Language and Framework Requirements for Adaptation Models

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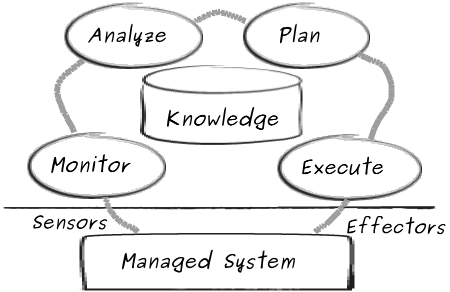
HPI

Introduction

Models@run.time for Self-adaptive Software

MDE & Models at Runtime for

- Knowledge
- Feedback Loop activities



Feedback Loop [Kephart and Chess, 2003]

Motivation

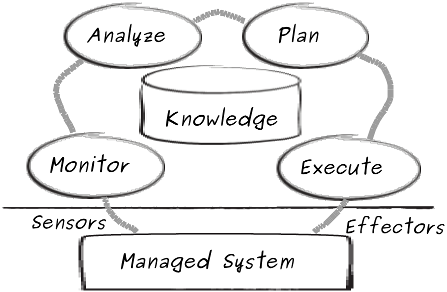
Models@run.time for Self-adaptive Software

- Focus on causal connection
  (e.g., discussions at MRT'09 and '10)

⇒ *Monitor* and *Execute*

- **Reusing** or **applying** existing techniques for decision-making
  (rule-based or search-based)

⇒ *Analyze* and *Plan*



Feedback Loop [Kephart and Chess, 2003]

Related Work

Example solutions:

- rule-based: ECA, policies
- search-based: Utility functions, goals

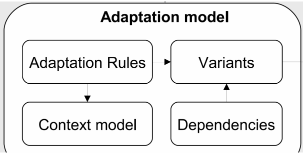
Characteristics (requirements):

- Performance
- Support for validation
- Scalability

Stitch [Cheng, 2008]

- Requirements!
- Policy-based language
- System administration tasks

```
RULE R_M
EVENT
   A new node N is detected onto the Platform
CONDITION
   N.profile == PDA
ACTION
   knowledge.domain.addNode(N)
```




```
rule BecomeDA : // Becomes a DA
  condition ElectedDA and not LowBatt and not DA
  effect DA
```

```
AdaptionPolicy ReplaceFiring
  (Description "Replaces firing component")
  (Observation energyReport (energy < 60))
  (Response RemoveComponent ReactiveFire)
  (Response A
    Distance
    Reactive
```

```
handsfree_util =
  if (context.handsfree AND STapp.handsfree) or
     (!context.handsfree AND !STapp.handsfree_offered) then 1 else 0
response_util =
  if (context.response >= STapp. response) then 1
  else 1 - ( (STapp.response - context.resonse) / STapp.response)
utility =
  if STapp.mem > context.mem then 0
  else weight_hf * handsfree_util + weight_rsp * response_util
```

[Dubus and Merle, 2006, Morin et al., 2008, Fleurey et al., 2009, Georgas et al., 2009, Floch et al., 2006]

Related Work

Example solutions:

- rule-based: ECA, policies
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- Scalability

Stitch [Cheng, 2008]

- Requirements!
- Policy-based language
- System administration tasks

No systematic investigation of requirements for analysis and planning activities in conjunction with models@run.time

```
RULE R_M
EVENT
  A new node N is detected onto the Platform
CONDITION
  N.profile == PDA
ACTION
  knowledge.domain.addNode(N)
```

```
rule BecomeDA : // Becomes a DA
  condition ElectedDA and not LowBatt and not DA
  effect DA
```

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AdaptionPolicy ReplaceFiring
  (Description "Replaces firing component")
  (Observation energyReport (energy < 60))
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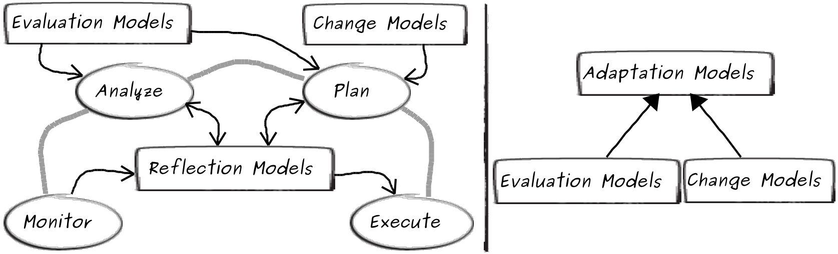
Adaptation Models

