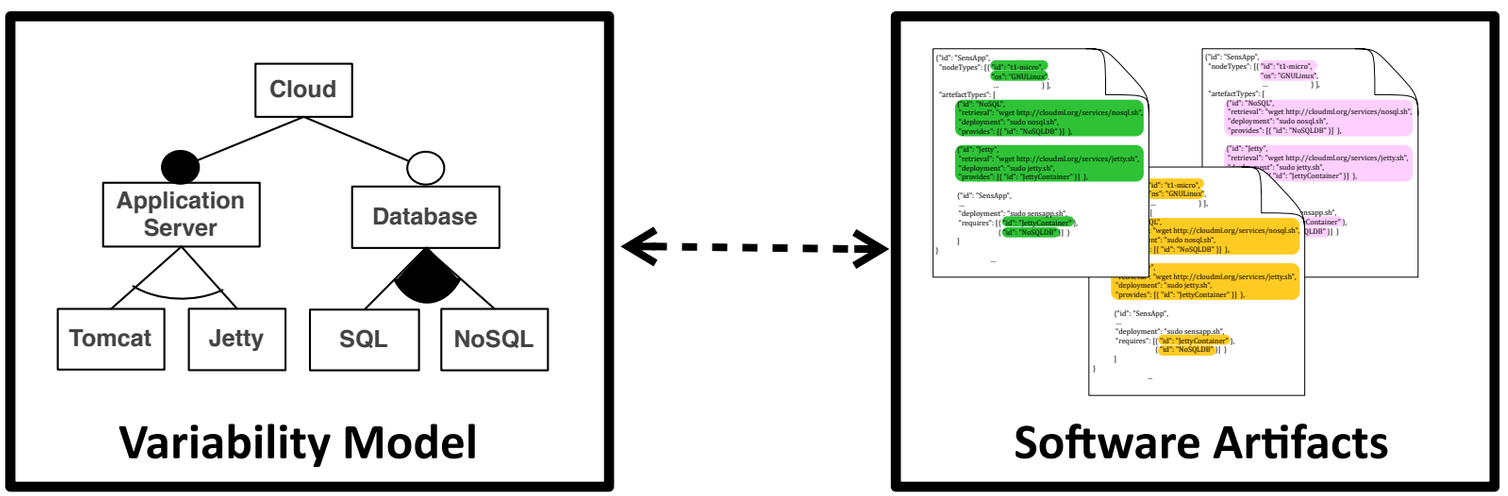
Evolving Dynamic Software Product Lines

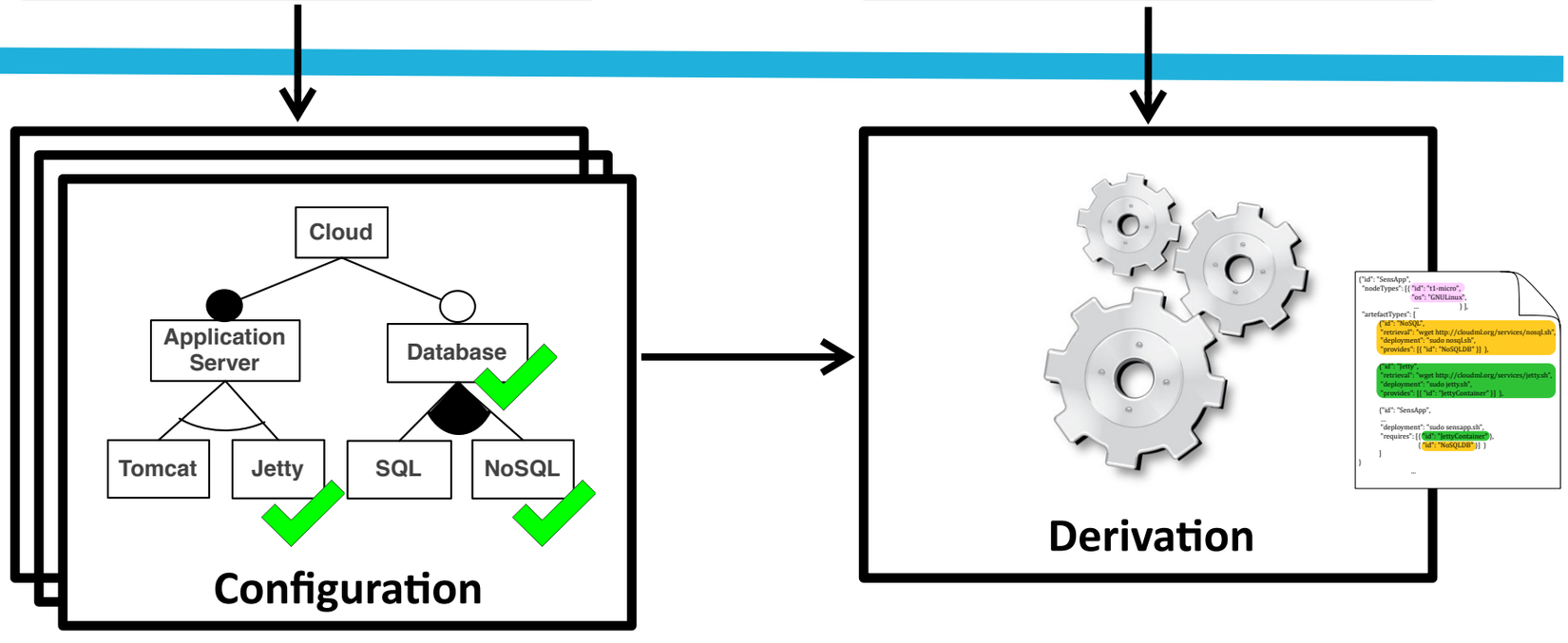
Clément Quinton, Luciano Baresi

EASSy, September 7-10, 2015 - Japan

Software Product Lines

Domain Engineering

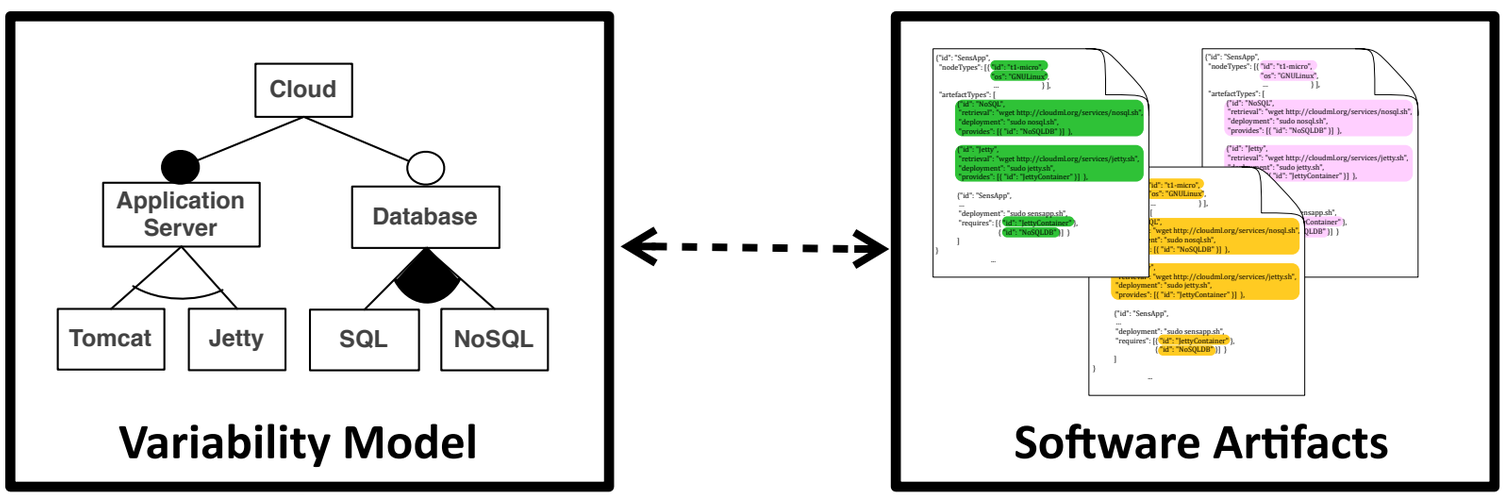


