Towards Self-Adaptable Languages

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GT VL — December 2, 2021

Context

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Software languages ...

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Vision : abstract self-adaption into high level language constructs

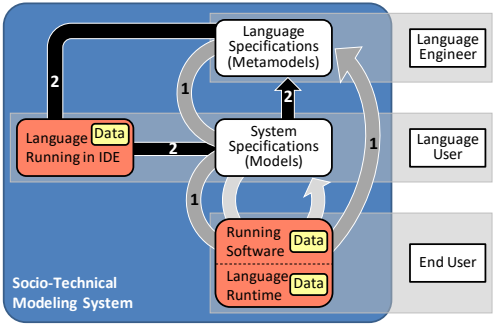
[1] Cf. `https://waymo.com`, `https://www.netflix.com`

What is a Self-Adaptable Language ?

" *A software language that abstracts the design and execution of feedback loops in the design-time environment and the run-time environment* "

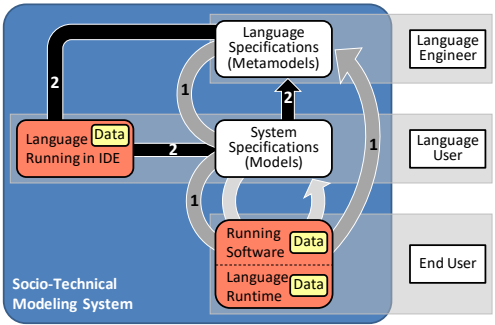
1. Free the language user from the implementation of :
   - The feedback loop
   - The trade-off analysis
2. Allow continuous and automatic evolution of itself

L-MODA | Languages, Models, and Data



L-MODA Conceptual Framework for Self-Adaptable Languages

L-MODA | Languages, Models, and Data



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1) Runtime Feedback Loop

Use run-time data, model & metamodel
→ adaptation of language semantics

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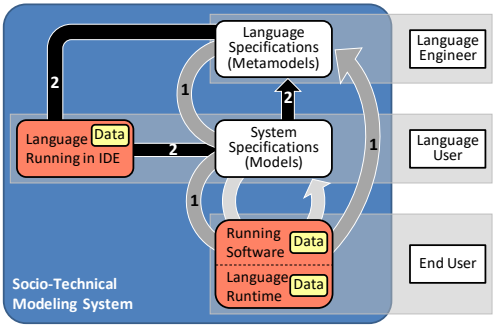

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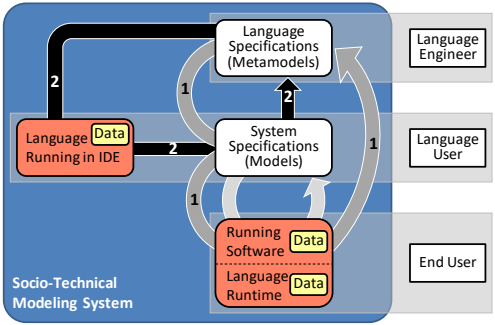
1) Runtime Feedback Loop

Use run-time data, model & metamodel
→ adaptation of language semantics

2) Design Feedback Loop

Use design-time data, models & metamodel
→ adaptation of syntax, pragmatics & semantics

L-MODA | Stakeholders



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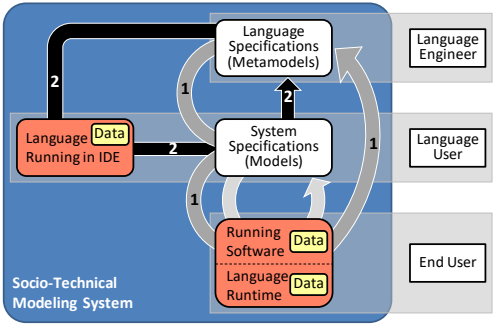

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Various uses of the feedback loops ...

