Towards Self-Adaptable Languages

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CCI Team talk — October 21, 2022

Gn j §0²§

Software ...

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- Evolve in complex/changing environment (e.g, Cloud, embedded systems)

Gnj§0²§

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- Need dynamic adaptation to best deliver the service (e.g., Waymo[1], Netflix[1])

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-_ _nj I 9@ §}9H§ O℮T]9L9q§_nj _j§n _X\ ℮O®O℮ ℮9jX«9XO Hnj §}«H§

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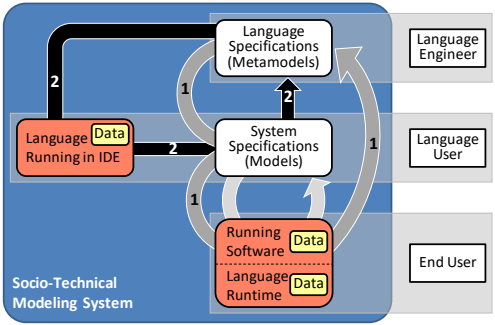
¯ \9§ _ 9 ~0ɐT]8L9q§9@ɐ0 d9jX«9X0 y

" *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

d]gmK8 B d9jX«9XO J gnLOe J 9jL K9§9



L-MODA Conceptual Framework for Self-Adaptable Languages

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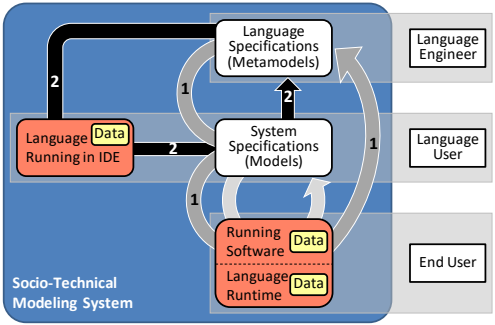


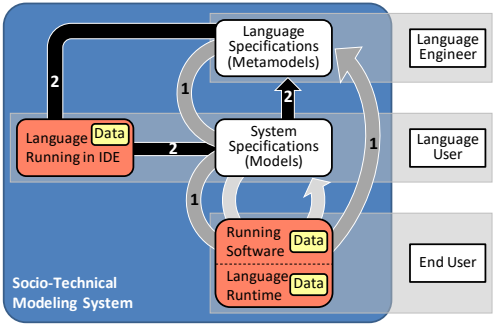
L-MODA Conceptual Framework for Self-Adaptable Languages

os |«j§_hO S00L@9Hc dnnq

Use run-time data, model : metamodel

! adaptation of language semantics

d]gmK8 B d9jX«9XO J gnLOe J 9jL K9§9



L-MODA Conceptual Framework for Self-Adaptable Languages

os |«j§_hO SOOL@9Hc dnnq

Use run-time data, model : metamodel

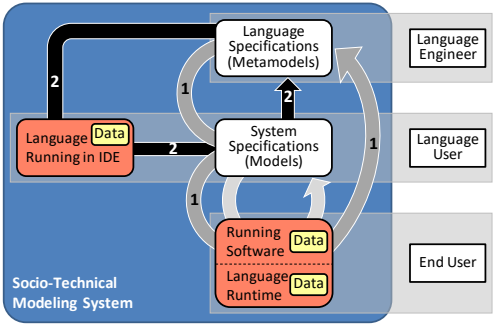
! adaptation of language semantics

©s KO _Xj SOOL@9Hc dnnq

Use design-time data, models : metamodel

! adaptation of syntax, pragmatics : semantics

d]gmK8 B ~§9c0\neLO}



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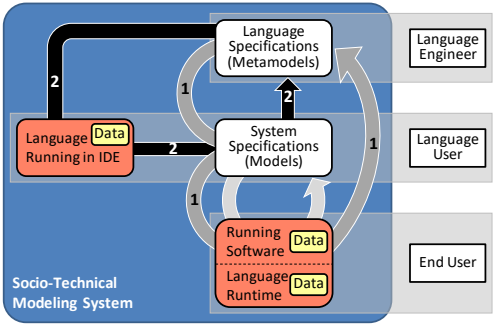
Various uses of the feedback loops ...



