International Journals of Advanced Research in Computer Science and Software Engineering
ISSN: 2277-128X (Volume-9, Issue-7)

Research Article | **July 2019**

Organic Computing

Matthew N. O. Sadiku, Philip O. Adebo, Sarhan M. Musa and Olaniyi D. Olaleye
Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX77446, United States
Email: sadiku@ieee.org; philip.adebo@gmail.com; smmusa @pvamu.edu; niyi_olaleye@yahoo.com

Abstract: ***Computing systems are becoming more and more complex and heterogeneous. Several approaches have been suggested for controlling self-organization process in complex systems. One of those approaches is organic computing, which aims at mastering complexity in technical system. It is closely related to autonomic computing and exhibits the same properties: self-organizing, self-configuring, self-healing, self-protecting, self-explaining, and context-aware. This paper provides a brief introduction to organic computing.***

Key Words: organic computing, autonomic computing

I. INTRODUCTION

It has long been observed that computing systems are growing in complexity for developing and maintaining, but human beings dislike complexity. There is a need for approaches which can effortlessly cope with complexity. The vision of achieving self-management in our complex computing systems has been realized by a proliferation of initiatives such as adaptive infrastructure, proactive computing, self-aware computing, autonomic computing, and organic computing.

Like autonomic computing, organic computing (OC) is an approach to handle the growing system complexity. While autonomic computing is based on the autonomic nervous system, organic computing is based on information processing in biological entities. The field of organic computing aims at translating well-evolved principles of biological systems to engineering complex system design.

A major concept applicable to autonomic and organic computing are the so-called self-X properties like self-organization, self-configuration, self-optimization, self-healing or self-protection, shown in Figure 1 [1]. More specifically [2]:

- *Self-organization* means the system's ability to organize its operation without an external control and to adapt to changes of itself and the environment. It is related to change of structure of system. Some components can leave while others can join according to certain goal.
- *Self-configuration* enables the system to find a working initial configuration. A system is meant to be configured by following high-level policies and adjust the rest of the system automatically.
- *Self-optimization* allows the system to autonomously make best use of the available. The system should at all times be optimizing itself with as little manual input as possible.
- *Self-healing* describes the detection of and automatic recovery from failures. A system should to be highly resistant to errors and are supposed to fix any problems in the system by itself. It can correct its errors.
- *Self-protection* enables the system to react properly to attacks. The system protects itself against dangerous environments by adapting to them.
- *Self-adaptation* describes the ability of a system to adapt to a changing environment according to a predefined model. Self-adaptive systems can deal with unforeseeable changes of requirements due to changes of environment or resources during runtime.

II. CONCEPT OF ORGANIC COMPUTING

The trend in computing community is to make technical systems organic. Organic refers to the systems that are capable of autonomously reacting to changes in their environment. Organic computing proposes new approaches to design organic systems that have the ability to observe their environment and the capabilities to adapt to changing environmental conditions. These systems exhibit the following self-* properties**:** self-organising, self-adapting, self-configuring, self-healing, self-protecting, and self-explaining. IBM was the first company to propose a concept for systems implementing these properties. Thus, organic computing can be regarded as an extension of the autonomic computing vision of IBM.

© *www.ijarcsse.com, All Rights Reserved*

An organic computing system (or just organic system) typically consists of a large number of autonomous and self-managed entities, where individual entities cooperate to determine the behavior of the entire ensemble system. An "organic computer" is a system that adapts dynamically to the current conditions of its environment. Organic computers are illustrated in Figure 2 [3]. Organic computing systems behave life-like and are inspired by biological phenomena or nature. Nature has evolved to cope with scale, complexity, heterogeneity, dynamism, unpredictability, and lack of guarantees. Given a goal and a budget, an organic computer finds the best way to accomplish the goal with the minimal amount of resources and energy. Organic computing builds upon other research directions [4]:

- *Machine learning*: A machine learning mechanism is needed to fulfill the self-improving property. OC architecture explicitly allows for self-learning using artificial neural networks. The learning mechanism in the OC architecture is an integral part of the controller. The goal of machine learning is to provide solutions which are trained by data or experience coming from their operating environment.
- *Optimisation:* The organic computing system optimises the number of tasks finished in a certain time period.
- *Multi agent systems*: Organic systems are usually not isolated but work together with other intelligent systems. The interaction enables the agents to achieve a higher goal which could not be achieved by any of its individual agents.
- *Human machine interaction:* Multi agent systems interact with humans and an interface is needed.

Organic computing additionally has the following five properties: self-awareness, adaptability, trust, approximation, and controlled emergence.