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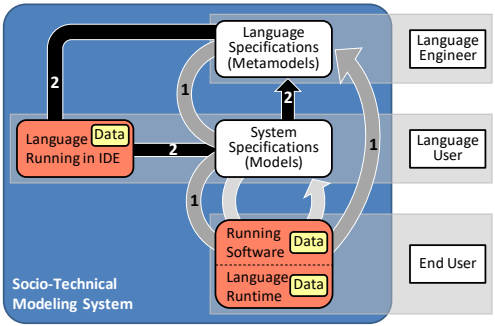

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Examples for the Runtime Feedback Loop :

Delegation of responsabilities

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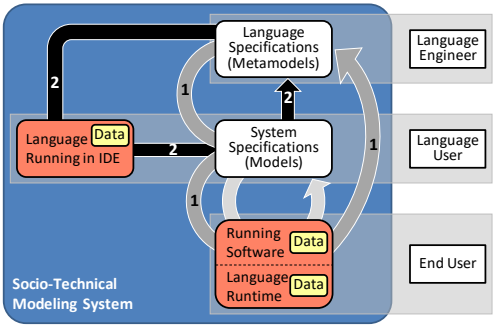

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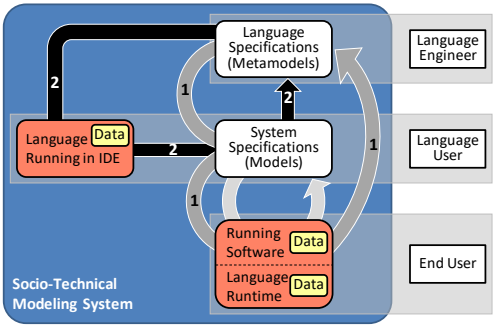

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Language user custom adaptations
Configure the adaptations for a system

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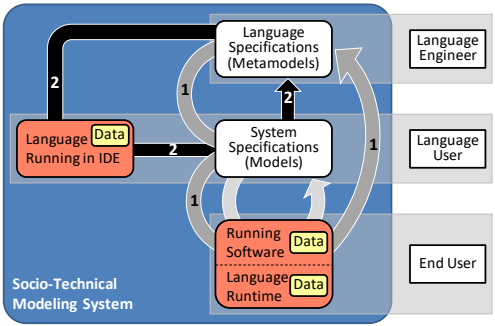

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Various uses of the feedback loops ...

Examples for the Runtime Feedback Loop :

Language engineer in complete control
Tailor the language to a particular trade-off

Language user custom adaptations
Configure the adaptations for a system

End-user preferences
Indicate preference for trade-offs

Delegation of responsabilities

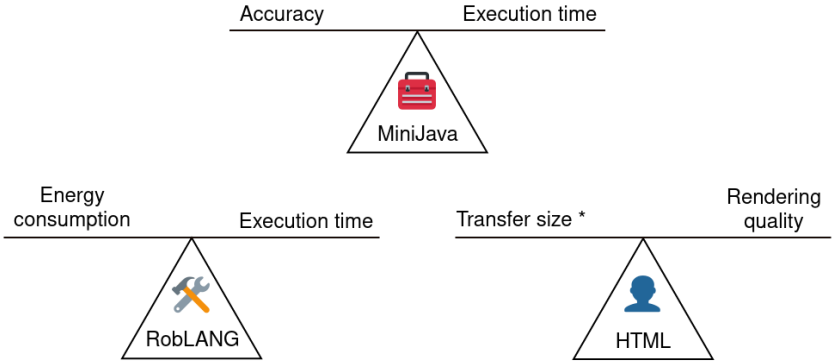
Experimentation

The case of Self-Adaptable Virtual Machines

What are Self-Adaptable Virtual Machines

- A specific case of Self-Adaptable Languages
- Runtime Feedback loop in language operational semantics
- *In our experiment :* Pluggable architecture with delegation of responsibilities