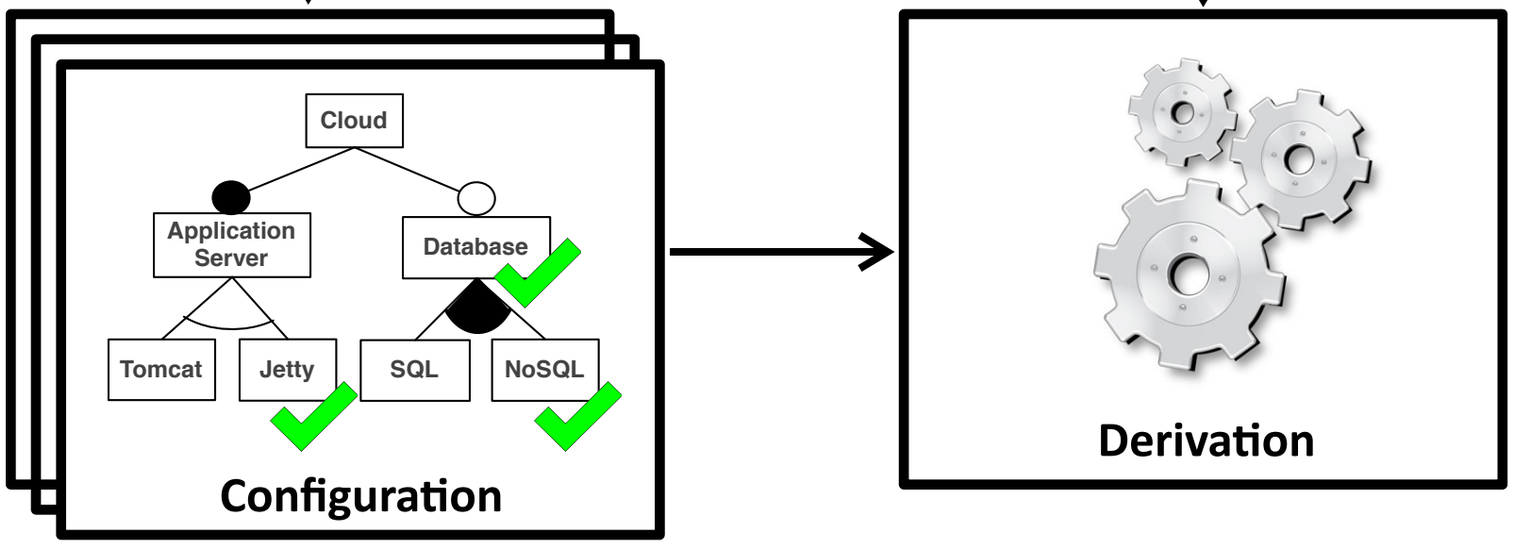


Application Engineering

Software Product Lines

Domain Engineering



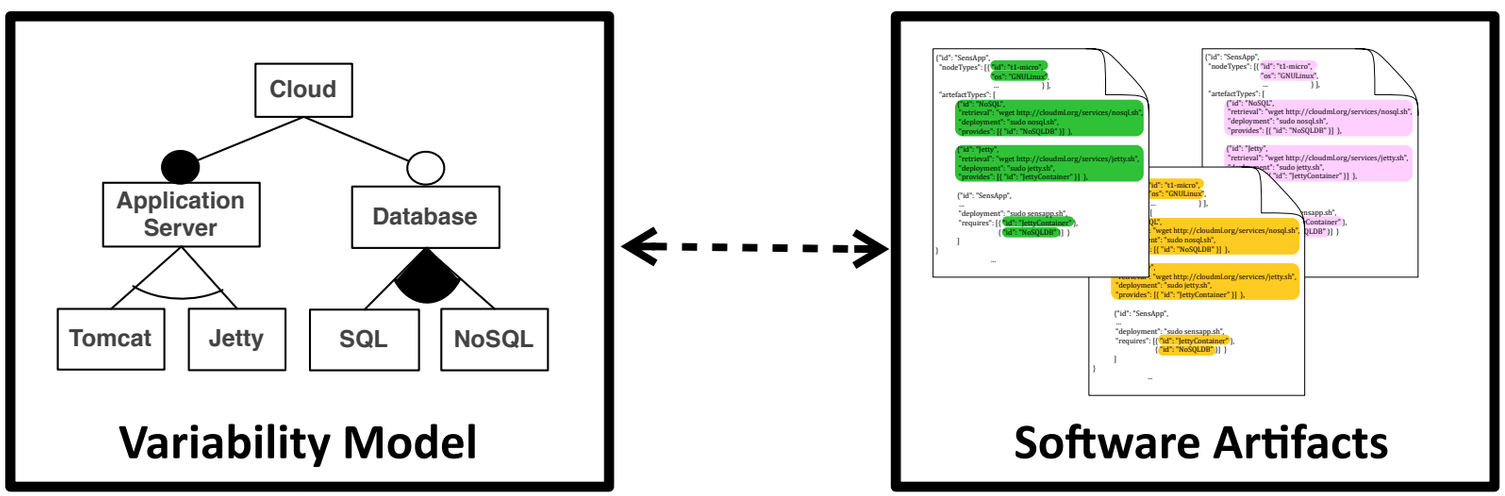


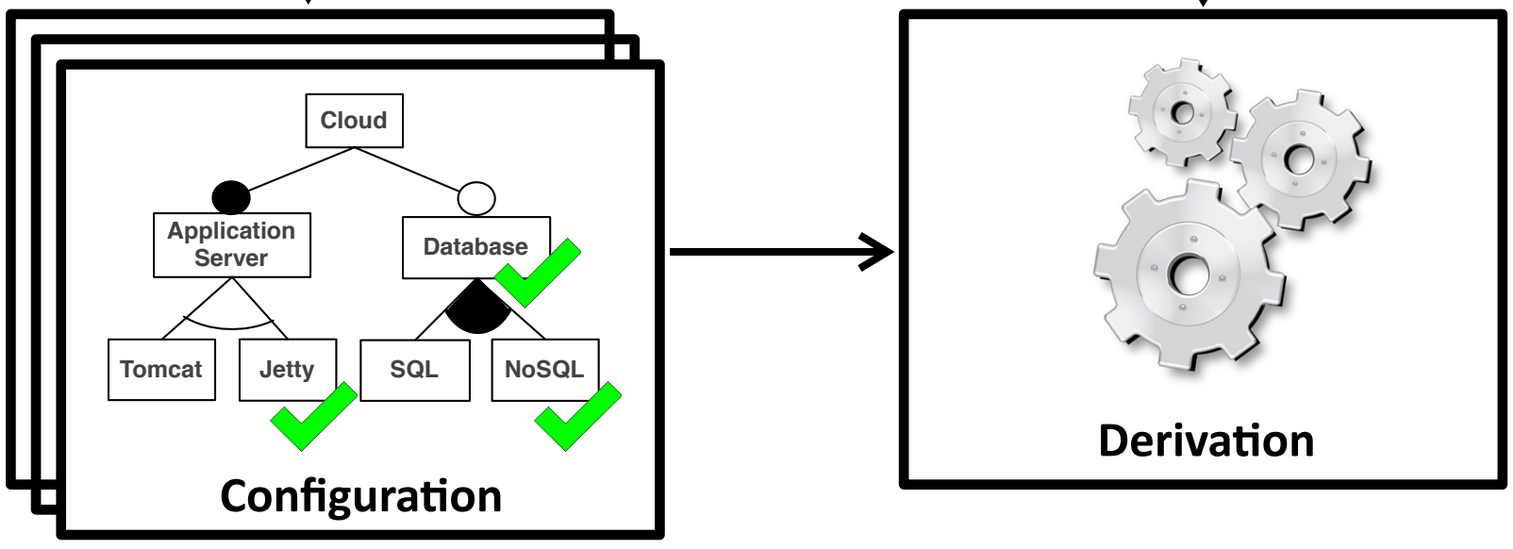
Application Engineering

Design Time | Runtime

