Autonomic Computing – Panacea or Poppycock?
EASe 2005 Birds of a Feather Session

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1. Definitions[†]

au·to·nom·ic (àwtə nómmik)
adj.
    1. *Physiology.*
        a. Of, relating to, or controlled by the autonomic nervous system.
        b. Occurring involuntarily; automatic: *an autonomic reflex.*
    2. Resulting from internal stimuli; spontaneous.

au·ton·o·mic·i·ty (àwtə nóm i síttee)
n.
    1. The state of being autonomic.

au·ton·o·mous (aw tónnəməs)
adj.
    1. Not controlled by others or by outside forces; independent: *an autonomous judiciary; an autonomous division of a corporate conglomerate.*
    2. Independent in mind or judgment; self-directed.
    3.
        a. Independent of the laws of another state or government; self-governing.
        b. Of or relating to a self-governing entity: *an autonomous legislature.*
        c. Self-governing with respect to local or internal affairs: *an autonomous region of a country.*
    4. Autonomic.
[From Greek autonomos : auto-, *auto-* + nomos, *law*]

[†] Adapted from *American Heritage Dictionary of the English Language, 4th edition.*

pan·a·ce·a (pànnə see ə)
n.
    A remedy for all diseases, evils, or difficulties; a cure-all.
[Latin panacea, from Greek panakeia, from panakes, *all-healing* : pan-, *pan-* + akos, *cure.*]

pop·py·cock (póppee kòk)
n.
    Senseless talk; nonsense.

[Dutch dialectal pappekak : pap, *pap* (from Middle Dutch pappe, perhaps from Latin pappa, *food*) + kak, *dung* (from kakken, *to defecate*, from Middle Dutch kacken, from Latin cacare.]

2. A Brief History of Autonomicity

Autonomic Computing arose out of a need for a means to cope with rapidly growing complexity of integrating, managing, and operating computer-based systems as well as a need to reduce the total cost of ownership of today's systems.

Autonomic Computing (AC) as a discipline was proposed by IBM in 2001, with the vision to develop self-managing systems [1]. As the name implies, the influence for the new paradigm is the human body's autonomic system, which regulates vital bodily functions such as the control of heart rate, the body's temperature and blood flow—all without conscious effort.

The vision is to create *selfware* through *self-** properties. The initial set of properties, in terms of objectives, were *self-configuring, self-healing, self-optimizing* and *self-protecting*, along with attributes of *self-awareness, self-monitoring* and *self-adjusting*. This self-* list has grown: *self-anticipating, self-critical, self-defining, self-destructing, self-diagnosis, self-governing,*

self-organized, self-reflecting, and *self-simulation,* for instance [2][3].

3. Some EASe Success Stories

Although the Autonomic Computing initiative itself is still very much in its infancy, there have been, nevertheless, a number of success stories in developing autonomic systems reported at EASe 2004 and EASe 2005, along with the identification of a number of challenges:

- Rouff *et al.* [4] [8] describe a forthcoming NASA mission which is a concept for future missions involving swarm technology, which will necessitate autonomic behavior, and which highlights great challenges for verification of this class of systems.
- Sterritt *et al.* [5] highlight the importance of a reflex-healing dual strategy to facilitate the addition of autonomic capabilities to the telecommunications fault management architecture.
- Nichols and Bapty [6] describe an adaptive image processing environment that allows solutions of complex image processing problems to be built and executed rapidly on a number of hardware architectures.
- Shetty *et al.* [7] describe a language to define behaviors for the BTeV trigger system, which is being used as a model for tools for defining fault behavior and automatically generating software.
- Truszkowski *et al.* [9] describe the autonomic properties of two NASA legacy multi-agent systems, namely Agent Concept Testbed (ACT) and the Lights-Out Ground Operations System (LOGOS).
- Gracanin *et al.* [10] describe the use of a model-based architecture for the development of autonomic systems, using the COUGAAR architecture as a platform.
- Caseau [11] describes a set of adaptive methods and rules for routing messages in an Enterprise Application Environment, which yields a form of autonomic behavior.
- Sterritt and Chung [12] describe a proof-of-concept self-healing tool for the personal computing environment, which incorporates a pulse monitor and vital signs health monitor.
- The correspondence between elements of control systems and those of autonomic systems is identified by Diao *et al.* [13], who propose a Deployable Testbed for Autonomic Computing (DATC), in order to benefit from the methodologies of control theory, and simultaneously address the challenges of applying control theory to computing systems.
- Randles *et al.* [14] highlight the need for a meta-framework for self-governance, in order to achieve large-scale autonomicity.
- Wang and Mathur [15] present an interceptor-based approach for constraint-violation detection, for which monitor code can be generated automatically from XML-based constraint specifications.
- The potential benefit of using well-established systems engineering concepts and techniques in the development of complex systems is evaluated by Bustard *et al.* [16], with particular reference to two existing well-established methodologies.
- An autonomic system that supports transparent stream synchronization in multimedia streaming applications, with necessary components installed on the fly, is described by Friedland and Pauls [17].
- An autonomic system integration platform where holistic design models capture system structure and target system resources and autonomic behavior, is proposed by Shetty *et al.* [18].
- Rash *et al.* [19] describe a tool to support fully formal requirements-based programming, and describe its application to a system that exhibits autonomic properties.
- A comprehensive prototype autonomic system, in which self-optimizing agents provide a self-healing layer with ability to discover, diagnose, and react to discontinuities in real-time processing, is discussed by Messie *et al.* [20].
- Sterritt and Hinchey [21] describe apoptosis and self-destruction, the "ultimate" self-protection mechanism in autonomic systems, as applied to space missions.
- PACT – Personal Autonomic Computing Tools – describes efforts, in terms of prototypes, to increase the degree of autonomicity in today's personal systems [22].
- Baldassari *et al.* [23] describe an experimental cluster management system, which, although small, demonstrates a decrease in overhead as the cluster size grows.
- A theoretical protocol for autonomic distribution of services in a P2P environment is presented by Saffre and Blok [24], who aim to demonstrate that distribution that meets the requirements of the community can be achieved without centralized resource management.