Motivating Examples

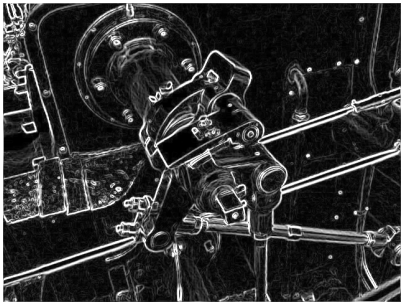


* Transfer size is proportional to energy consumption (Cf. `https://www.websitecarbon.com/`)

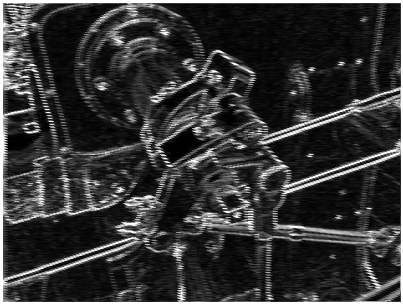
Adaptations

Adaptations (MiniJava)

Applied Approximate Loop Unrolling [1] on image processing algorithm (Sobel)



Standard output



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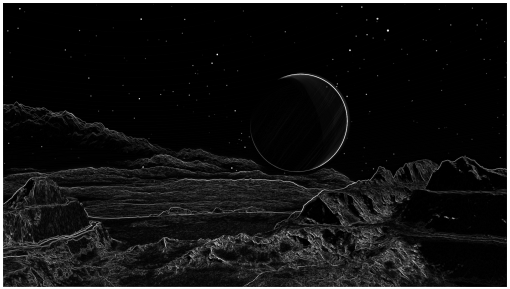

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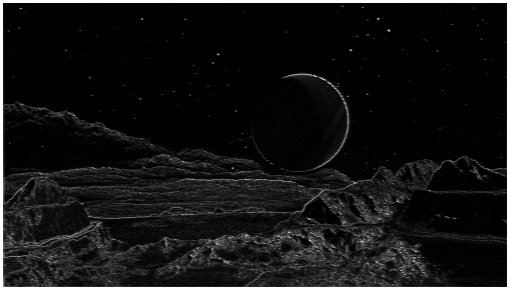

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Adaptations (RobLANG)

Applied a motor speed reduction on basic actions

Rational : $P_i = P_{max}(\frac{Speed_i}{Speed_{max}})^3$ [2]

Three programs studied :

- Move forward/backward
- Turn left/right
- Combination of moves and turns (square patterns)

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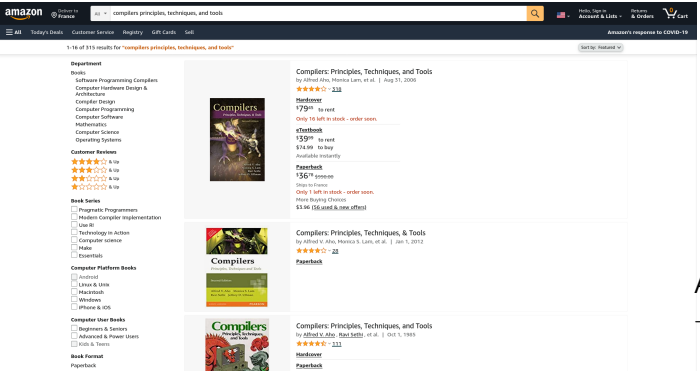
[2] A. Al-Mofleh, S. Taib, W. Salah, *et al.*, "Importance of energy efficiency: From the perspective of electrical equipments," in *Proceedings of the 2nd International Conference on Science and Technology (ICSTIE)*, 2008

Adaptations (HTML)