Dynamic Software Product Lines

Domain Engineering





Application Engineering

Design Time | Runtime

Dynamic Software Product Lines

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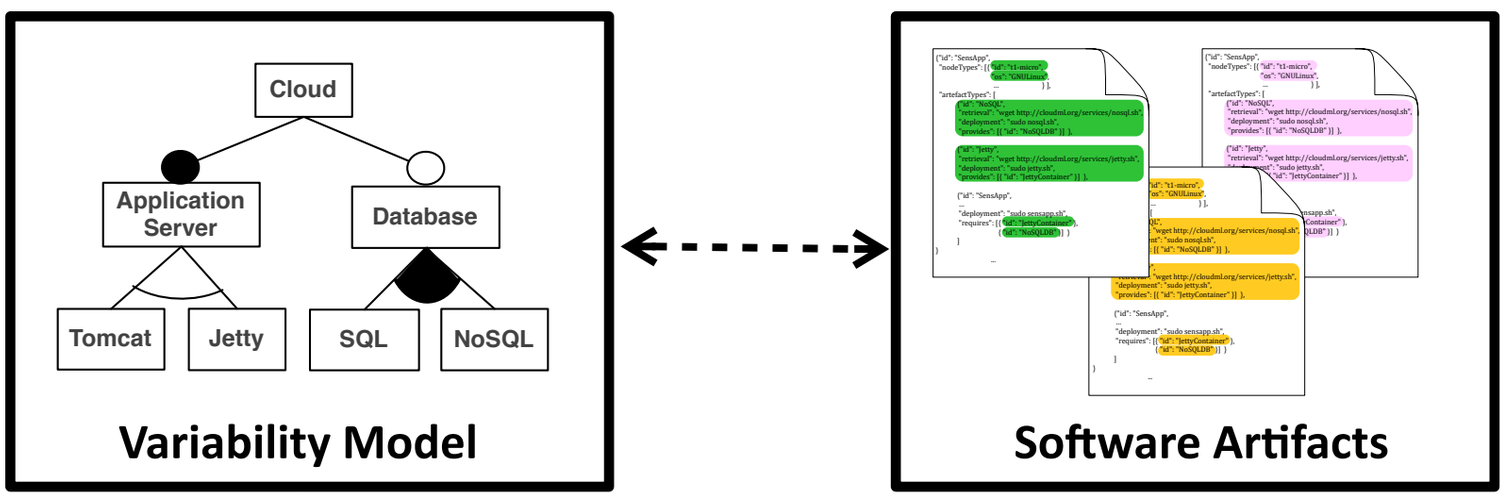
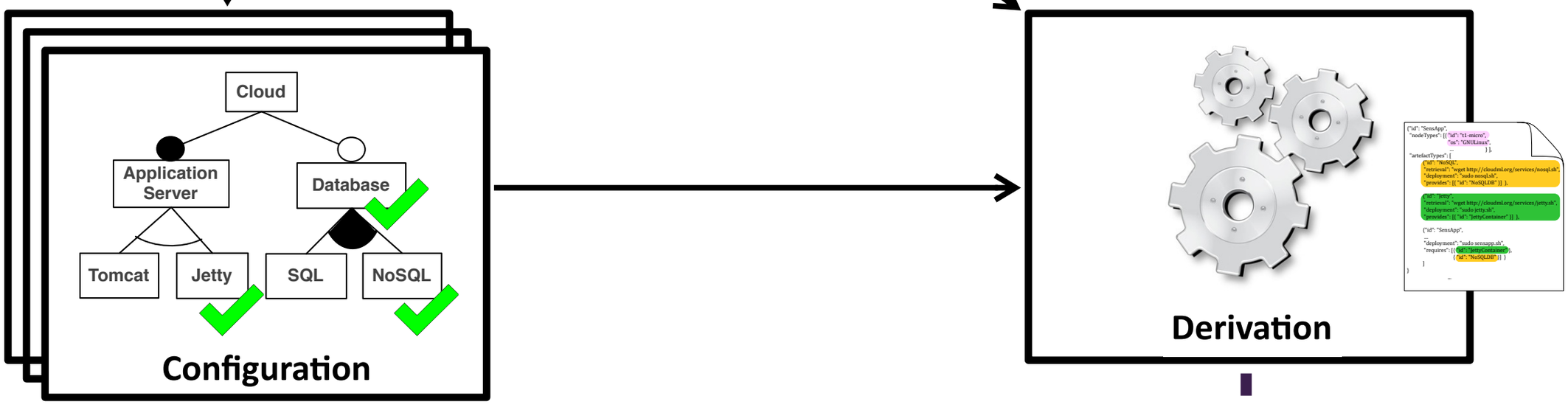


