Autonomic Computing and A.I.

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"Short" Bio

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- Biography—Roy Sterritt is a member of Faculty in Computing and Engineering at Ulster University. He spent several years in industry with IBM, first at their UK headquarters in Portsmouth, and then at the IBM Hursley Labs in Winchester. Initially he was a Software Developer in their KBS department but then became a Product Development Manager with responsibility for tools to support risk assessment and project management in personal and mobile environments which were used widely in the UK and US. Roy's academic research career began in 1996 when he was appointed to the first of a series of joint University of Ulster and Nortel research projects investigating parallel, automated and intelligent approaches to the development and testing of fault management telecommunications systems.

- Roy's main focus of research is Systems and Software Engineering of Autonomic (Self-Managing Computer-Based) Systems, essentially a research area developed from a call from industry to deal with the complexity and total cost of ownership of our systems of systems (IBM 2001). To date he has 250+ publications in the field including research collaborations with NASA, IBM TJ Watson Center, BT, SAP, HP and Core Systems as well as many academic partners. The research with NASA also lead to 16 US patents. He was the founding chair of the IEEE Task Force and subsequently Technical Committee on Autonomous & Autonomic Systems and elected chair of IEEE Technical Committee on Engineering of Computer-Based Systems. He has held many other IEEE roles such as; IEEE CS Publications board member, chair of the Conference Publications Operations Committee (CPOC); served on the IEEE CS Technical & Conferences Activities Board (T&C Excom and Opcom) and chaired the Conference Advisory Committee (CAC). He has been appointed to the many editorial boards including the NASA Journal on Innovations in Systems and Software Engineering, ACM Transactions on Autonomous and Adaptive Systems (TAAS), AIAA Journal of Aerospace Computing, Information, and Communication, Journal of Autonomic and Trusted Computing, and Multiagent and Grid Systems - An International Journal; and served on steering and/or program committees of the majority of the conferences in his field at some stage during the last 20+ years.

- This extensive research community activity and NASA collaboration during the *noughties* lead to the common query from colleagues and management "are you ever at home?". As such Roy scaled back his international activity during the *tens* and took on institutional roles such as; Placement Coordinator-looking after 400+ students while seeking and on year-long industrial placement; Manager of CPPD (Continuous Personal and Professional Development) including developing outreach courses and summer schools in both Computer Science and Space Science. Yet with 16 patents with NASA, Roy also took the opportunity to explore spinning out the Autonomic Research as well as continuing that research into the 2020s, in particular, through his PhD researchers.