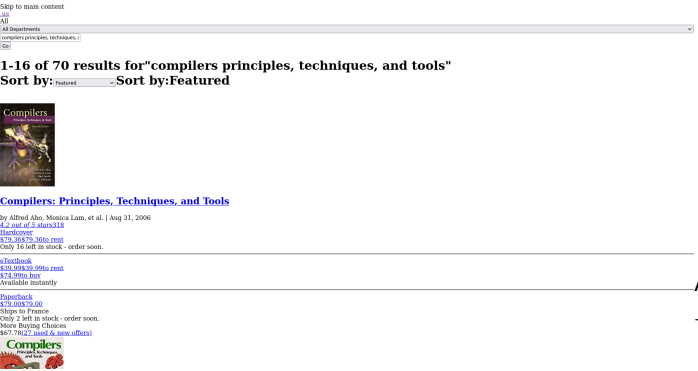


Standard website

- Conditional loading of resources
- Perforation of HTML lists
- Image degradation

Applied on the top 100 websites
→ 45 still deliver the content

Adaptations (HTML)



Adapted website

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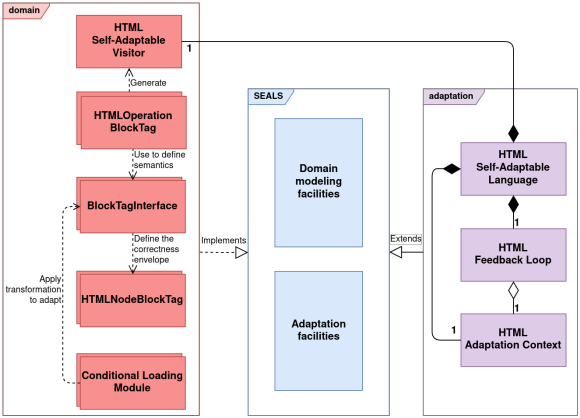
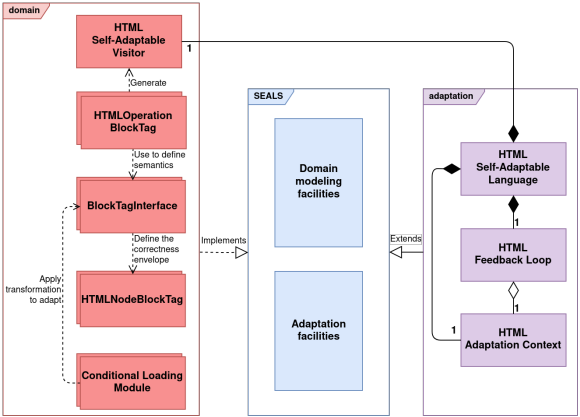
SEALS : A Framework for Building Self-Adaptable Virtual Machines



Approach overview on the HTML use case

SEALS : A Framework for Building Self-Adaptable Virtual Machines

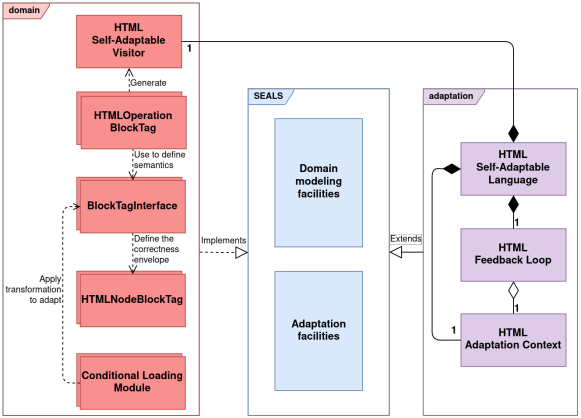
- Modeling of domain concepts
  1. Define the abstract syntax
  2. Create the correctness envelope
  3. Implement the operational semantics



Approach overview on the HTML use case

SEALS : A Framework for Building Self-Adaptable Virtual Machines

- Modeling of domain concepts
  1. Define the abstract syntax
  2. Create the correctness envelope
  3. Implement the operational semantics
- Adaptation process' specialization
  1. Specialize the Adaptation Context
  2. Specialize the Feedback loop
  3. Connect the components