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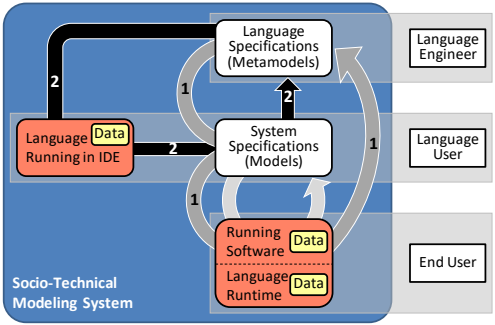


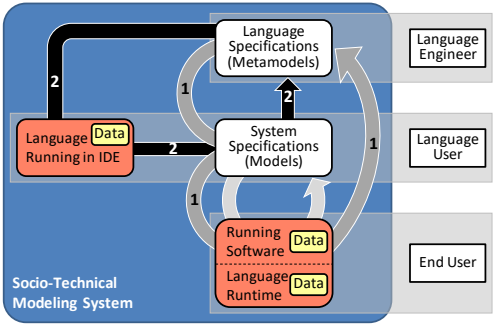
L-MODA Conceptual Framework for Self-Adaptable Languages

Various uses of the feedback loops ...

Examples for the Runtime Feedback Loop :

Delegation of responsabilities

d]gmK8 B ~§9c0\neL0}



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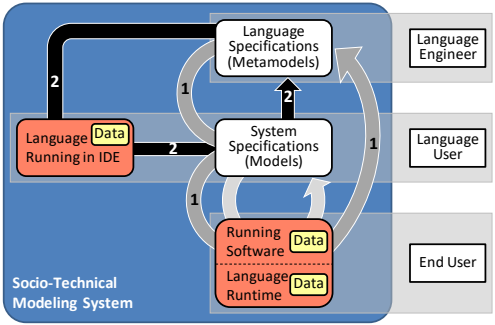
Various uses of the feedback loops ...

Examples for the Runtime Feedback Loop :

> d9jX«9X0 0jX_j00} _j HnhqeO§0 Hnj§}ne
> Tailor the language to a particular trade-off

Delegation of responsabilities

d]gmK8 B ~§9c0\neL0}



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Various uses of the feedback loops ...

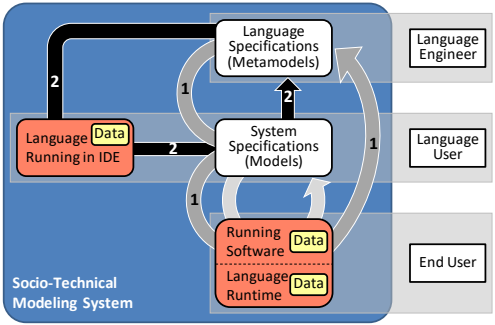
Examples for the Runtime Feedback Loop :

d9jX«9X0 0jX_j00} _j Hnhqe0§0 Hnj§}ne
Tailor the language to a particular trade-off

d9jX«9X0 « 0} H« §nh 9L9q§9§_nj
Configure the adaptations for a system

Delegation of responsabilities

d]gmK8 B ~§9c0\neL0}



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Various uses of the feedback loops ...

Examples for the Runtime Feedback Loop :

- d9jX«9X0 0jX_j00} _j Hnhqe0§0 Hnj§}ne
  Tailor the language to a particular trade-off
- d9jX«9X0 « 0} H« §nh 9L9q§9§_nj
  Configure the adaptations for a system
- NjL]« 0} q}0T0}0jH0
  Indicate preference for trade-offs