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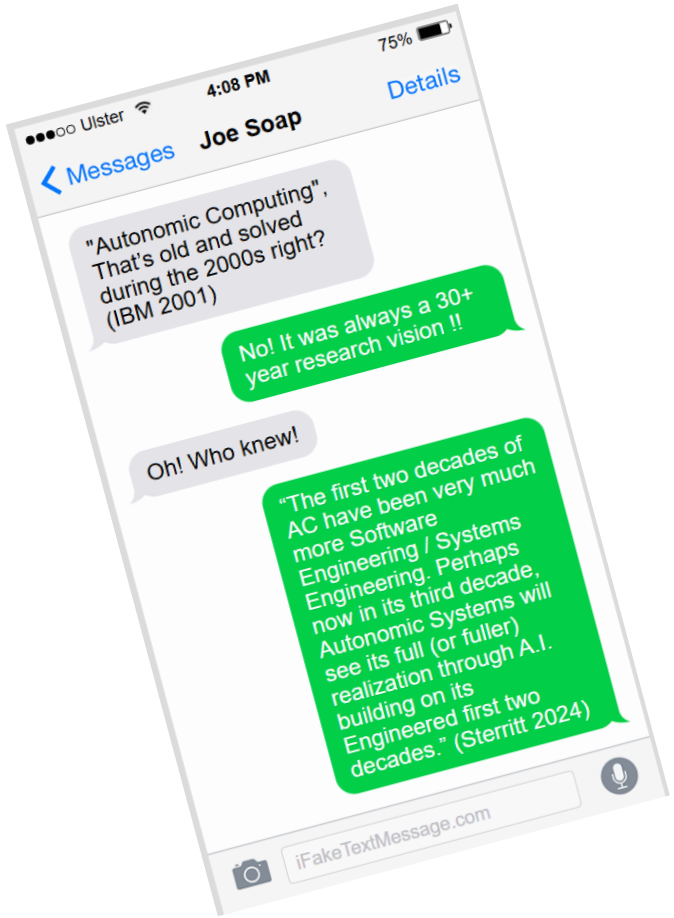
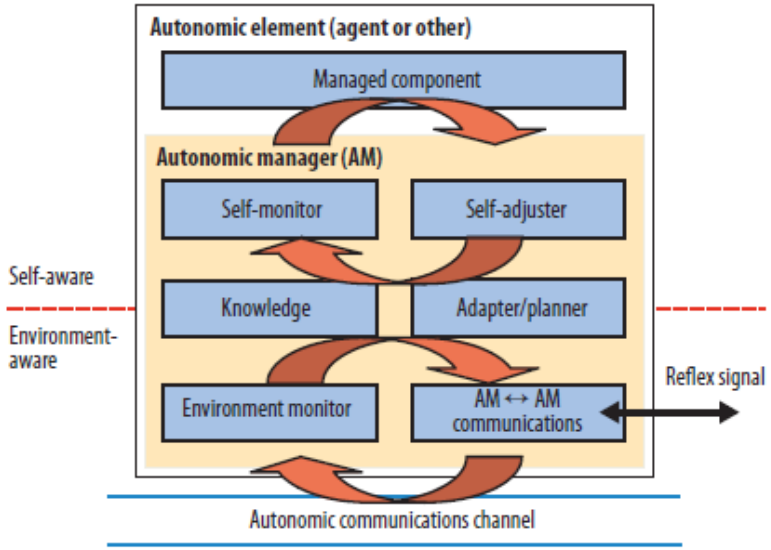
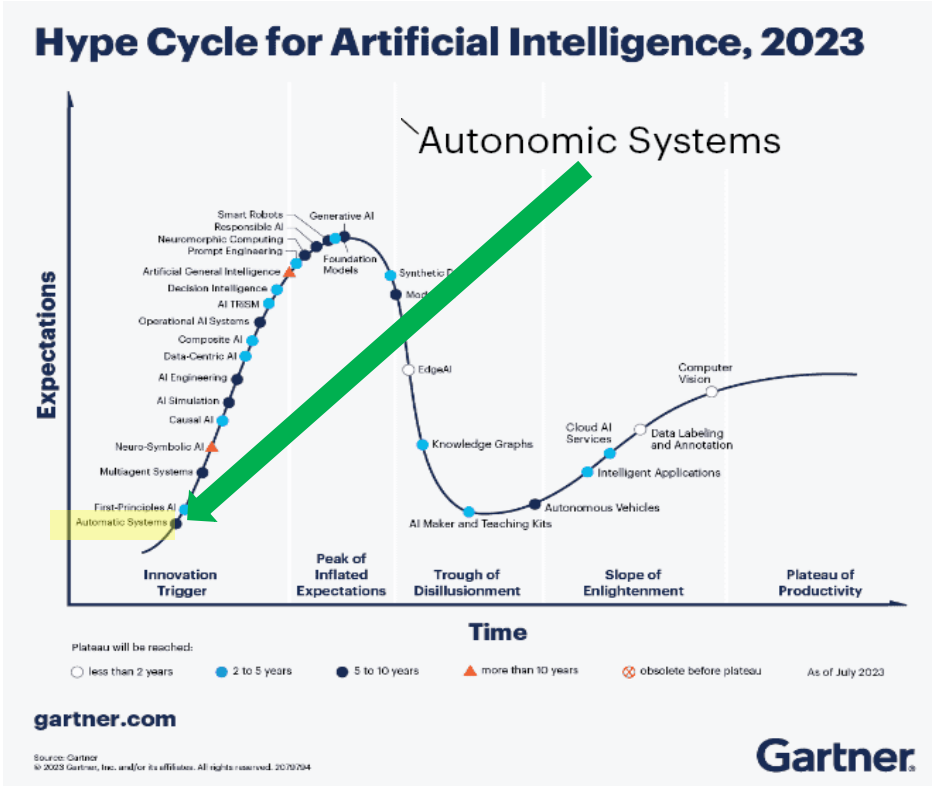
Autonomic Systems







