

A Framework for Evaluating Quality-Driven Self-Adaptive Software Systems (SAS)

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How are we evaluating our approaches for SAS?

Lack of standard mechanisms to certify adaptive software systems

No clear assessment methods for self-adaptation	Performance as the de facto assessment mechanism	No explicit definition of evaluation properties	Lack of separation of concerns in the assessment
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United States Air Force Chief Scientist (AF/ST). Technology Horizons a Vision for Air Force Science & Technology During 2010-2030. Technical report, U.S. Air Force, 2010.

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A Relevant Problem for SEfSAS

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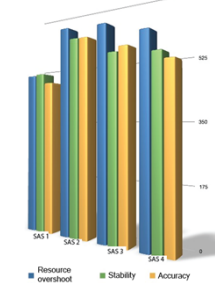
A Relevant Problem for SEfSAS

It is time to develop standard mechanisms for the assessment of self-* goals achievement !

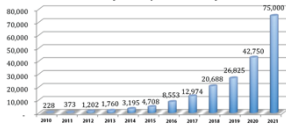
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Why?

SAS Benchmarking



Self-Adaptive Systems Adoption



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Outline

- 1 Methodology
- 2 Characterization Dimensions
- 3 Properties & Metrics
- 4 Evaluation Process
- 5 Conclusions and Future Work

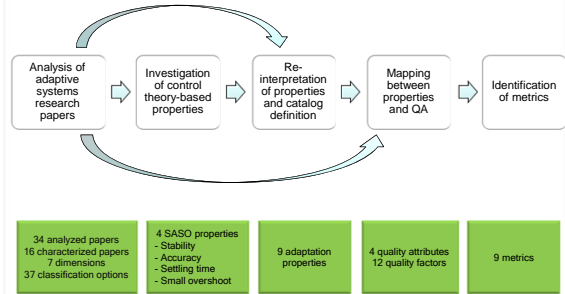
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THE EVALUATION FRAMEWORK

An initial catalog of adaptation properties and the foundations of a process to drive the assessment of adaptive software systems

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Our Methodology



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Characteristic	Count [list of approaches]
Spectrum Classification	
Control Engineering	1 [20]
Hybrid	5 [3, 4, 5, 8, 27]
Hybrid-Software	1 [24]
Software Engineering	9 [1, 6, 9, 10, 14, 15, 18, 23, 25]
Monitoring Mechanisms	
Monitor internal context	15
Monitor external context	2 [14, 18]
Non specified	1 [23]
Controller's Structure	
Feedback control	2 [20, 23]
Adaptive control	9 [1, 3, 4, 8, 9, 10, 14, 24, 27]
Reconfigurable Control	4 [5, 6, 15, 18, 25]
Managed System's Structure	
Non-modifiable	4 [3, 8, 20, 27]
Modifiable with reflection	12 [1, 4, 5, 6, 9, 10, 14, 15, 18, 23, 24, 25]
Adaptation Properties	
Settling time	4 [1, 4, 14, 27]
Small overshoot	4 [1, 4, 14, 20]
Scalability	3 [1, 6, 9]
Stability	2 [1, 20]
Accuracy	2 [5, 24]
Termination	2 [8, 25]
Consistency	3 [15, 18, 25]
Robustness	1 [6]
Security	0

Summary of Our Systematic Review



cf. Paper Tables 1, 2: The Characterization Model

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Applying Our Framework

Application case: Appleby et al. Océano [1]

Dynamic allocation of infrastructure resources to guarantee contracted SLAs

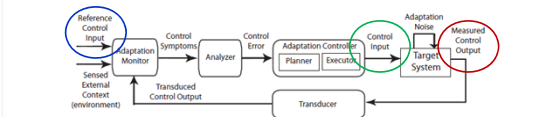


cf. Sections 2, 3 : for the proposed definition and possible values for each of the characterization dimensions

Appleby et al. Océano - SLA based management of a computing utility. In 7th IFIP/IEEE International Symposium on Integrated Network Management, pages 855-868, 2001

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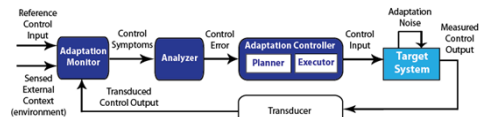
The Characterization Model



Adaptation goal	Reference inputs	Measured outputs	Computed control actions
Self-* properties, and functional and non-functional requirements	The way how adaptation goals are specified	Values measured in the managed system	The way how the managed system is affected: structural, behavioral
Self-managing	SLAs: average response time per request $\leq x$	Response time per request in an interval of time	1. Assign CPU 2. Process allocation 3. Load balancing