Delegation of responsabilities

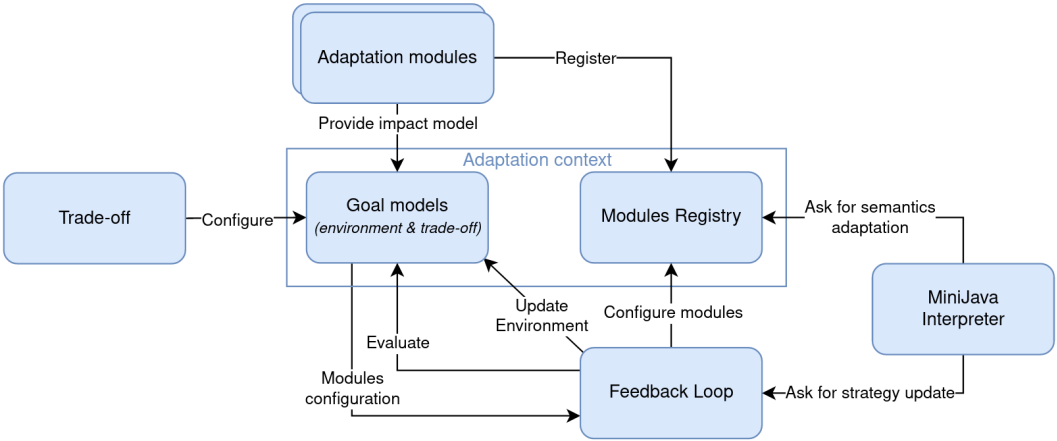
N²qO}_hOj§9§_nj

¦\O H9 O nT ~OeT]8L9q§9@eO -_}§«9e g9H_jO

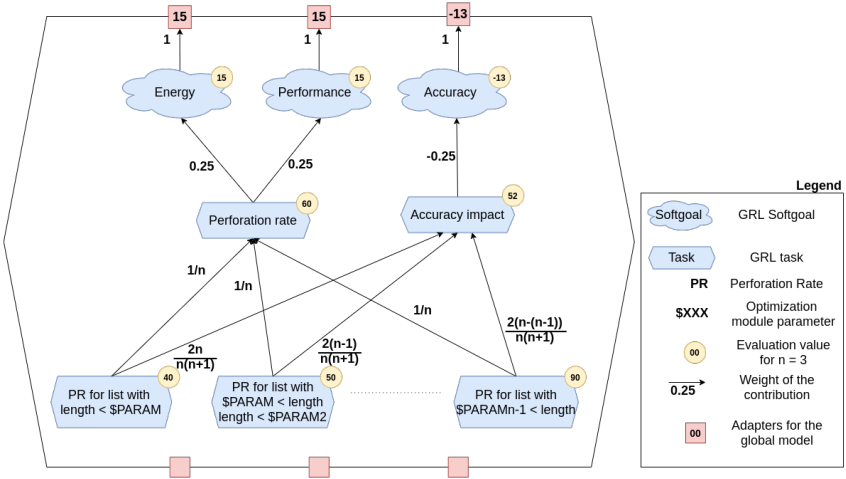
¯ \9§ 9}0 ~0ɐT]8L9q§9@ɐ0 - _}§«9ɐ g 9H_j0

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

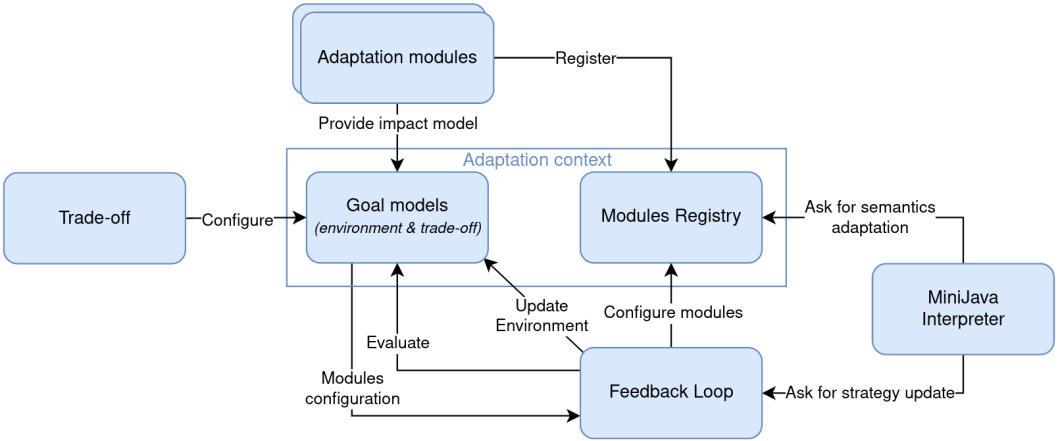
8}H_§OH§«}O nT ~OeT]8L9q§9@eO -_}§«9e g 9H_jO rg_j_`9®9s