[2],[3]

"***Autonomic systems*** *are examples of accelerated AI automation. They are self-managing physical or software systems, performing domain-bounded tasks that exhibit three fundamental characteristics: autonomy, learning and agency. When traditional AI techniques aren't able to achieve business adaptability, flexibility and agility, autonomic systems can be successful in helping with implementation. Autonomic systems will take five to ten years until mainstream adoption but will be transformational to organizations."* [1]

1. L. Perri, "What's New in the 2022 Gartner Hype Cycle for Emerging Technologies", Gartner, Online: https://www.gartner.com/en/articles/what-s-new-in-the-2022-gartner-hype-cycle-for-emerging-technologies, August 10, 2022.
2. N. Arya, "Gartner Hype Cycle for AI in 2023", KDnuggets, https://www.kdnuggets.com/gartner-hype-cycle-for-ai-in-2023, September 25, 2023.
3. A. Jaffri, "The AI Hype Cycle 2023: New Technologies on the Innovation Trigger", https://www.gartner.com/en/podcasts/thinkcast/the-ai-hype-cycle-2023-new-technologies-on-the-innovation-trigger

What is Autonomic Computing?

"Computer systems that can regulate themselves much in the same way as our autonomic nervous system regulates and protects our bodies"

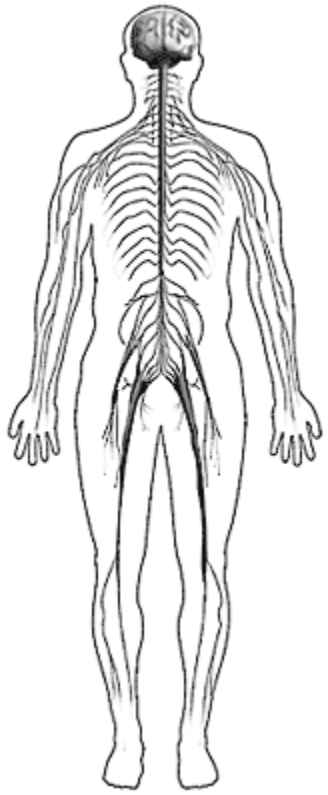
Paul Horn,
director of IBM research, 2001

AUTONOMIC COMPUTING:
IBM's Perspective on the State of Information Technology

P. Horn, (2001) "Autonomic computing: IBM perspective on the state of information technology", IBM T.J. Watson Labs, NY, 15th October 2001. Presented at AGENDA 2001, Scotsdale, AR. (originally available http://www.research.ibm.com/autonomic/), (Web archive: https://web.archive.org/web/20110916160342/http:/www.research.ibm.com/autonomic/manifesto/autonomic_computing.pdf)