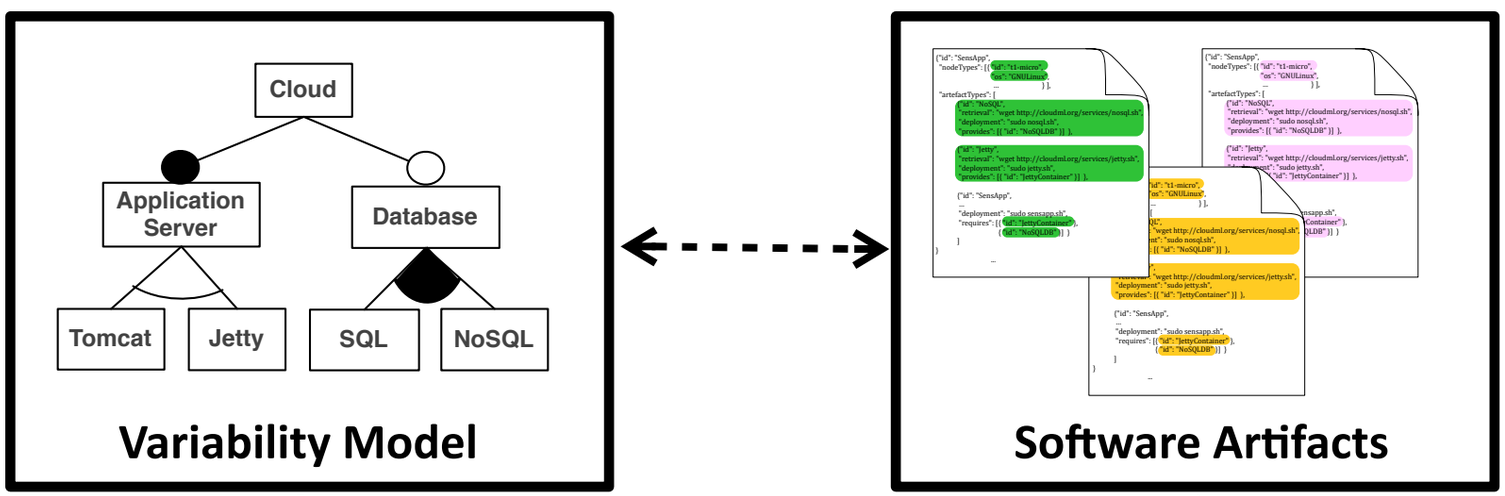


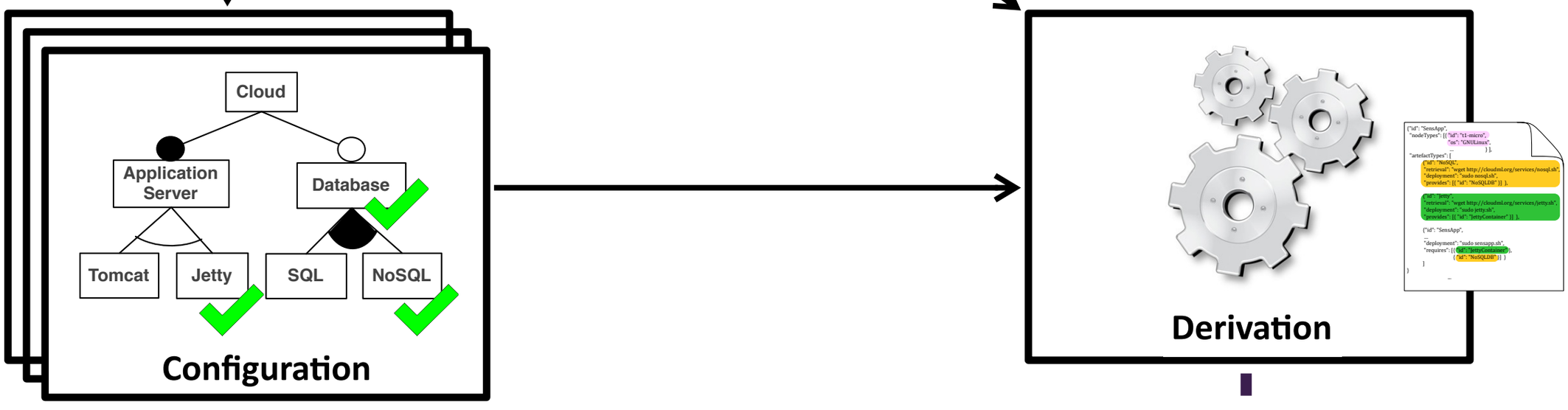
Application Engineering

Design Time | **Runtime**

Dynamic Software Product Lines

Domain Engineering





Application Engineering

Adaptation