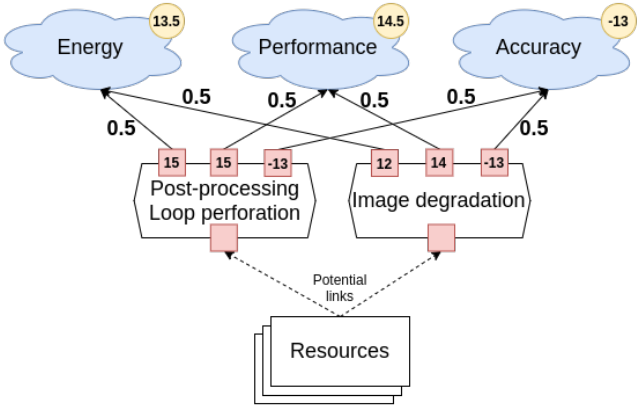
^hq9H§ gnLOe

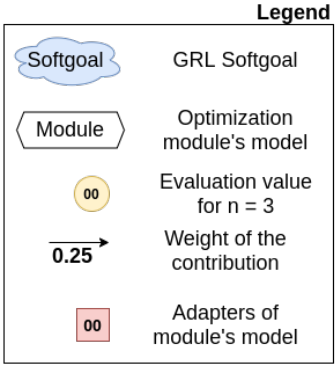

15
15
-13
1
1
1
Energy
Performance
Accuracy
15
15
-13
0.25
0.25
-0.25
Perforation rate
Accuracy impact
60
52
1/n
1/n
1/n
2n / n(n+1)
2(n-1) / n(n+1)
2(n-(n-1)) / n(n+1)
PR for list with length < $PARAM
PR for list with $PARAM < length length < $PARAM2
PR for list with $PARAMn-1 < length
40
50
90
Legend
Softgoal
GRL Softgoal
Task
GRL task
PR
Perforation Rate
$XXX
Optimization module parameter
00
Evaluation value for n = 3
0.25
Weight of the contribution
00
Adapters for the global model