Human Bodies are Self-Managing Systems

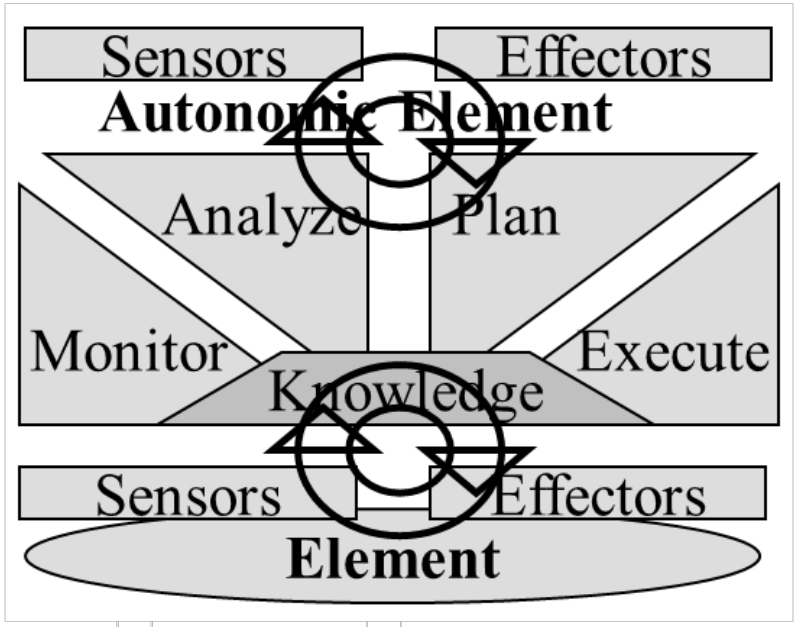
Autonomic Nervous System

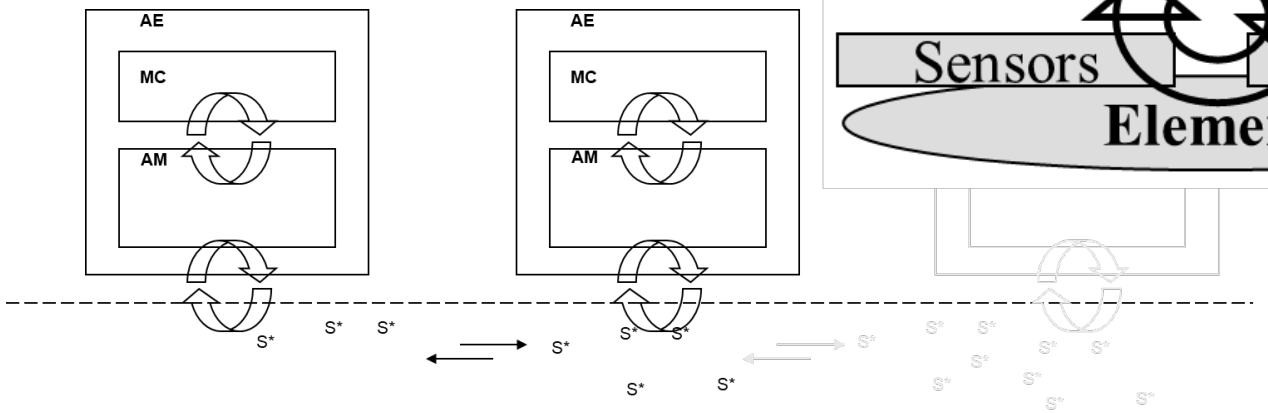


Fight or Flight

Rest and Digest

IBM's Autonomic Computing





Key

S*	Self-* event messages	AE	Autonomic Element (AM+MC)
		MC	Managed Component
		AM	Autonomic Manager (Stationary agent)