MDE and models@run.time perspective (MODELS'10 Workshops)



Requirements for adaptation models concerning:

- **Languages** (meta-models, constraints, model operations etc.)
- **Frameworks** (execution environment)

Note: Not claiming a *complete* enumeration or *finalized* definitions

Language Requirements (LR)

Functional LR	
LR-1 *Functional Specification/Goals*	***LR-6*** *Evaluation Conditions*
LR-2 *Quality Dimensions*	***LR-7*** *Evaluation Results*
LR-3 *Preferences*	***LR-8*** *Adaptation Options*
LR-4 *Access to Reflection Models*	***LR-9*** *Adaptation Conditions*
LR-5 *Events*	***LR-10*** *Adaptation Costs/Benefits*
	LR-11 *History of Decisions*

⇒ Concepts contained or referenced by adaptation models
⇒ Expressiveness of the language

Non-functional LR	
LR-12 *Modularity, Abstractions, Scalability*	***LR-15*** *Formality*
LR-13 *Side Effects*	***LR-16*** *Reusability*
LR-14 *Parameters*	***LR-17*** *Ease of Use*

⇒ Quality of the language and adaptation models

Functional Language Requirements (I)

To-be specification of the running system (reference values)

LR-1 *Functional Specification/Goals*
Desired behavior, what the system should do

LR-2 *Quality Dimensions*
Desired QoS, how the system should be

LR-3 *Preferences*
Balancing competing quality dimensions or goals

Functional Language Requirements (I)

To-be specification of the running system (reference values)

LR-1 *Functional Specification/Goals*
Desired behavior, what the system should do

LR-2 *Quality Dimensions*
Desired QoS, how the system should be

LR-3 *Preferences*
Balancing competing quality dimensions or goals

As-Is situation of the running system

LR-4 *Access to Reflection Models*
Monitor & Execute changes through causally connected models

LR-5 *Events*
Trigger for analysis and planning; locating runtime phenomena

Functional Language Requirements (II)

Analysis of the running system

LR-6 *Evaluation Conditions*
Relate as-is (LR-4, 5) and to-be (LR-1, 2, 3) situations.

LR-7 *Evaluation Results*
Identify adaptation need, annotate reflection models (LR-4)

Functional Language Requirements (II)

Analysis of the running system

- ***LR-6*** *Evaluation Conditions*
  Relate as-is (LR-4, 5) and to-be (LR-1, 2, 3) situations.
- ***LR-7*** *Evaluation Results*
  Identify adaptation need, annotate reflection models (LR-4)

Planning of adaptation

- ***LR-8*** *Adaptation Options*
  Variability (config. space) and how to change reflection models
- ***LR-9*** *Adaptation Conditions*
  Applicability of adaptation options (by LR-4, 5, 7, 8)
- ***LR-10*** *Adaptation Costs and Benefits*
  Select options wrt goals, qualities and preferences (LR-1, 2, 3)
- ***LR-11*** *History of Decisions* wrt analysis and planning

Non-functional Language Requirements (I)

Characteristics and qualities of a language and models

LR-12 *Modularity, Abstractions and Scalability*
Composition of sub-models and different abstraction levels to promote scalability

LR-13 *Side Effects*
Explicit meta-information about side effects on reflection models $\rightsquigarrow$ consistency of the running system

LR-14 *Parameters*
Built-in mechanism to adjust adaptation models at runtime

Non-functional Language Requirements (II)

LR-15 *Formality*

How formal the modeling language should be?

⇝ Online or offline V&V of adaptation models

LR-16 *Reusability*

Degree of dependency between languages for adaptation models and reflection models

LR-17 *Ease of Use*

Modeling paradigm, notations, tools

⇝ Support engineers in creating, validating and verifying adaptation models

Framework Requirements (FR)

- Framework: Execution environment of adaptation models
- Specific requirements for executing/applying adaptation models

Framework Requirements	
FR-1 *Consistency*	***FR-4*** *Priorities*
FR-2 *Incrementality*	***FR-5*** *Time Scales*
FR-3 *Reversibility*	***FR-6*** *Flexibility*

Note: Typical non-functional requirements (reliability, security, etc.) of software are relevant for such frameworks as well, but left here.

