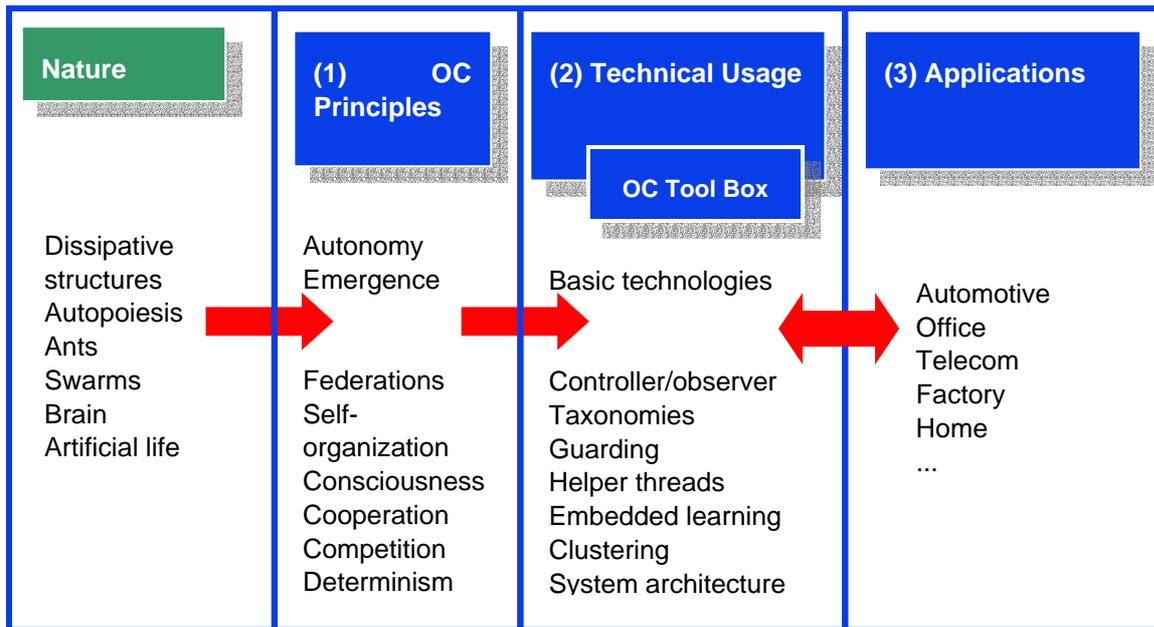


Fig. 1: The OCI research program. The arrows show the flow of information, not the time sequence. All three research areas are investigated in parallel with the application area providing a focus for the work during the whole project.

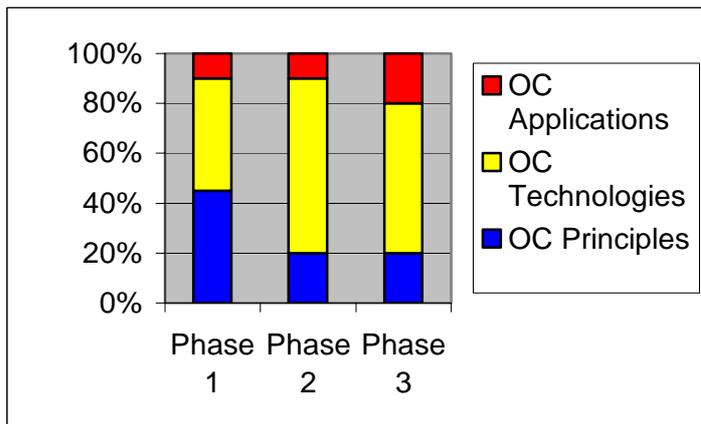


Fig. 2 A rough estimate of resource distribution during the three project phases.

OC research is, at least as far as basic research is concerned, *interdisciplinary*. Contributions for the understanding of emergent and self-organized systems are expected from computer science, neuroinformatics, biology, brain science and the engineering disciplines. We see this research initiative as a unique chance to establish a successful interdisciplinary cooperation.

The OC initiative has been started by a group of researchers from three German universities (Universität Hannover, Universität Karlsruhe and Universität Augsburg). In the mean time the initiative comprises more than 40 researchers from all over Germany and is being extended to other European and non-European countries. It is backed by the GI (German Informatics Society), the ITG (Informationstechnische Gesellschaft), the VDE (Verein Deutscher Elektrotechniker) as well as by Siemens Corp. Research and Daimler Chrysler.

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