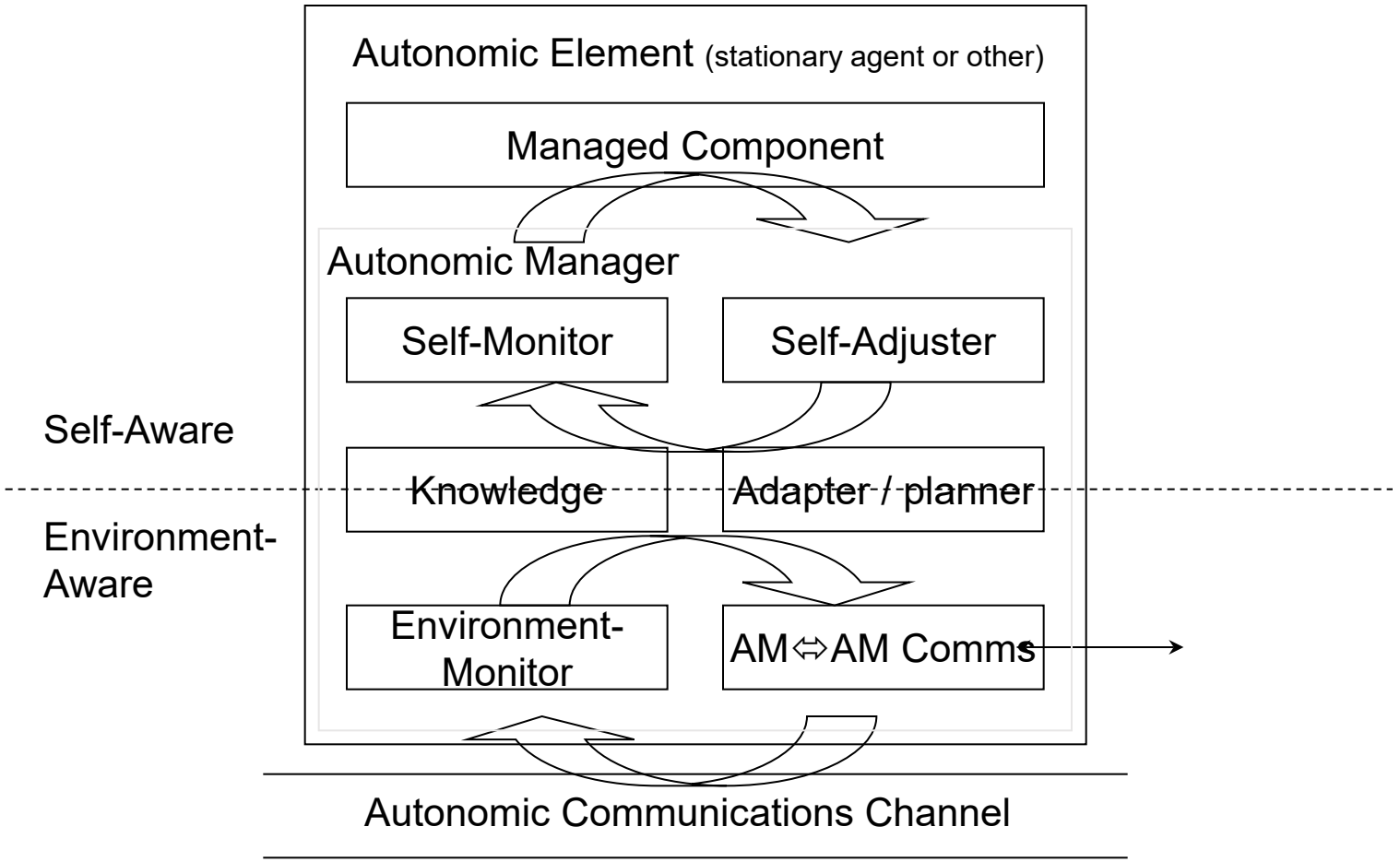
AUTONOMIC COMPUTING

- GOAL
  - SELF MANAGEMENT
- OBJECTIVES *what*
  - SELF CONFIGURING
  - SELF HEALING
  - SELF OPTIMISING
  - SELF PROTECTING
- ATTRIBUTES *how*
  - SELF AWARE
  - ENVIRONMENT AWARE
  - SELF MONITORING
  - SELF ADJUSTING
- APPROACHES
  - MAKE (SYSTEMS/ SOFTWARE ENG)
  - ACHIEVE (ADAPTIVE LEARNING)