- *Self-awareness*: It can observe itself and optimize its behavior to meet its goals. To get such behavior, the systems must be aware of their surroundings and their environment. Self-awareness (or introspection) means that the system can observe itself while it is executing.
- *Adaptability*: OC systems are easier to maintain, because they can automatically configure themselves and are more convenient to use because of automatic adaptation to new situations. Adaptation is the ability of the computer to change what if necessary. Self-healing is a special case of adaptation.
- *Trust*: Organic systems must be trustworthy to avoid the risk of losing control. They should adjust to human needs in a trustworthy way. Trust consists of several facets such as safety, reliability, credibility and usability.
- *Approximation:* Approximate computation means that the computer does not always use the most available precision to accomplish a task. It is approximate because it uses the least amount of precision to accomplish a given task. An organic computer can choose automatically between a range of representations to optimize execution.
- *Emergence*: Emergent global behavior is a key aspect of OC systems. Emergent phenomena are often identified when the global behavior of a system appears more coherent and directed than the behavior of individual components of the system.

III. APPLICATIONS

Examples of application domains of organic systems include information technology, wetware computing, traffic management and control, cloud services, communication protocols, and robotic systems.

- *Wetware Computer*: A wetware computer is an organic computer composed of organic material such as living neurons. It is also known as an artificial organic brain or a neurocomputer. Although wetware is still largely conceptual, there has been limited success with construction and prototyping. Unlike conventional computer architecture which operates in binary, neurons are capable of existing in thousands of states and communicate with each other through its many synaptic connections. In 1999 William Ditto and his team at Georgia Institute of technology created a basic form of a wetware computer capable of simple addition [5].
- *Robotics*: OC can be used to realize a self-organizing, reliable, adaptive, and robust aerial robotic ensembles that are capable of adjusting to new situations. The approach is limited to single, isolated robots – information exchange with other robots or collaborative efforts among robotic teams were not envisaged in the original design concept. The Robot Operating System (ROS) provides a high-level software interface for programing and communicating with different kinds of robots [6]. It is not possible to predict the exact positions of the robots.
- *Organic Mobile Cloud Computing:* Mobile devices have become an integral and indispensable part of our life. . Mobile cloud computing (MCC) is the new type of cloud computing which utilizes the techniques of cloud computing for the treatment and storage of mobile devices data in the cloud. Organic mobile cloud computing is a system which allows methods to be annotated and offloaded automatically to cloud servers [7].

© www.ijarcsse.com, All Rights Reserved

IV. BENEFITS AND CHALLENGES

OC has fulfilled the vision of self-organizing technical systems adapting robustly to dynamically changing environments. The benefit of such systems is that they are dependable and can compensate for some failures. Such systems can maintain themselves and would not need of humans for their operation and maintenance. They should enable future ICT systems to carry out certain tasks on their own. As the systems become increasingly more complex, powerful, and smaller, our environment will be filled with collections of autonomous systems, which are equipped with intelligent sensors and actuators and can communicate and to organize themselves.

It is practically impossible to build circuits using only organic materials because one needs to use metals for the interconnects. Due to the high complexity it is hardly possible to design the behavior of each component for every potentially situation. The performance of the organic computers is so poor that there is no chance in the foreseeable future that they will replace the silicon-based computer chips in current computing devices. The use of self-organization in computing systems may lead to unpredictable global effects. The list of challenges is by no means complete [8].

V. CONCLUSION

Organic computing is an initiative that has the goal of creating computing systems that are self-organizing, self-configuring, self-healing, self-protecting, and self-explaining.

Organic computing systems are dynamic, composed of vast number of adaptable components, and located in an ever changing environment. As an idea whose time simply has come, organic computing is thriving from multiple roots. More information on organic computing can be found in books in [3,9,10].

REFERENCES

[1] A. Niederquell, "Self-adaptive systems in organic computing: Different concepts of self-improvement," https://arxiv.org/pdf/1808.03519.pdf

[2] U. Brinkschulte, "Model-driven design and organic computing - Contradictory or synergetic approaches to overcome the embedded software crisis," *Proceedings of IEEE International Symposium on Object/Component/Service-Oriented Real-Time Distributed Computing*, 2009, pp. 91-92.

[3] R. P. Wurtz (ed.), Organic *Computing*. Berlin, Germany: Springer-Verlag, 200, p. 11.

