

# Self-Adaptive Software Systems: Properties and Assessment

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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

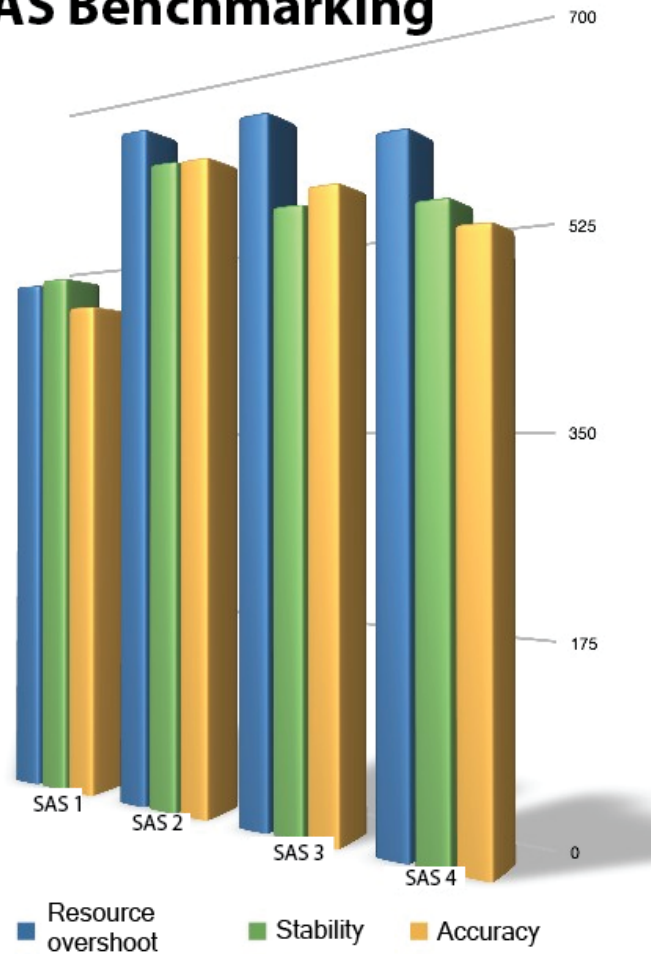
Lack of separation of concerns in the assessment

# A Relevant Problem for SEfSAS

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

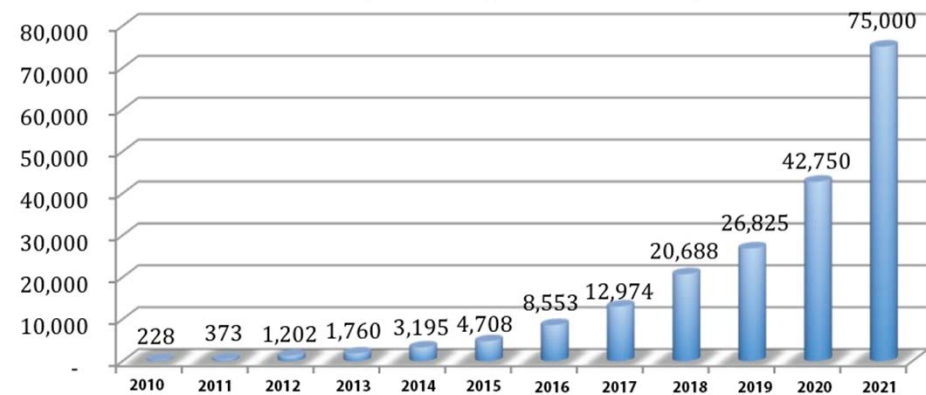
# Why?

## SAS Benchmarking



In SASs we trust ...