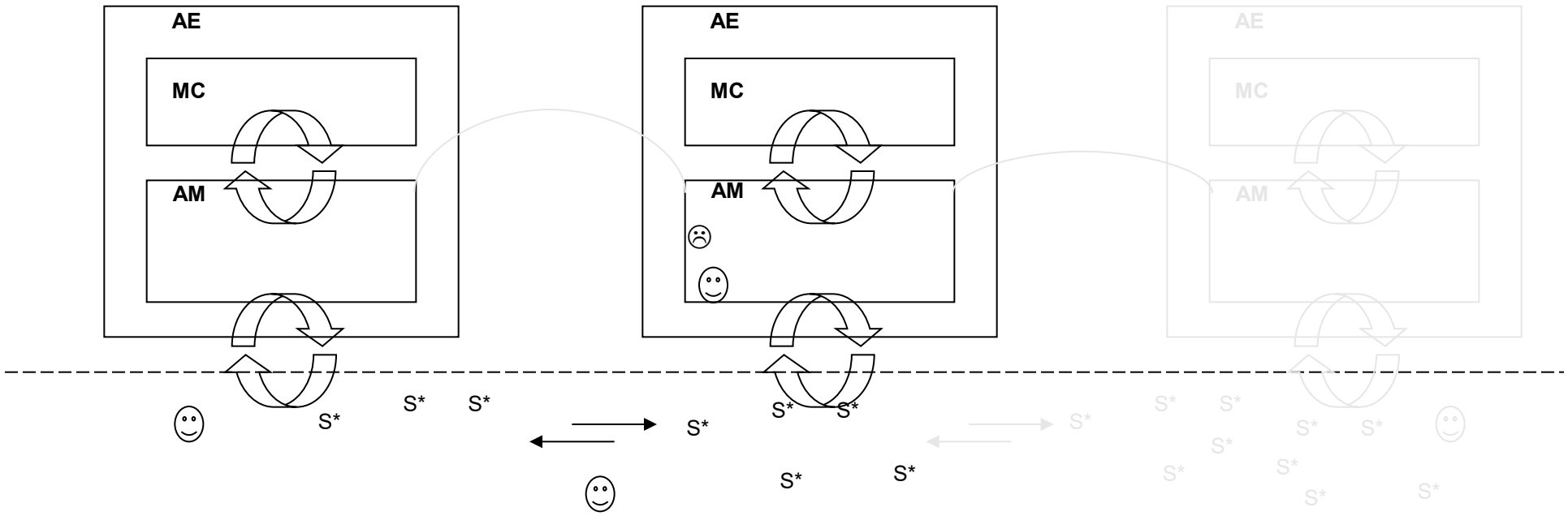
The AC Tree

Sterritt et al ECBS 2003

Autonomic Computing – The Autonomic Manager



Autonomic Computing – The Autonomic Environment



Key

S*	**Self-* event messages**	**AE**	**Autonomic Element (AM+MC)**
		MC	**Managed Component**
		AM	**Autonomic Manager (Stationary agent)**
☺	**Autonomic Agent (Mobile agent)**		

“Autonomic Computing”

Innovations Syst Softw Eng (2005) 1: 79–88
DOI 10.1007/s11334-005-0001-5

STATE OF THE ART

Roy Sterritt

Autonomic computing

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Abstract Autonomic computing (AC) has as its vision the creation of self-managing systems to address today's concerns of complexity and total cost of ownership while meeting tomorrow's needs for pervasive and ubiquitous computation and communication. This paper reports on the latest autonomic systems research and technologies to influence the industry; it looks behind AC, summarising what it is, the current state-of-the-art research, related work and initiatives, highlights research and technology transfer issues and concludes with further and recommended reading.

1 Introduction

Autonomic computing (AC), as the name suggests, is a metaphor based on biology. The autonomic nervous system within the body is central to a substantial amount of nonconscious activity that allows us as individuals to proceed with higher level activity in our daily lives [1]. Typical examples that have been highlighted are heartbeat rate, breathing rate, reflex reactions upon touching a sharp or hot object and so on [2–4]. The aim of using this metaphor is to express the vision to enable something similar to be achieved in computing, in other words, to create the self-management of a substantial amount of computing function to relieve users of low-level management activities, allowing them to place emphases on the higher level concerns of running their business, their experiments or their entertainment.

The need and justification for AC is based on the ever increasing complexity in today's systems. It has been expressed that the information technology (IT) industry's single focus has been on improving hardware performance, with software burgeoning with additional features to maximise on this additional capacity, at the neglect of other vital criteria. This has created a trillion-dollar industry with consumers consenting to the hardware–software upgrade cycle. Its legacy, though, is a mass of complexity within systems of systems, resulting in an increasing financial burden per computer (often measured as the TCO: total cost of ownership).

In addition to the TCO implications of complexity, complexity in itself is a blocking force to achieving dependability [5]. Dependability, a long-standing desirable property of all computer-based systems, integrates such attributes as reliability, availability, safety, security, survivability and maintainability [6]. Dependability was identified by both US and UK Computer Science Grand Research Challenges; “Build systems you can count on”, “Conquer system complexity” [7] and “Dependable systems (build and evolution)” [8]. The autonomic initiatives offer a means to achieve dependability while coping with complexity [5].

Initial reaction to the autonomic initiative was “is there anything new?”, and to some extent, this question can be justified as artificial intelligence (AI) and fault tolerant computing (FTC), among other research disciplines, have been researching many of the envisaged issues within AC for many years. For instance, the desire for automation and effective robust systems is not new; in fact, this may be considered an aspect of best practice systems and software engineering. Similarly, the desires for systems self-awareness, awareness of the external environment and the ability to adapt are also not new, being major goals of several fields within AI research. What is new is AC's holistic aim of bringing all the relevant areas together to create a change in the industry's direction; selfware instead of the hardware and software feature upgrade cycle of the past that created the complexity and TCO quagmire. Yet, a danger lies in that the self-* properties may just become the next marketing cycle of features–autonomics inside, and ultimately, AC would fall prey to the public impression of not meeting perceived expectations. As such, it must be kept in the foreground that this is a long-term strategic initiative with evolutionary deliverables enroute.