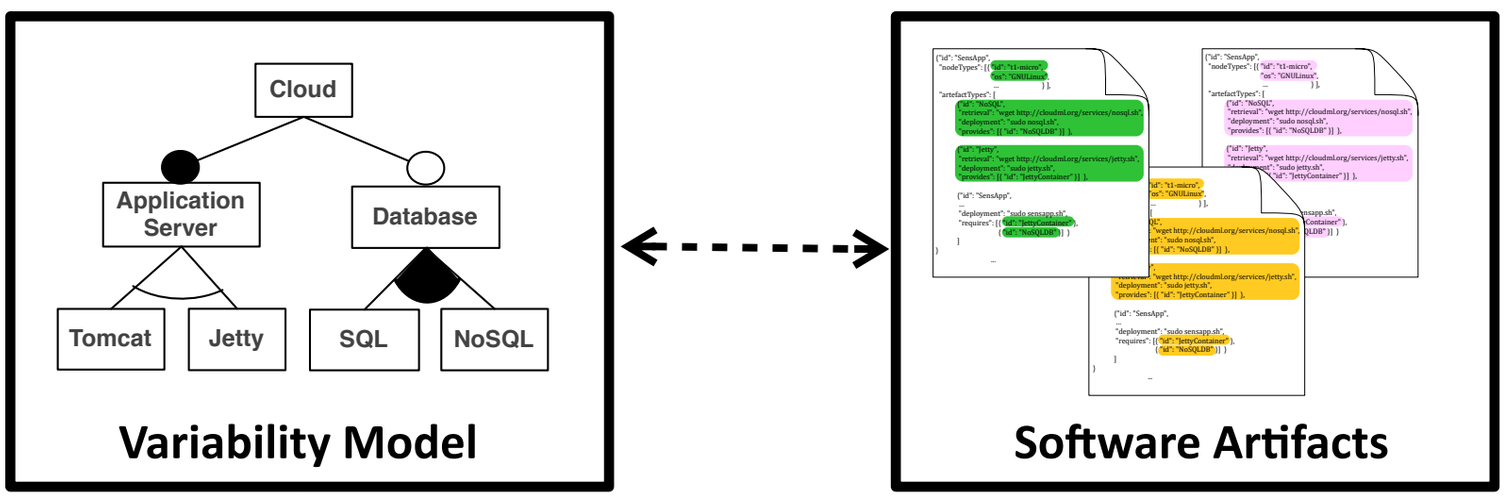
Reconfiguration

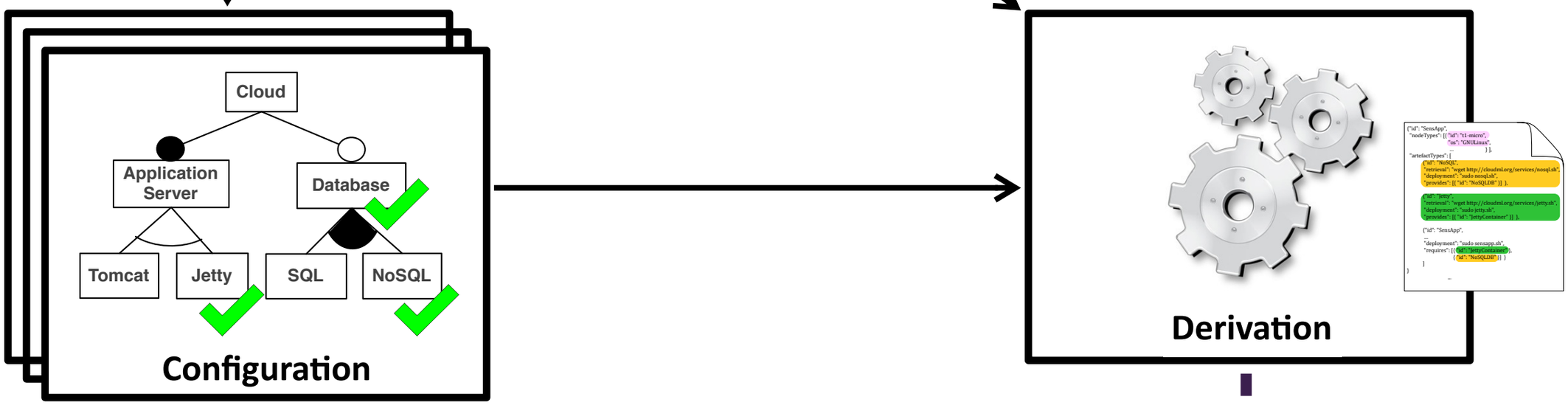
Design Time

Runtime

Dynamic Software Product Lines

Domain Engineering





Application Engineering