## Self-Adaptive Systems Adoption



# Outline

1

Characterization  
Dimensions

2

SAS Properties  
and Metrics

3

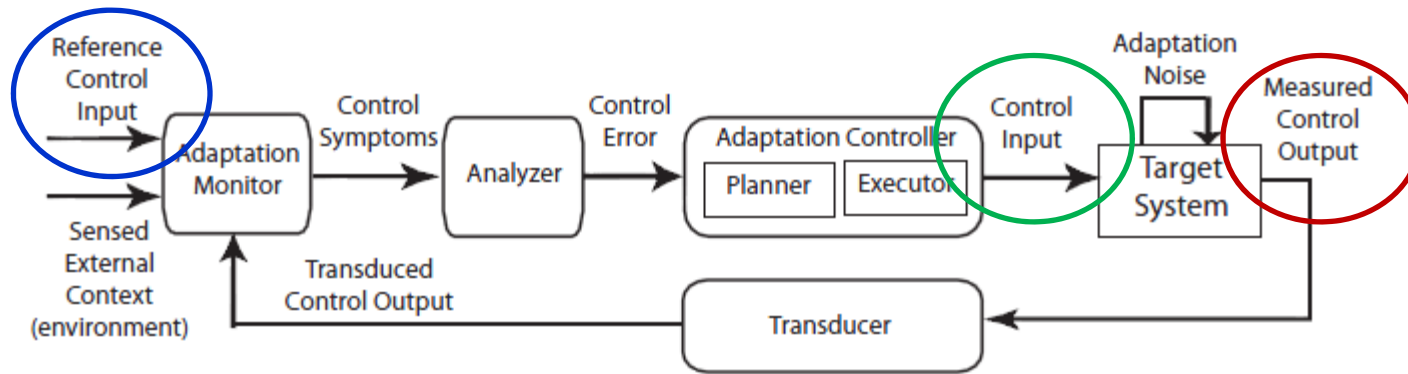
Runtime V&V

4

Challenges

# SAS: CHARACTERIZATION DIMENSIONS

# The Characterization Model



## Adaptation goal

Self-\* properties, and functional and non-functional requirements

Self-management

## Reference inputs

The way how adaptation goals are specified

SLAs: average response time per request  $\leq x$

## Measured outputs

Values measured in the managed system

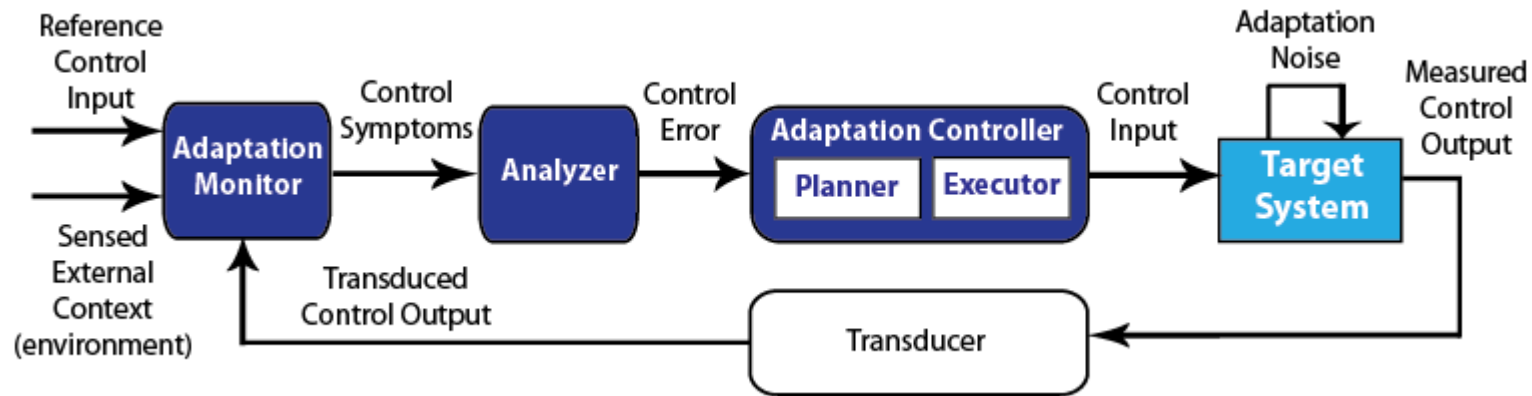
Response time per request in an interval of time