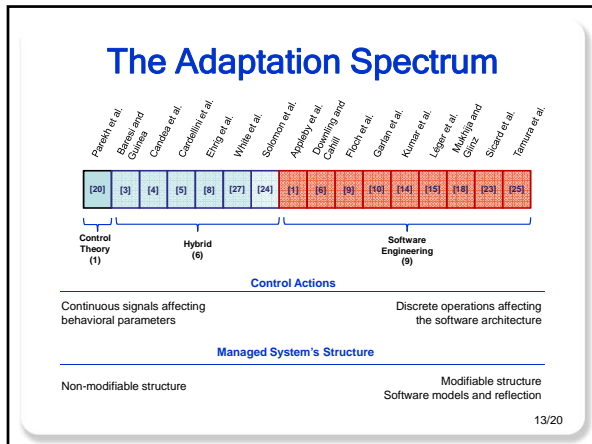
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The Characterization Model



System Structure	Adaptation Properties	Evaluation and Metrics
Controller and managed system	Observable and measurable properties for assessing the adaptation	The way how researches are evaluating their approaches
C: MAPE-based MS: Modifiable/ reflection	Settling time	Performance of the adaptation process (response time)

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Catalog of Adaptation Properties

	Adaptation Property	Property Verification Mechanism	Where the Property is Observed
From Control Theory	Stability	Dynamic	Managed system
	Accuracy	Dynamic	Managed system
	Settling Time	Dynamic	Both
From seminal SAS papers	Small Overshoot	Dynamic	Managed system
	Robustness	Dynamic	Controlled
	Termination	Static	Controlled
	Consistency	Both	Managed system
	Scalability	Dynamic	Both
	Security	Dynamic	Both

1. Assign CPU
2. Process allocation
3. Load balancing

cf. Paper Section 4.2: Adaptation Properties

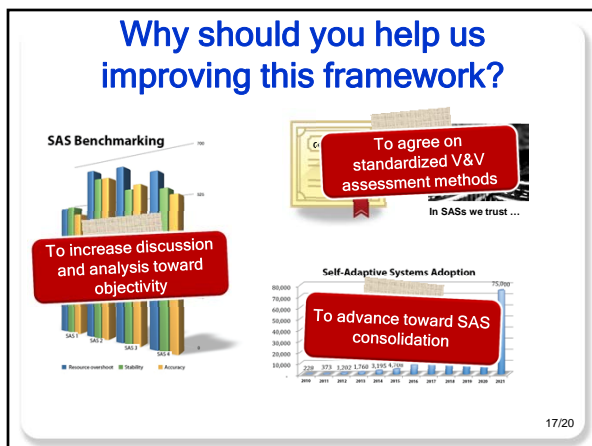
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Mapping Properties and QAs

Adaptation Property	Quality Attributes
Stability	Performance: Latency, Throughput, Capacity
	Dependability: Safety, Integrity
	Security: Integrity
Accuracy	Performance: Latency, Throughput, Capacity
Settling Time	Performance: Latency
Small Overshoot	Performance: Performance of the adaptation process (response time)
Robustness	Dependability: Availability, Reliability
	Safety: Interact. Complex, Coupling Strength
Termination	Dependability: Reliability, Integrity
Consistency	Dependability: Maintainability, Integrity
Scalability	Performance: Latency, Throughput, Capacity
	Security: Confidentiality, Integrity, Availability

cf. Paper Section 4.3: Mapping properties to quality attributes

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Conclusions

No properties → no standard metrics → no evaluation
Is performance all about it?

Many promising adaptation approaches!
can we trust them?

Control theory properties and QAs as cornerstones

Our evaluation framework paves the way toward improving SAS assessment

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Summary

A Relevant Problem for SEISAS

It is time to develop standard mechanisms for the assessment of self-* goals achievement!

Why?

Our Methodology

Catalog of Adaptation Properties

A Process for Evaluating Self-Adaptation

Why should you help us improving this framework?

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Future Work

Refinement and application of the adaptation properties catalog

Standardization of properties and metrics

Trade-off considerations when assessing multiple adaptation properties

Adaptive instrumentation for supporting run-time monitoring and run-time V&V

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Thank you!

This work has been inspired in part by many of the discussions that took place in Dagstuhl seminar 10431 on SEISAS. We thank all of the seminar participants!

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