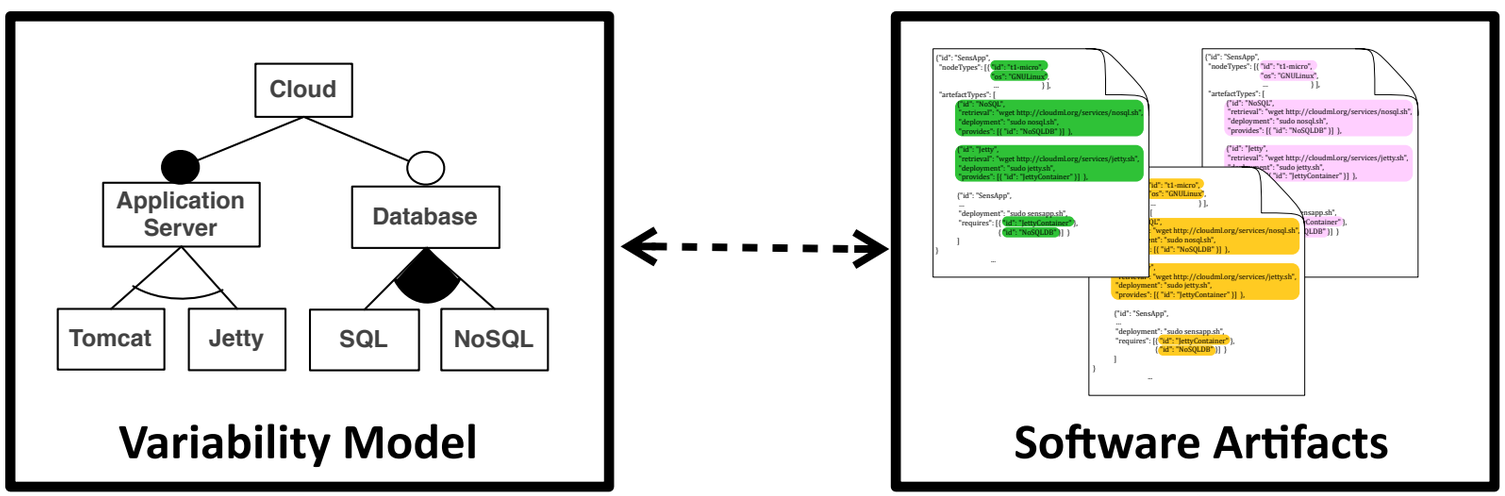
Adaptation

Reconfiguration

Design Time | Runtime

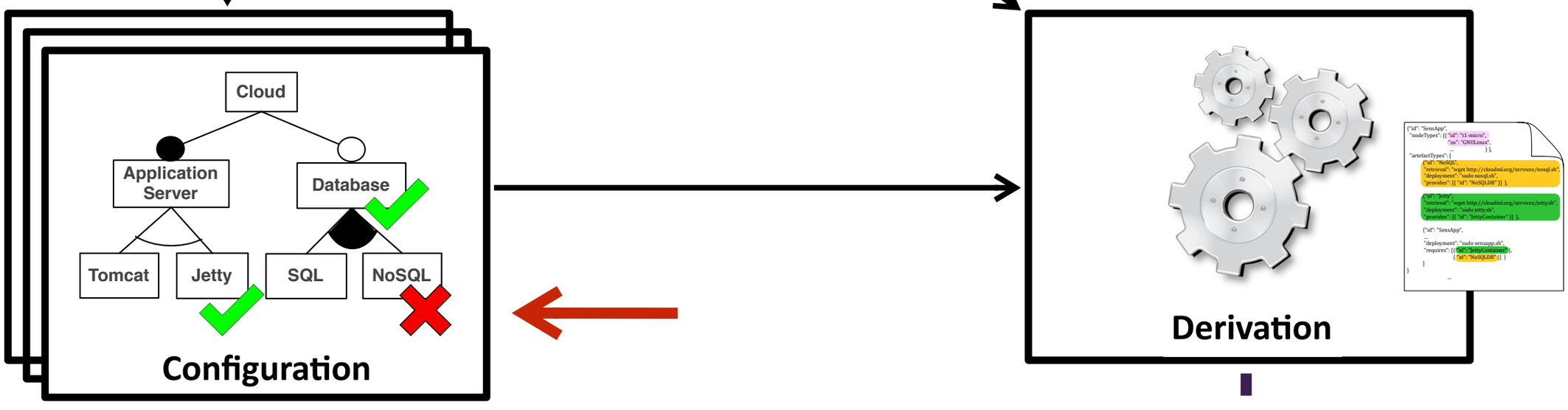
Dynamic Software Product Lines

Domain Engineering



Adaptation

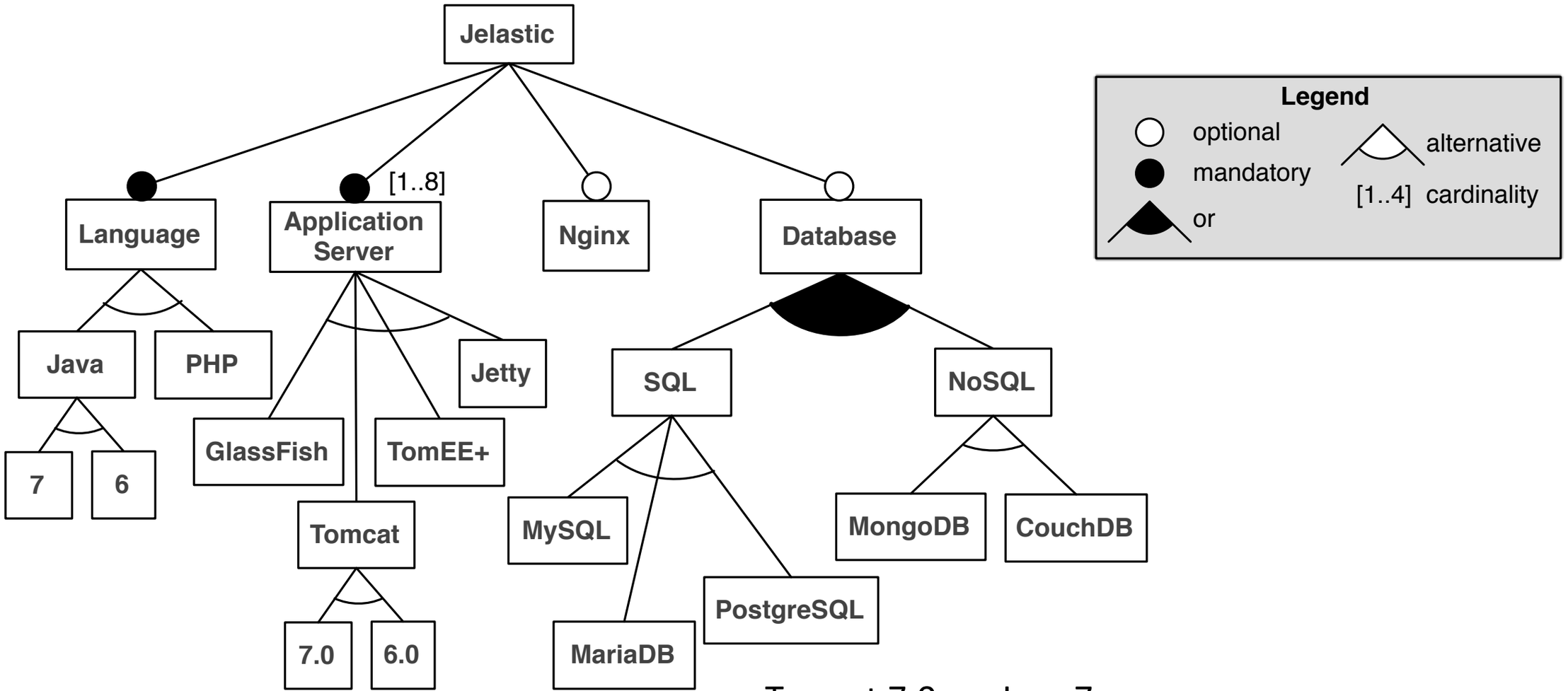