## Computed control actions

The way how the managed system is affected: structural, behavioral

- Assign CPU
- Process allocation
- Load balancing

# The Characterization Model



## System Structure

Controller and managed system

Immutable/Modifiable

## Adaptation Properties

Observable and measurable properties for assessing the adaptation

Response time

## Evaluation and Metrics

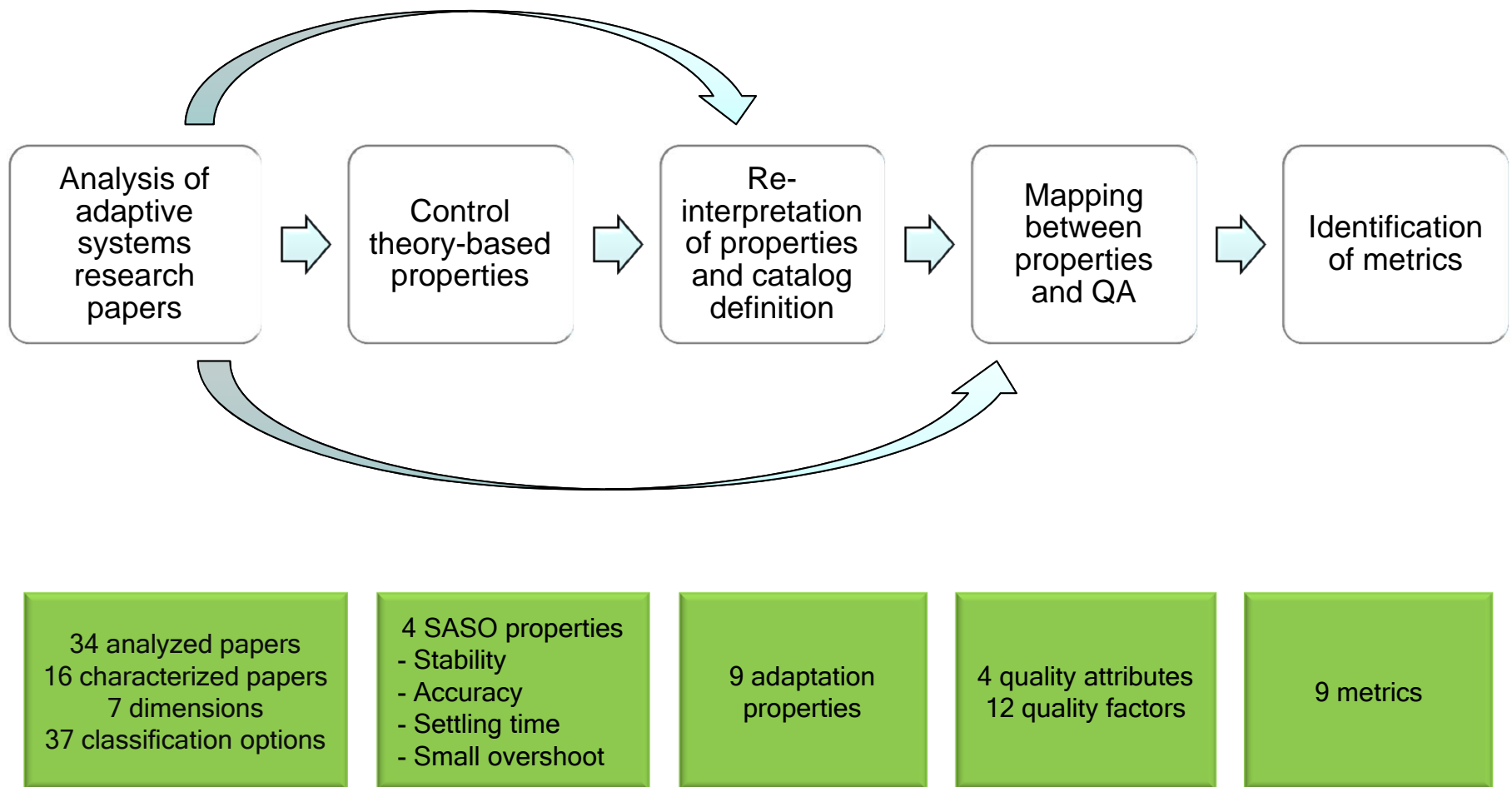
The way how researches are evaluating their approaches

Performance of the adaptation process (response time)