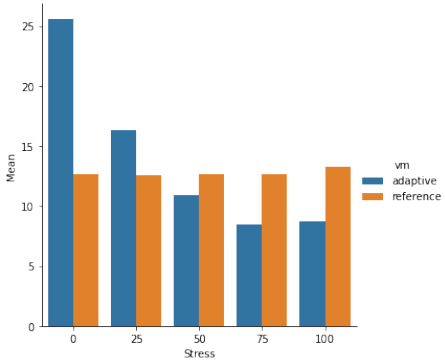
Approach overview on the HTML use case

Evaluate the relevance of proposed adaptation

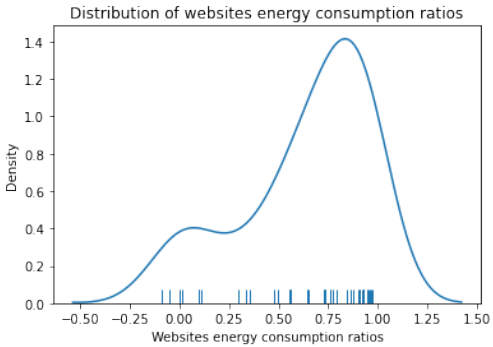
TL;DR : Good results but ...

- Correct adaptations of MiniJava
- Up to 10x more actions on RobLANG
- Energy reduction from -8.7% to 97.2% with a mean of 63.8% [54.2%, 73.4%]
- Performance overhead
- Lack of control on the adaptations
- Deal with the diversity of programs oblivious of the adaptations performed

Evaluate the relevance of proposed adaptation



Sobel filter mean execution time depending on the CPU usage



Distribution of energy reduction ratios

Compare Language-level vs System-level abstractions

Attempt to implement as library of the language

VMs	Feedback loop	Trade-off reasoning	Feedback loop calls	Interaction with the domain
MiniJava	=	=	+	+
RobLang	=	+ +	+	-
HTML (JS)	=	=	=	-

Comparison of implementation simplicity (+ in favor of language-level)

Conclusion

- The concept of Self-Adaptable Language and its conceptual framework
- Promising results for adaptations of language operational semantics
- A framework to implement Self-Adaptable Virtual Machines

Future work

For the SEALS Framework :

- Language tooling for better understanding by the language user.
- Managing the feature interaction between adaptations
- A principled approach to Self-Adaptable Virtual Machines

Support of the Runtime Feedback Loop

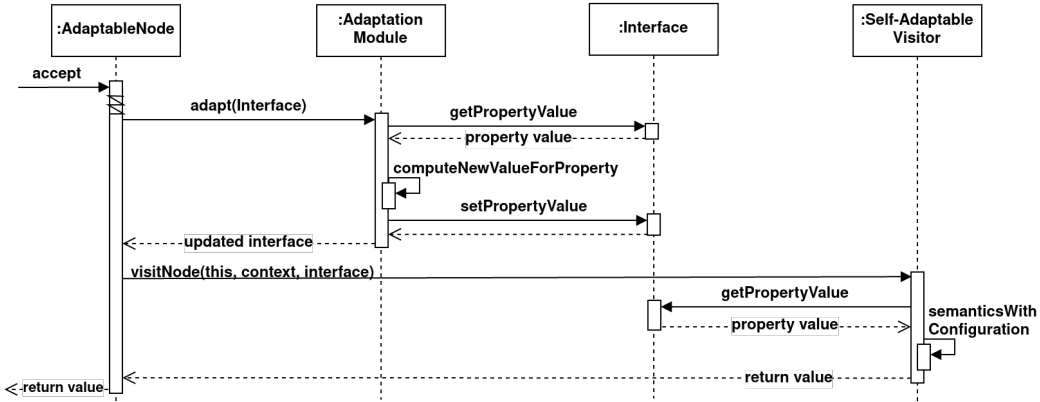
- Feedback loop configuration
- Support for impact/software analysis
- ...

Support of the Design Feedback Loop

- Detect evolution opportunities
- Navigate in evolution of programs
- ...

Thanks for your attention !

Correctness envelope implementation



Example of use of the correctness envelope

References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