Reconfiguration



Application Engineering

Design Time | Runtime

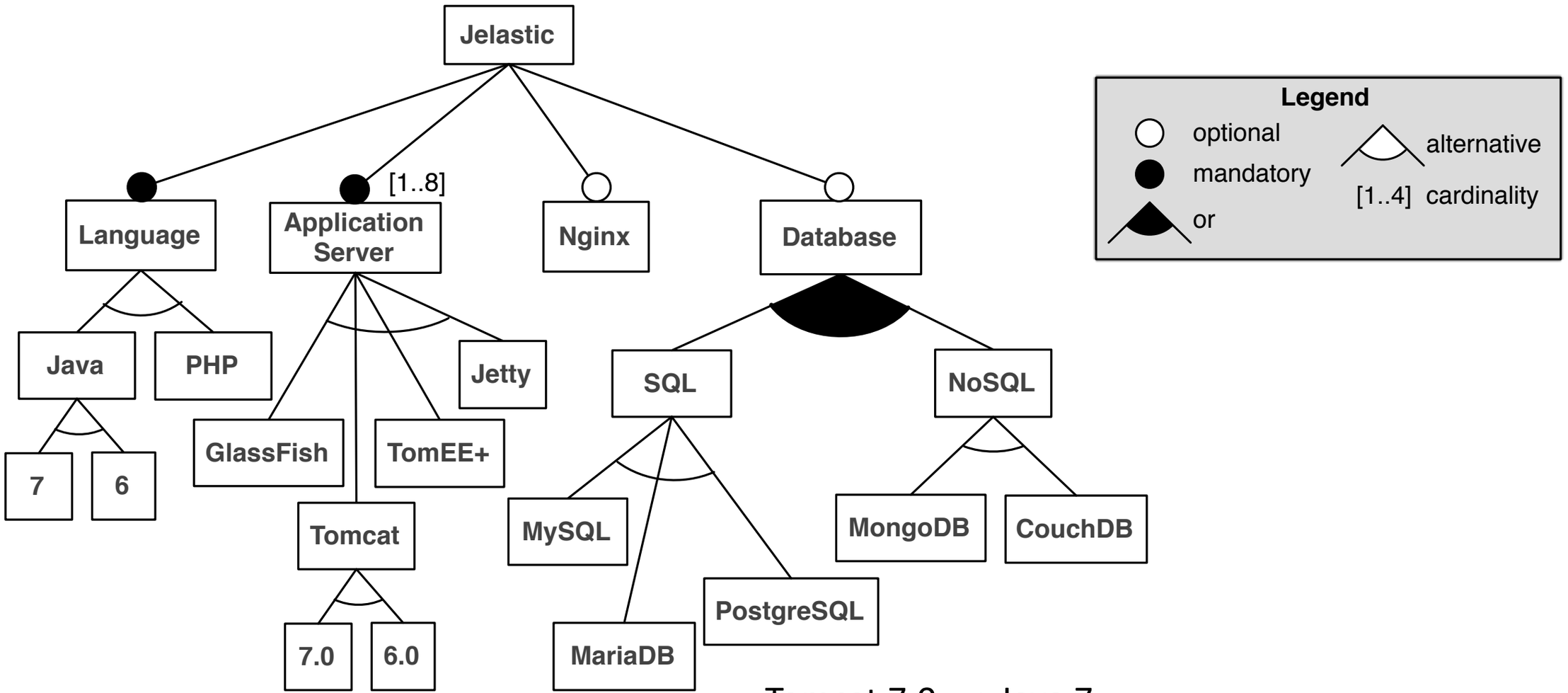
Why DSPL for Adaptive Systems?



Tomcat 7.0 ⟶ Java 7

[2,*] Application Server ⟶ Nginx

Why DSPL for Adaptive Systems?