8}H_§OH§«}O nT ~OeT]8L9q§9@eO -_}§«9e g 9H_jO rg_j_`9®9s

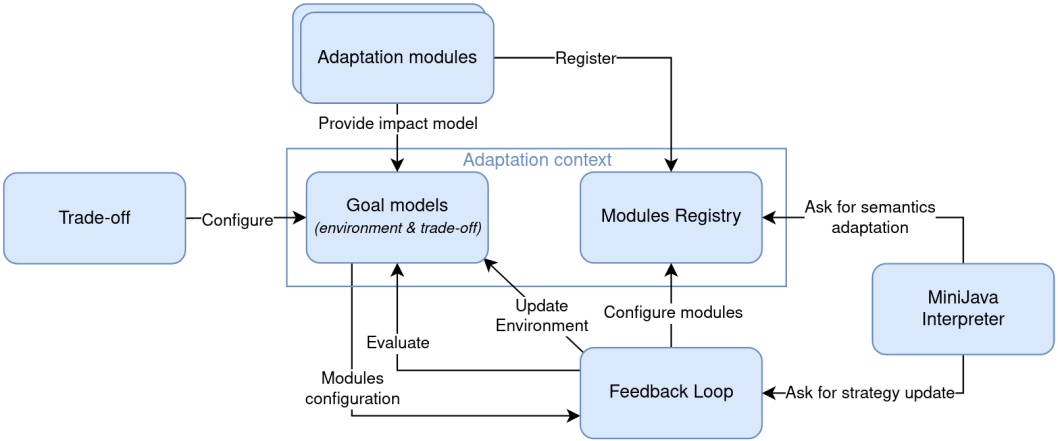


Wen@9e Wn9e g nLOe

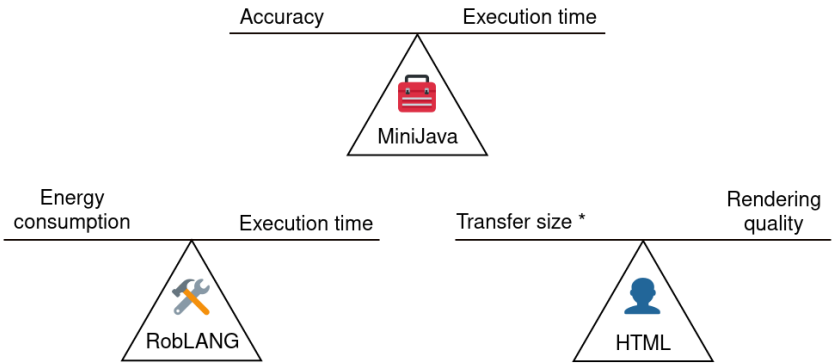




8}H_§OH§«}O nT ~OeT]8L9q§9@eO -_}§«9e g 9H_jO rg_j_`9®9s



g n§_®9§_j X N²9 h qe0



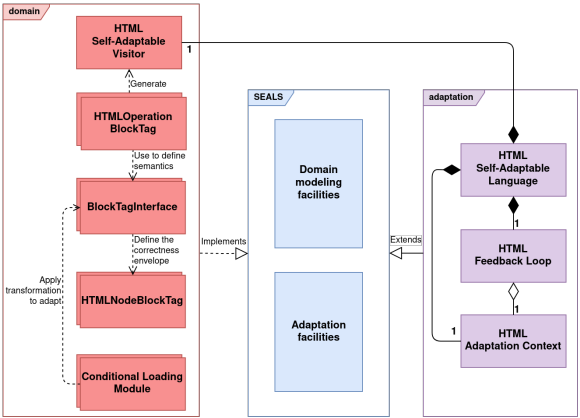
* Transfer size is proportional to energy consumption (Cf. **\§§q I¤¤°°°u°O@ _§OH9}@njuHnh¤**)

N®9¢«9§0 §\0 }0¢0®9jH0 nT q}nqn 0L 9L9q§9§_nj

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

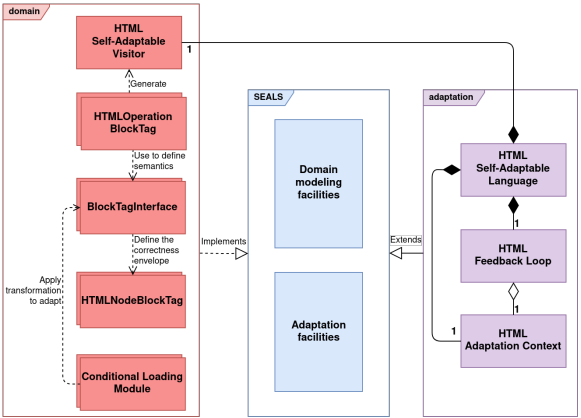
~N8d~ I 8 S}9h0°n}c Tn} ?«_eL_jX ~OeT]8L9q§9@e0 -_}§«9e g9H_j0



Approach overview on the HTML use case

~N8d~ I 8 S}9h0°n}c Tn} ?«_eL_jX ~OeT]8L9q§9@e0 -_}§«9e g9H_j0

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



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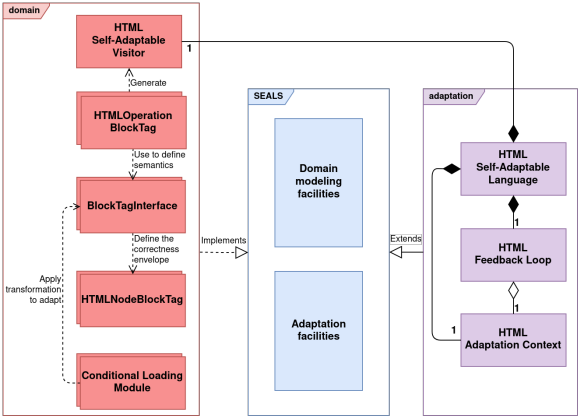
~N8d~ I 8 S}9h0°n}c Tn} ?«_eL_jX ~OeT]8L9q§9@eO -_}§«9e g9H_j0

- 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

8L9q§_®0 ~§}«H§«}9℮ mq0}9§_nj9℮ ~0h9j§_H

Join work with L. Thomas van Binsbergen and Damian Frölich

8L9q§_®0 ~§}«H§«}9℮ mq0}9§_nj9℮ ~0h9j§_H

Based on a language definition :

8L9q§_®0 ~§}«H§«}9℮ mq0}9§_nj9℮ ~0h9j§_H

Based on a language definition :

- Abstract syntax as metamodel
- Semantic domain merged in the metamodel
- Modular definition of the semantics (I-MSOS)

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To make it adaptive we need :

8L9q§_®0 ~§}«H§«}9℮ mq0}9§_nj9℮ ~0h9j§_H

Based on a language definition :

- Abstract syntax as metamodel
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To make it adaptive we need :

- Additional semantics rules for adaptation
- Mechanism for adaptation rule introduction
- Dynamic selection of semantics rule to apply

g 0§9]e9jX«9X0 Tn} m}_X_j9e ~0h9j§_H

```
1  model imp.ecore with sd
2
3  rule program,
4      Program(command) ăZ Program(newcommand)
5  resolve
6      command ăZ newcommand
7
8  rule program_error,
9      Program(command) ăZ sd.RuntimeError()
10 resolve
11     command ăZ termination sd.RuntimeError()
12
13 rule assign_set,
14     Assignment(name, sd.Integer(n))
15     ăZ
16     sd.NilValue()
17 bind
18     self.value = sd.Integer(n)
```

```
1  rule if_then,
2      If(sd.Boolean(b), c1, c2) ăZ c1
3  where
4    b == true
```