4. Challenges for the Future

4.1 Learning from Past Experience

Several promising fields of engineering and computer science have suffered badly from unwarranted claims, exaggeration of benefits, or extrapolation of minor results to make claims of finding the "holy grail."

Formal methods for system specification and design, for example, have failed to live up to the exaggerated claims that were made about their benefits. Unfounded claims included that formal methods would result in fully correct computer systems [25]. What protagonists failed to consider is that they would result in systems that were correct with respect to their specifications. If specifications were flawed then too would be the resulting systems. Of course, formal methods offer opportunities to uncover errors in specifications, resulting in high quality software systems that are often cheaper to develop since errors are uncovered early [26][27]. Notwithstanding these benefits, formal methods are often considered to have failed to meet up to the claims made for them. Unfortunately, these claims were unreasonable.

Neural networks, evolutionary programming, and fuzzy logic have all suffered similar fates. Despite useful results and contributions to the advancement of Computing, early claims that these approaches could offer some form of "magic wand" that would solve a multitude of problems, or even *all* problems, simply could not be lived up to. The result is a cynical view by the public, funding agencies, and even researchers themselves, as to the benefits of these disciplines.

A similar situation arose with the field of Artificial Intelligence itself. In the 1950s and 1960s, protagonists claimed (falsely) to have invented computers that could think. In reality, all they had accomplished at the time was a computer program that could solve a single simple problem. The techniques that were produced were well worth pursuing further, but were far from embodying the elusive "machines that think."

Herb Simon, in his memoirs [28], recounts that his students claim he told them in class one Monday morning that over the weekend he and Alan Newell had invented a computer program that could think. Simon admits that to have made such a claim would be ludicrous, and didn't recall doing so; he concedes, however, that there were so many "witnesses" that he must have made such a claim.

Such outlandish claims were used by the opponents of Artificial Intelligence to "demonstrate" that computers would never be able to do the sorts of things that the proponents of AI were claiming [29], and indeed had a major role in influencing the findings of the 1973 Lighthill Report, which all but ended funding for AI research in the UK at the time.

4.2 A Balanced View

We believe that Autonomic Computing has much to offer in the advancement of complex computer–based systems.

We expect to see many additional *self–* properties being added to the portfolio of behaviors expected of an autonomic computing system. We anticipate many new biologically–inspired metaphors being developed and incorporated into future autonomic systems.

We believe, however, that the community needs to keep a balanced view. While we see autonomic computing and the autonomic metaphor as being a major step forward and a useful contribution to the future of Computing, we must be careful not to make unfounded claims for it, nor to have unreasonable expectations of it.

4.3 Panacea of Poppycock?

We certainly don't see Autonomic Computing as "poppycock", but we realize we're probably preaching to the choir on that.

Nor, however, do we see it as a panacea. In fact, we do not believe that any such panacea exists nor could exist. The development of computer–based systems involves the complex interactions between a number of stakeholders, meeting a variety of desiderata such as cost, lead–time, functional and non–functional requirements, development standards both self–imposed (e.g., quality standards, or for certification purposes) and mandated (by government and other bodies), ease of use, maintainability, etc.

The Autonomic Computing community is performing some excellent work, both research and applied. We believe that many of the results currently being produced will become standard practice in a variety of domains in the future. This is particularly true in situations where computer systems must be autonomous, either because they are required to perform tasks that are not possible for humans to perform (e.g., deep space exploration), or tasks that require decisions to be made so quickly that waiting for human intervention is just not feasible. We believe that these classes of autonomous systems will exhibit autonomic properties more and more in the future. In fact, we believe that the autonomous systems of the future will greatly rely on autonomic properties for their viability, and their very existence.

We must be careful, however, not to make the mistakes that many other communities have made. That is, we must be conscious of the limitations of Autonomic Computing, and not make claims for it that we cannot substantiate. However, we must continue to pursue the

field and ensure that its contributions are both developed further and applied in practice. We must demonstrate successes and the sustainability of the effort, without succumbing to the hyperbole that has stifled progress in other disciplines.

Right now it's only a notion but I think I can get money to make it into a concept and then later change it into an idea.

Woody Allen, *"Annie Hall"*

Acknowledgements

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