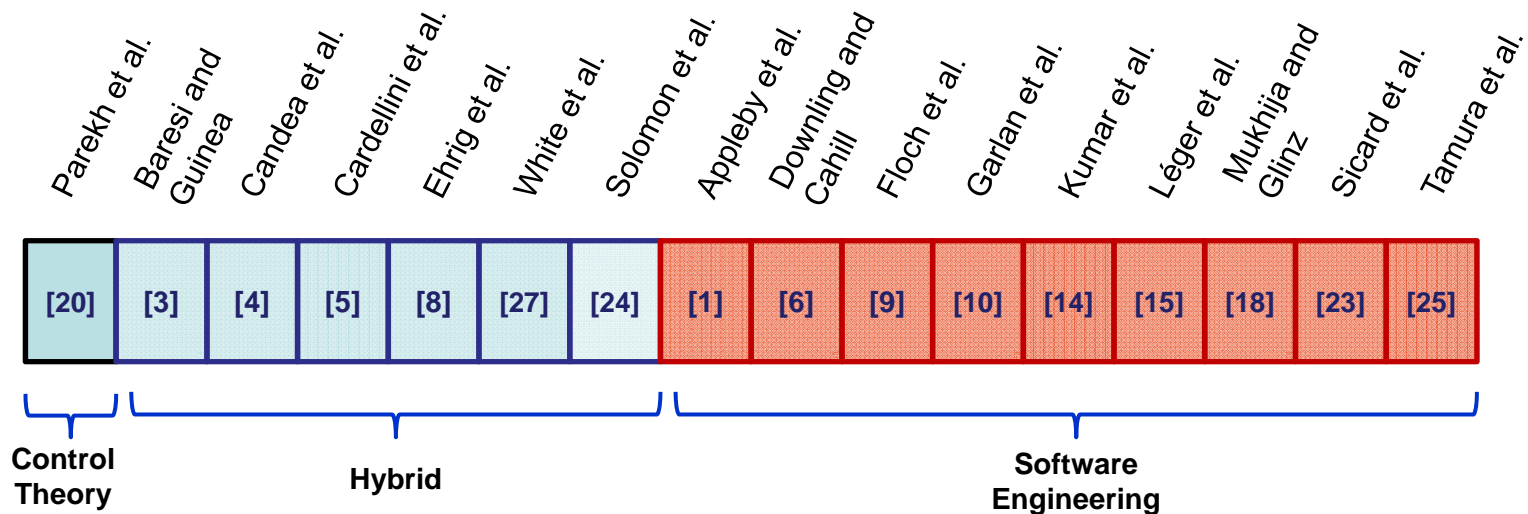


# SAS PROPERTIES

# A Catalog of Adaptation Properties



# The Adaptation Spectrum



## Control Actions

Continuous signals affecting behavioral parameters

Discrete operations affecting the software architecture

## Managed System's Structure

Non-modifiable structure

Modifiable structure  
Software models and reflection

Characteristic	Count [list of approaches]
<b>Spectrum Classification</b>	
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]
<b>Monitoring Mechanisms</b>	
Monitor internal context	15
Monitor external context	2 [14, 18]
Non specified	1 [23]
<b>Controller's Structure</b>	
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]
<b>Managed System's Structure</b>	
Non-modifiable	4 [3, 8, 20, 27]
Modifiable with reflection	12 [1, 4, 5, 6, 9, 10, 14, 15, 18, 23, 24, 25]
<b>Adaptation Properties</b>	
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 SAS Mechanisms and Properties

# 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 sys
	Robustness	Dynamic	Controller
	Termination	Static	Controller
	Consistency	Both	Managed system
	Scalability	Dynamic	Both
	Security	Dynamic	Both

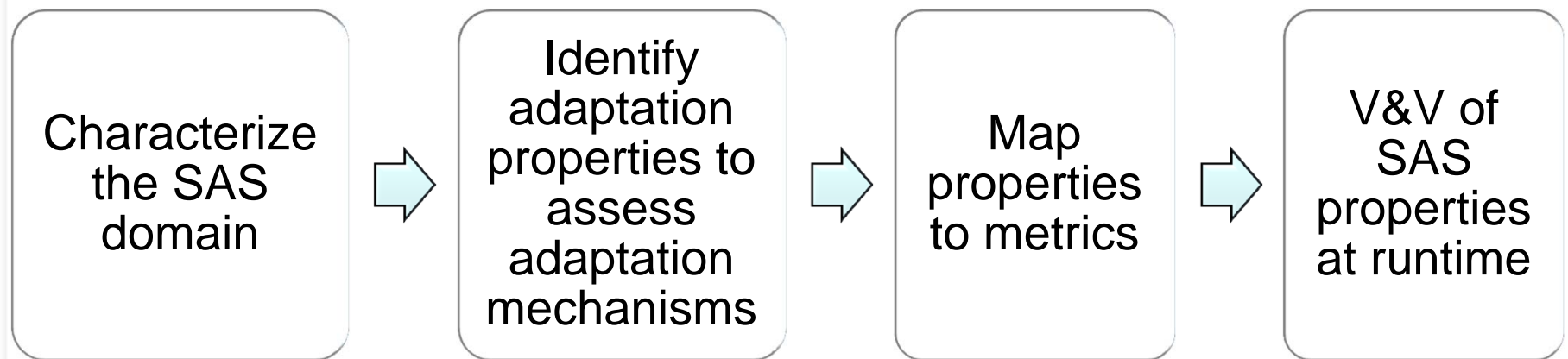
-Assign CPU  
- Process allocation  
- Load balancing