- Model merging metamodel and dynamic information

g 0§9]ę9 j X«9X0 Tn} m}_X_j 9ę ~0 h 9 j §_H

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```

- Model merging metamodel and dynamic information
- A set of semantic rules
  - Conclusion as reduction over concepts
  - Reduction premises
  - Side condition
  - Binding computed values

g 0§9]ę9 j X«9X0 Tn} ~0 h 9 j §_H 8L9q§9§_n j

```
1  model imp.ecore with sd
2  semantics imp.sem
3
4  ApproximateDouble{
5
6      match Assignement(VarRef(def), expr)
7      where def.type == Float
8
9      Before binop_rhs rule binop_rhs_f,
10         Binop(Double(n1), a2)
11         ăZ
12         Binop(Float(n1), a2)
13
14     Before binop_result rule binop_result_f,
15         Binop(Number(n1), Double(n2))
16         ăZ
17         Binop(Number(n1), Float(n2))
18 }
```

- Dependence to the semantics
- Pointcut definition
  - Structural matching
  - Additional constraints
- Adaptation rules
  - Kind of adaptation rule
  - Affected rule in semantics
  - Adaptation semantic rule

~Hnq0 nT 0h9j§_H }«e0

~Hnq0 nT 0h9j§_H }«e0

- I Original semantics rules defined in the global scope

a+QT2b Q7 b2K MiB+b `mH2b

- P`B;BM H b2K MiB+b `
  BM i?2 ;HQ# H b+QT2
- / Ti iBQM BMi`Q/m+2
  i?`Qm;? M2r b+QT2b

a+QT2b Q7 b2K MiB+b `mH2b

- P`B;BM H b2K MiB+b `
  BM i?2 ;HQ# H b+QT2
- / Ti iBQM BMi`Q/m+2
  i?`Qm;? M2r b+QT2b
- AMbi MiB iBQM Q7 b+
  mbBM; K i+? 2tT`2bbB

aPa b 7 KBHv Q7 h` MbBiBQM bvbi2Kb

M / TiBp2 H M;m ;2 Bhq ;bjhmi+im`2+? i? i ,

8!2 _;h; ;! ;h hi Bb hhaX

: S ! _- b2H2+ib i?2 +m``2MiHv +iBp2 i` MbBiBQM 2MpB`QMK2Mi M/ i?2 +m``2Mi bi i2X

aiBHH QM;QBM;

- h`v iQ T`Qp2 r2 + M ;2M2` i2 /2i2`KBMBbiB+ b2K MiB+
- 6BMBb? i?2 +Q/2 ;2M2` iQ` # b2/ QM i?2 K2i @H M;m
- .Q i?2 2tT2`BK2Mi iBQM M/ r`Bi2 i?2 T T2`

`iB+H2b QM i?2 bm#D2+i

- h?2 +QM+2Ti Q7 a2H7@ /Ti #H2 G M;m ;2 M/ Bib +Q
  :X CQmM2 mt- PX " ` Bb- "X i*QHKQ2K`/Hb a2H7@ /Ti #H2 G M;m ;2b- yk R
  *?B+ ;Q- lMBi2/ ai i2b- P+iX kykRX (?iiTb,ff/QBXQ`;f R3 H@yjjR33Re
- 7` K2rQ`F iQ BKTH2K2Mi a2H7@ /Ti #H2 oB`im H J
  :X CQmM2 mt- PX " ` Bb- "X i*QHKQ2K a2H7- 7` K2rQ`F 7Q` #mBH/BM; a2H7@
  J +?BM2b- a G1 ky-k*?B+ ;Q- lMBi2/ ai i2b- P+iX kykRX R9 fj93eey3Xj93eNRk
- PM;QBM; rQ`F QM bT2+B}+ iBQM Q7 /TiBp2 b2K MiB
  SH MM2/ bm#KBbbBQM iQ SG.A kykj U/2 /HBM2 LQp2K#2`-

S2`bT2+iBp2b

- h2bi M//2#m;T`Q;` Kb`mMMBM;QMaGb M//Ti iB
- aT2+B}+iBQMQ7a2H7@/TiBp2PT2`iBQMHa2KM
- q`BiBM;Kv S?.i?2bBb

¦\9jc Tn} ´n«} 9§§Oj§_nj R