AI and Autonomic Computing

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***Abstract*—This paper summarizes a session of the track "AI and Autonomic Computing". The research work deals with the general question 'can Autonomic Computing benefit from or be a significant part of the latest A.I. incarnation – Generative AI, as it moves towards Artificial General Intelligence (AGI)?'**

Keywords; *Artificial Intelligence; A.I.; Autonomic Computing; Autonomic Systems; Generative A.I.; Artificial General Intelligence.*

I. INTRODUCTION

Gartner's Hype Curve for Emerging Tech 2022 has Autonomic Systems (re-)appearing (Figure I-1) 20+ years after Autonomic Computing was launch by IBM, as a call to industry and academia, in 2001 [1].

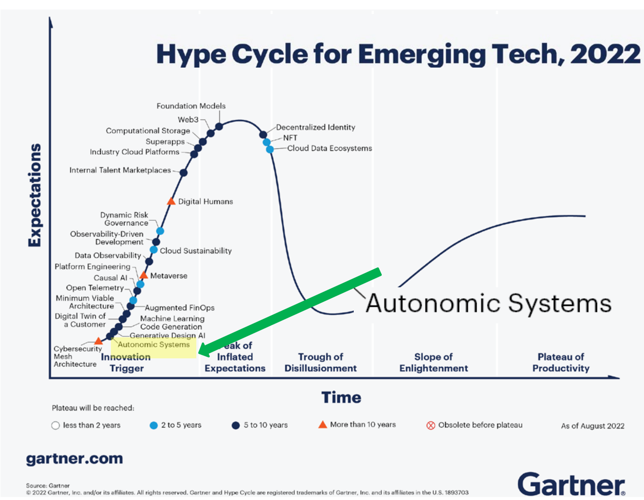

Figure I-1 Gartner's Hype Cycle for Emerging Tech 2022

"***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.*" [2]

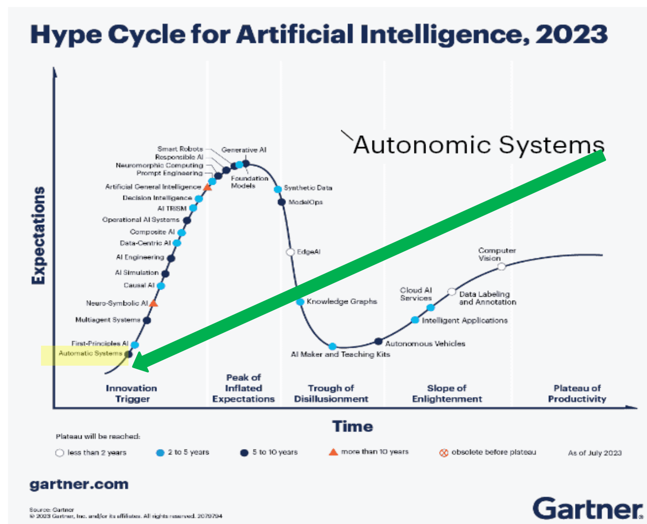

Figure I-2 Gartner's Hype Cycle for A.I 2023 has Autonomic Systems on the curve (5-10 years to reach plateau)

Autonomic Systems then appeared the following year, this time on the 2023 Hype Curve for **AI** (Figure I-2) [3][4];

"... 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. ..."* [3]*(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 [5]? 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)?

II. SUBMISSIONS

The first paper is about "Synthetic Data Generation for Autonomic Computing", by Saunders et.al. [6], where the paper discusses an approach that integrates data generation capabilities into the Autonomic Computing MAPE-K (Monitor Analyse Plan Execute and Knowledge Loop) to mitigate problems with data scarcity in autonomous space missions. The purpose of this work is to enhance the decision-making abilities of an Autonomic Manager by providing it with the ability to use simulation and data generation. A Conditional Tabular Generative Adversarial Network (CTGAN) is used to generate new synthetic datasets. Synthetic datasets are then evaluated to assess their utility. The evaluation results show that synthetic data can closely resemble the original data. However, this paper does not address the challenges of equipping a swarm with the necessary hardware, focusing instead on the feasibility of the proposed data generation pipeline. The significance of this approach is the potential of adding Simulation into the MAPE-K (Figure II-1) -> MAPSE-K, as well as providing opportunities for synthetic data generation within the Autonomic Element/Manager when there is a scarcity of data due to it being, for instance, a start of a mission/sub-mission or broken or intermittent errors from sensors.