# 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	
	Safety	Availability Reliability
Termination	Dependability	Interact. Complex. Coupling Strength
Consistency	Dependability	Reliability Integrity
Scalability	Performance	Maintainability Integrity
Security	Security	Latency Throughput Capacity
		Confidentiality Integrity Availability

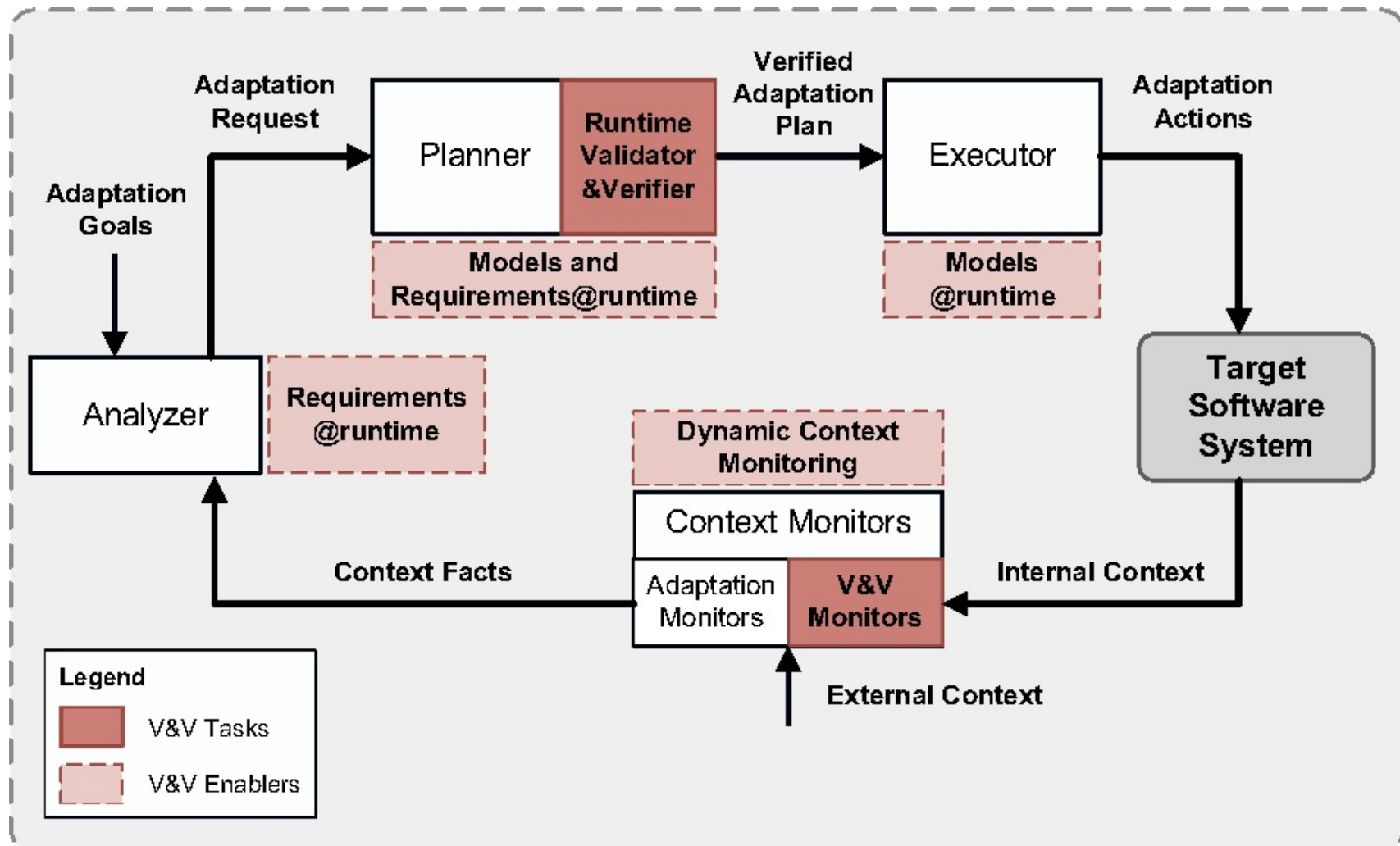
# **RUNTIME V&V OF ADAPTATION PROPERTIES**

# A Process for Assessing Self-Adaptation Properties

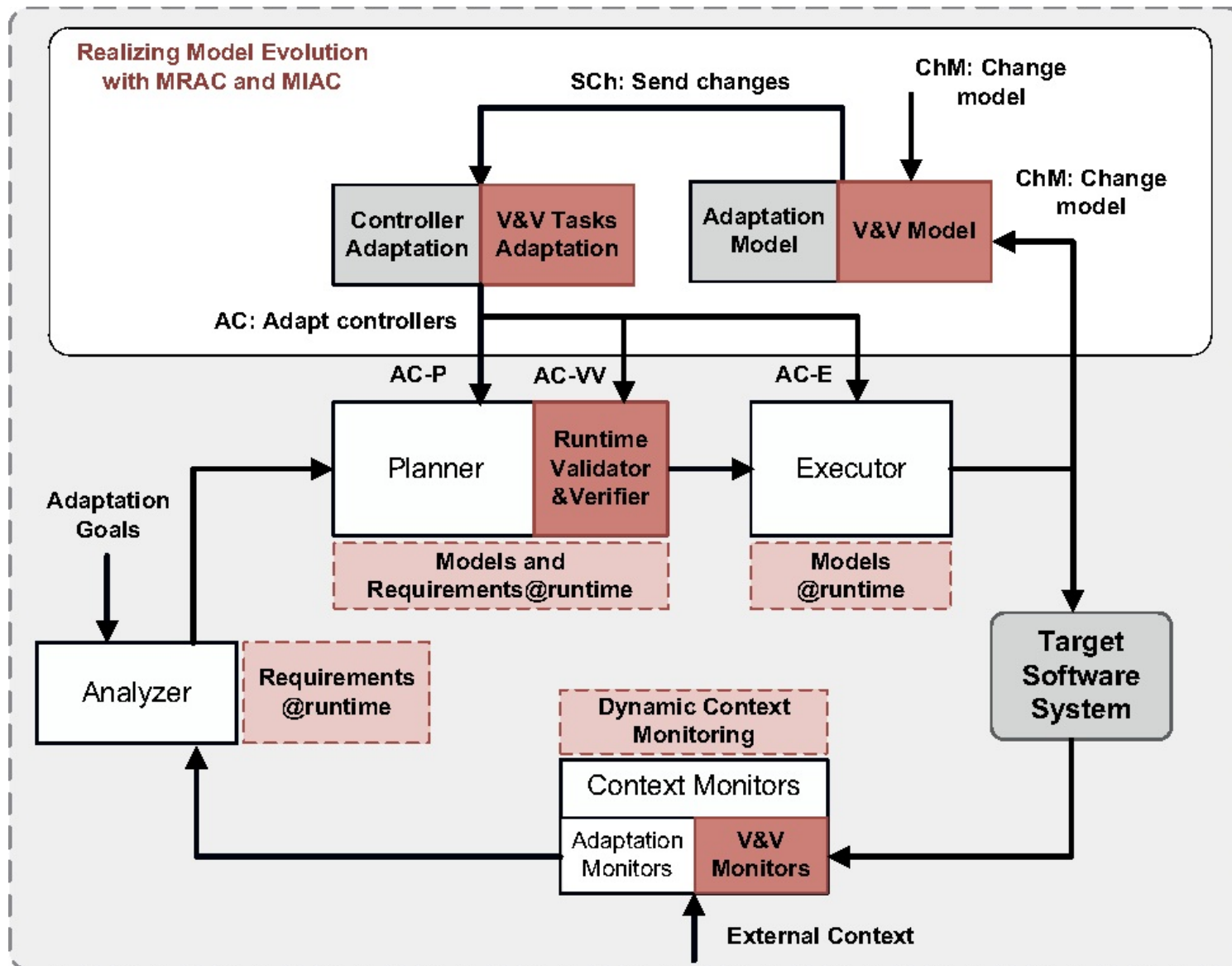




# V&V of SAS Properties at Runtime (1)



# V&V of SAS Properties at Runtime (2)



# Challenges Ahead

Behavioral vs. Structural SAS mechanisms: is any of them better/more effective? For a subset of domains? Which ones?

How to (automatically, efficiently, etc.) verify if a SAS mechanism preserves a given set of SAS properties at runtime?

Is it possible to find a set of principles (based on e.g., mathematical foundations) to design SAS mechanisms that guarantee a given set of SAS properties?

Trade-off considerations when assessing/enforcing multiple adaptation properties

# Thank you!



University of Victoria



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