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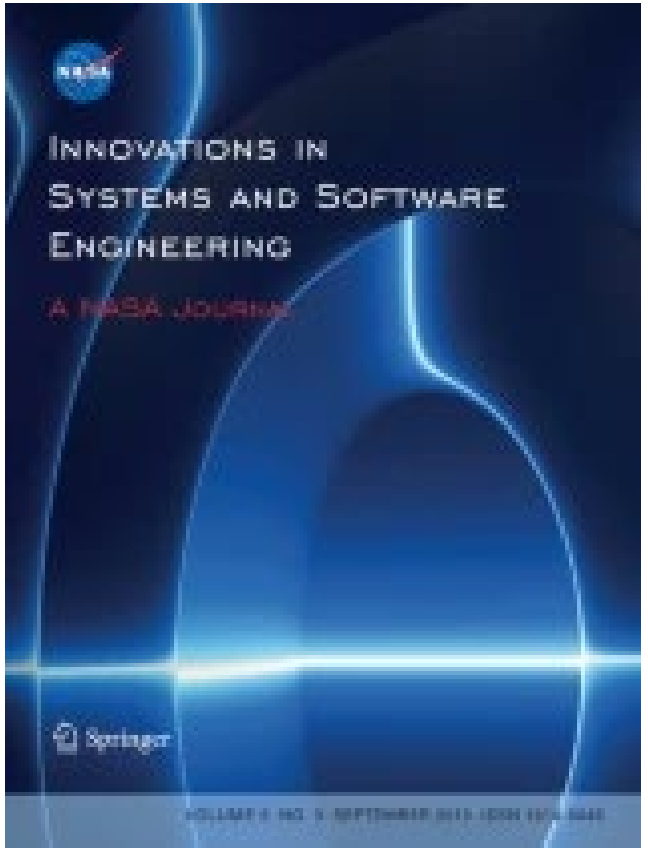
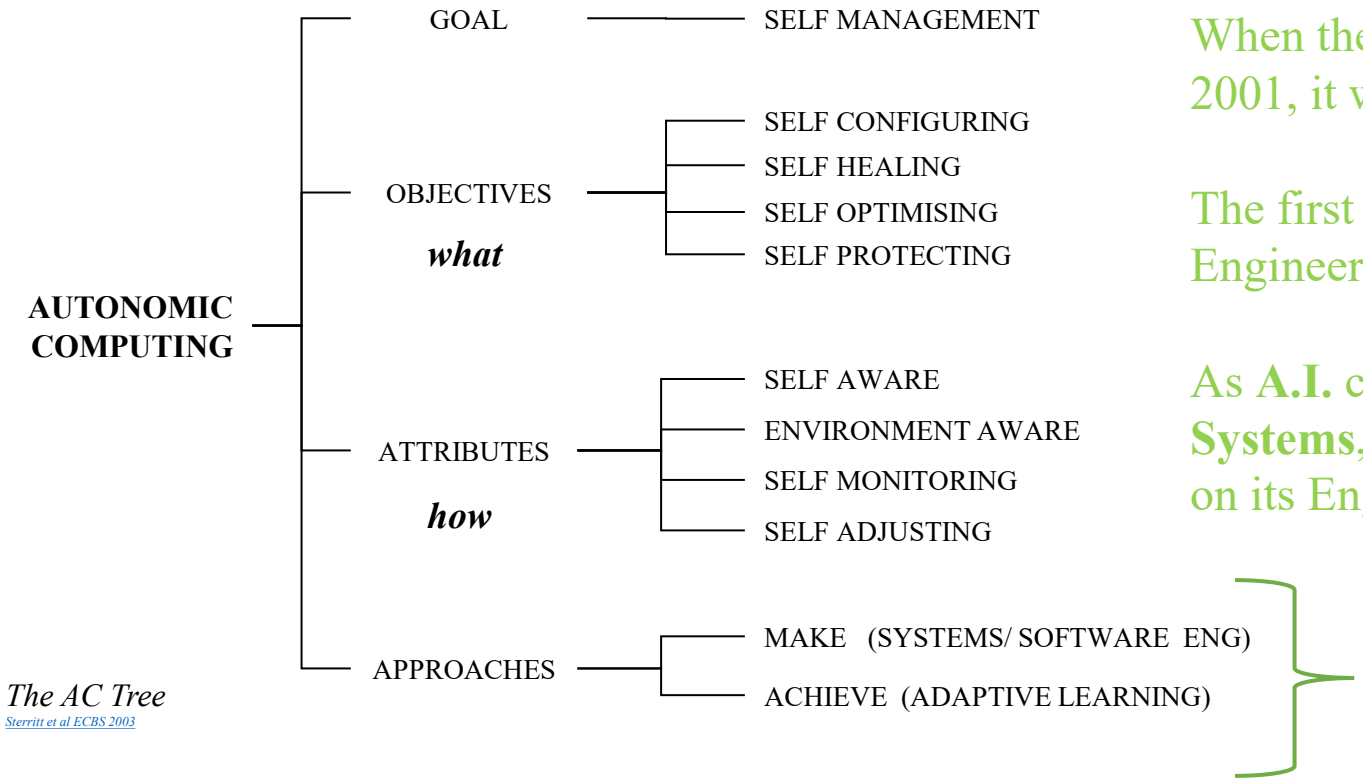