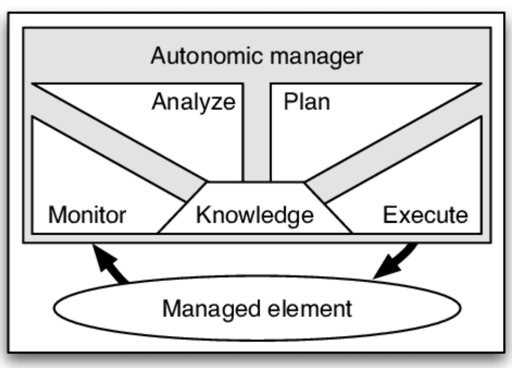

Figure II-1 IBM's Autonomic Element - "MAPE-K" Control Loop [5]

The second paper, "Hard Disk Drive Reliability: A Comparative Study of Supervised Machine Learning Algorithms for Predicting Drive Failure" by McLean and Sterritt, in [7], utilizes A.I. for essentially an A.C. application. Unexpected downtime and IT system outages can cost organizations millions of dollars in lost revenue, loss of opportunity, and negatively impacted reputation. Third party cloud services and infrastructure are commonly used by individuals and organizations as it offers the ability to create highly scalable applications without the huge cost of purchasing and maintaining their own hardware facility. Consequently, cloud service providers are challenged with ensuring that their data centers are reliable, as they have shared responsibility for the applications deployed in them. One of the most common causes of IT system failure in data centres is failing Hard Disk Drives (HDDs). It is proposed that if data centres were able to accurately predict imminent HDD failures, then appropriate action could be taken to prevent potential outages. This paper investigates the relationship between Self-Monitoring, Analysis, and Reporting Technology (SMART) attributes and HDD failure, implementing supervised machine learning methods to predict drive failure at various prediction horizons. Random Forest and XGBoost classifiers are observed to achieve the best prediction performance, with the Area Under the Receiver Operating Characteristic Curve (AUROC) calculated at 0.9185±0.0066 and 0.9162±0.0066 respectively at the shortest prediction horizon (0-24 hours prior to failure). Reallocated sectors count (SMART 5), reported uncorrectable errors (SMART 187), current pending sector count (SMART 197), and uncorrectable sector count (SMART 198) were found to be the most important SMART attributes for HDD failure prediction. This is significant as AI is being utilized in part of the AC self-healing process with preventative self-optimization, self-configuration and even self-protection.

Unfortunately, the third paper, "Supervising Quality Environments with an Autonomic Ledger (SQuEAL)" has had to be withdrawn, as the patent is still pending at time of going to press. Hopefully we'll see it at a future ICAS once the patent has been granted. In the mean-time, earlier SoK work on this area "Autonomic Computing in Total Achievement of Quality" [8] may be of interest.

III. CONCLUSIONS

This special session on *A.I. and Autonomic Computing* has only scratched a tiny part of the surface on the topic providing research examples of AC accelerated AI automation, with the aim to provide autonomy, learning and agency in their respective domain-bounded tasks.

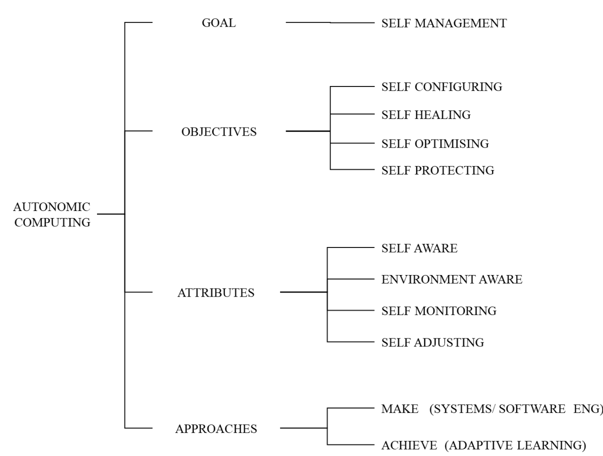

Figure III-1 Sterritt's Autonomic Computing Tree [9][10]

Interestingly, back in 2003 Sterritt had two "approaches" for AC on Figure III-1 Sterritt's Autonomic Computing Tree [9][10] "Make (systems/software engineering)" and "Achieve (AI/Adaptive Learning"). In an earlier version the approaches were "Engineer" & "Learn". In 2003 & 2005 the emerging AC community reached out to the A.I. community by running workshops at IJCAI (the top AI conference) e.g.[11], but found they (AC) were essentially just talking to themselves. Although an AI agenda was attempted as well as the Engineering approach [12].

When the Autonomic Computing vision was first proposed, 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.

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