Framework Requirements (I)

FR-1 *Consistency*

Preserve consistency of reflection models (running systems)

$\rightsquigarrow$ Conditions for performing adaptations (LR-9)

$\rightsquigarrow$ Transaction support for adaptation models

FR-2 *Incrementality*

For example,

- Locate need for analysis in reflection models by events
- Incremental planning
- Incrementally apply adaptation options on reflection models
- ...to avoid searching or copying potentially large models

FR-3 *Reversibility*

Reverse incremental operations (*do* and *undo* of operations)

Framework Requirements (II)

FR-4 *Priorities*

Organizing modular adaptation models by priorities, e.g., to order and analyze evaluation conditions based on criticality

FR-5 *Time Scales*

From exactly pre-defined adaptations for mission-critical situations to dynamically synthesizing adaptation plans

FR-6 *Flexibility*

Adapting adaptation models at runtime

$\rightsquigarrow$ Learning effects

$\rightsquigarrow$ Unanticipated scenarios

$\rightsquigarrow$ Hierarchical control

Adaptation Models and Feedback Loops

Language Requirements

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Framework Requirements

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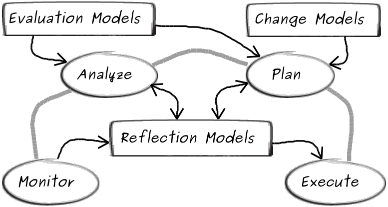
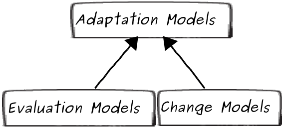
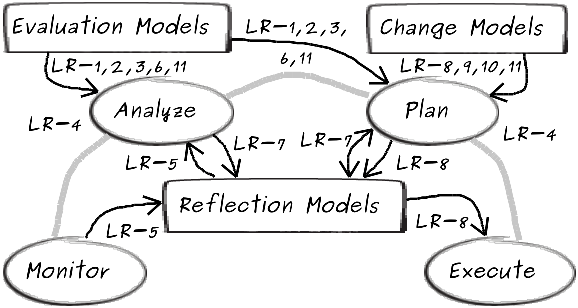




Relationships between requirements and loops? ⇝ **loop “patterns”**

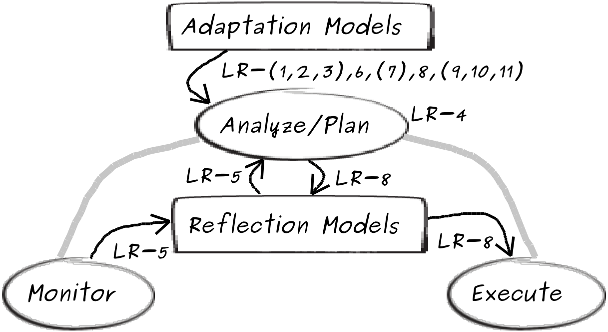
Decoupled Analysis and Planning



- Highlights LR where the corresponding concepts are relevant
- Explicitly covers all functional LR
- Rather sophisticated analysis and planning steps
- Rather longer time scales

⇝ **Search-based approaches**

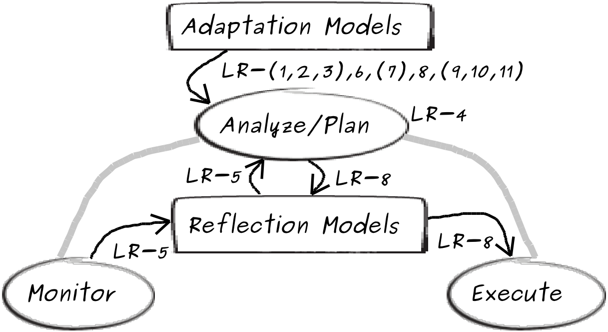
Coupled Analysis and Planning



- Highlights LR where the corresponding concepts are relevant
- LR written in brackets are only implicitly covered
- Precise specification of adaptation (like ECA $\approx$ LR-5, 6, 8)
- Rather short time scales

⇝ **Rule-based approaches**

Coupled Analysis and Planning



- Highlights LR where the corresponding concepts are relevant
- LR written in brackets are only implicitly covered
- Precise specification of adaptation (like ECA $\approx$ LR-5, 6, 8)
- Rather short time scales

⇝ **Rule-based approaches**

Extreme poles spanning a range of "patterns".

Conclusion and Future Work

Conclusion

- Adaptation models for self-adaptive software using MRT
- Language and framework requirements for adaptation models
- Adaptation models and feedback loops

Future Work

- Analyze existing approaches with respect to the requirements
- Engineer a language and framework for our approach
  (ICAC'09, MODELS'09 Workshops, SEAMS'10)
- Integration of multiple languages in a framework

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