1. R. Sterritt, “Autonomic Computing”. *Innovations of Systems and Software Engineering: A NASA Journal,* **1,** pp79–88, 2005.



The AC Tree
Sterritt et al ECBS 2003

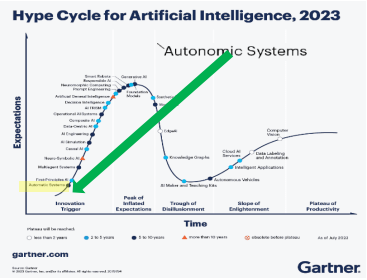
When the **Autonomic Computing** vision was first proposed in 2001, it was stated as a 20–30-year initiative.

The first two decades of AC have been very much more Software Engineering / Systems Engineering.

As **A.I.** comes of age, perhaps now in its third decade, **Autonomic Systems**, will see its full (or fuller) realization through A.I. building on its Engineered first two decades.

In an earlier version the approaches were "Engineer" & "Learn".

AI + AC Agenda



*"... Innovation Trigger, so for example on this year's Hype Cycle we have **Autonomic Systems** which is more around **actual evolution of AI into systems** which can take actions and decide or plans the tasks to accomplish, and to achieve, and can achieve some of those things in an autonomous kind of way as well, and then we also have multi-agents systems, which are kind of related to Autonomic Systems as well, where we have different AI agents collaborating together in order to achieve a particular outcome. …"* [1] (podcast 15mins 08secs in).

Does this A.I. view of Autonomic Systems fit with the original Autonomic Computing (AC) vision from IBM, first proposed in 2001, and researched over the next two decades? This determination is part of the aim of such research into AI+AC.

The main aim though is to establish 'can Autonomic Computing benefit from or be a significant contributor to the latest A.I. incarnation – **Generative AI**, as it moves towards **Artificial General Intelligence (AGI)**?

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1. A. Jaffri, "The AI Hype Cycle 2023: New Technologies on the Innovation Trigger", https://www.gartner.com/en/podcasts/thinkcast/the-ai-hype-cycle-2023-new-technologies-on-the-innovation-trigger

AIAC 2025 Contents

Synthetic Data Generation for Autonomic Computing

Catherine Saunders, Roy Sterritt, Peter Nicholl, Ian McChesney

Hard Disk Drive Reliability: A Comparative Study of Supervised Machine Learning Algorithms for Predicting Drive Failure

Alistair McLean, Roy Sterritt

~~Supervising Quality Environments with an Autonomic Ledger (SQuEAL)~~

~~Joel Bennett, Roy Sterritt~~

*** Apologies, paper withdrawn as patent still pending as going to press.

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