[4] M. Sommer, "Organic computing fundamentals – Learning from nature," http://www.matthiassommer.it/organic-computing/organic-computing-learning-from-nature/

[5] **"**Wetware computing," *Wikipedia*, the free encyclopedia https://en.wikipedia.org/wiki/Wetware_computer

[6] S. von Mannen, S. Tomforde, and J. Hahner, "An organic computing approach to self-organizing robot ensembles," *Frontiers in Robotics and AI*, November 2016.

[7] S. Nadouri and H. Fellah, "OMCC: Organic mobile cloud computing," *Proceedings of the 8th International Conference on Modelling, Identification and Control*, Algiers, November 2016, pp. 169-173.

[8] H. Schmeck, "Organic computing – A new vision for distributed embedded systems," *Proceedings of the Eighth IEEE International Symposium on Object-Oriented Real-Time Distributed Computing*, 2005.

[9] C. Muller-Schloer, H. Schmeck, and T. Ungerer (eds.), *Organic Computing: A Pradigm Shift for Complex Systems.* Springer, 2011.

[10] C. Muller-Schloer and S. Tomforde, *Organic Computing – Technical Systems for Survival in the Real World.* Springer, 2017.

ABOUT THE AUTHORS

Matthew N.O. Sadiku is a professor in the Department of Electrical and Computer Engineering at Prairie View A&M University, Prairie View, Texas. He is the author of several books and papers. His areas of research interest include computational electromagnetics and computer networks. He is a fellow of IEEE.

Philip O. Adebo is an instructor at Texas Southern University. He is currently working towards a PhD in Electrical and Computer Engineering Department, Prairie View A&M University with emphasis on power systems. His research interests include power and optimization of power systems.

Sarhan M. Musa is a professor in the Department of Engineering Technology at Prairie View A&M University, Texas. He has been the director of Prairie View Networking Academy, Texas, since 2004. He is an LTD Sprint and Boeing Welliver Fellow.

© www.ijarcsse.com, All Rights Reserved

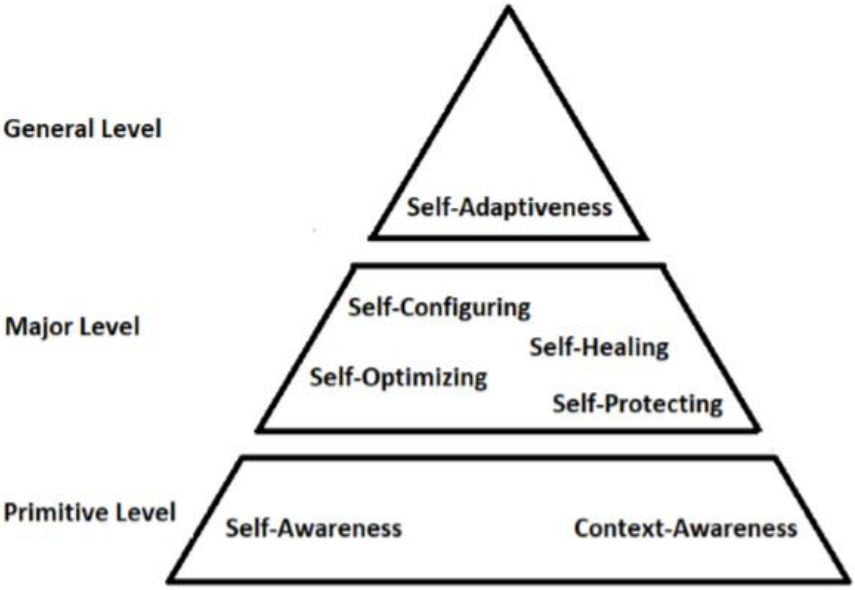

Figure 1 Hierarchy of self-X properties [1].

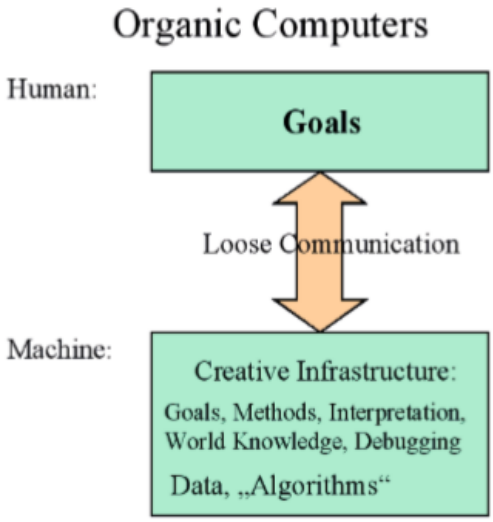

Figure 2 In organic computing, the only task humans hold on to is the setting of goals [3].

© www.ijarcsse.com, All Rights Reserved