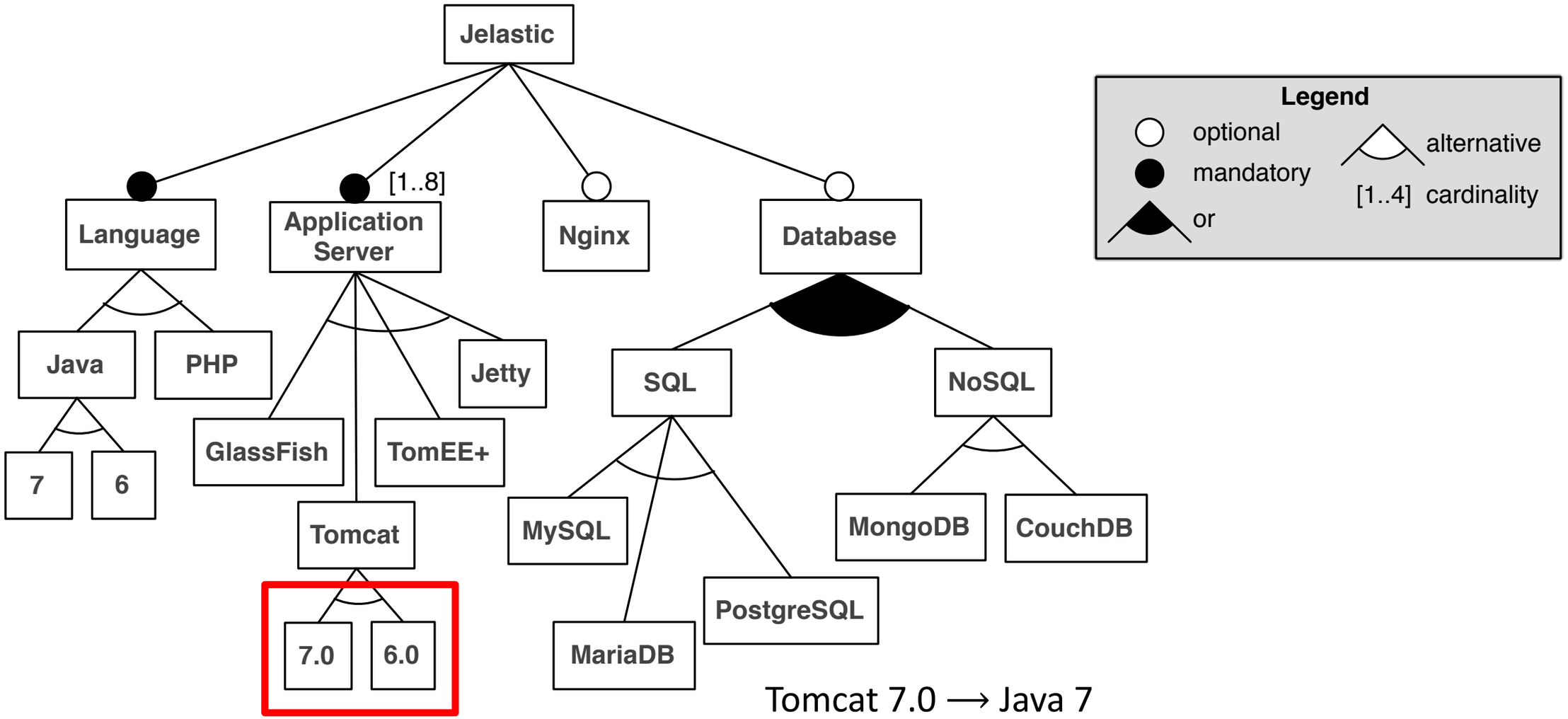


Tomcat 7.0 ⟶ Java 7

[2,*] Application Server ⟶ Nginx

- Adaptation capabilities are modeled (boundaries!)

Why DSPL for Adaptive Systems?



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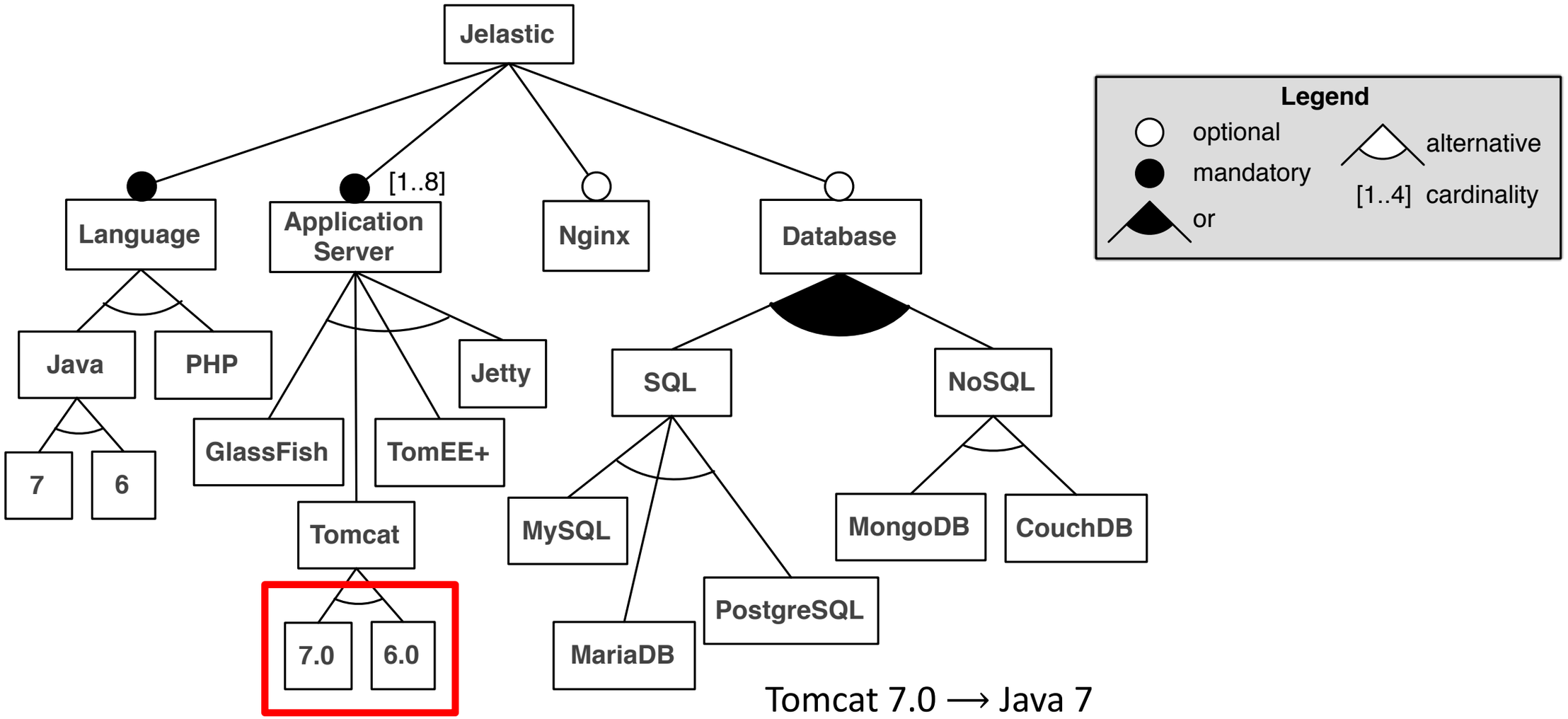
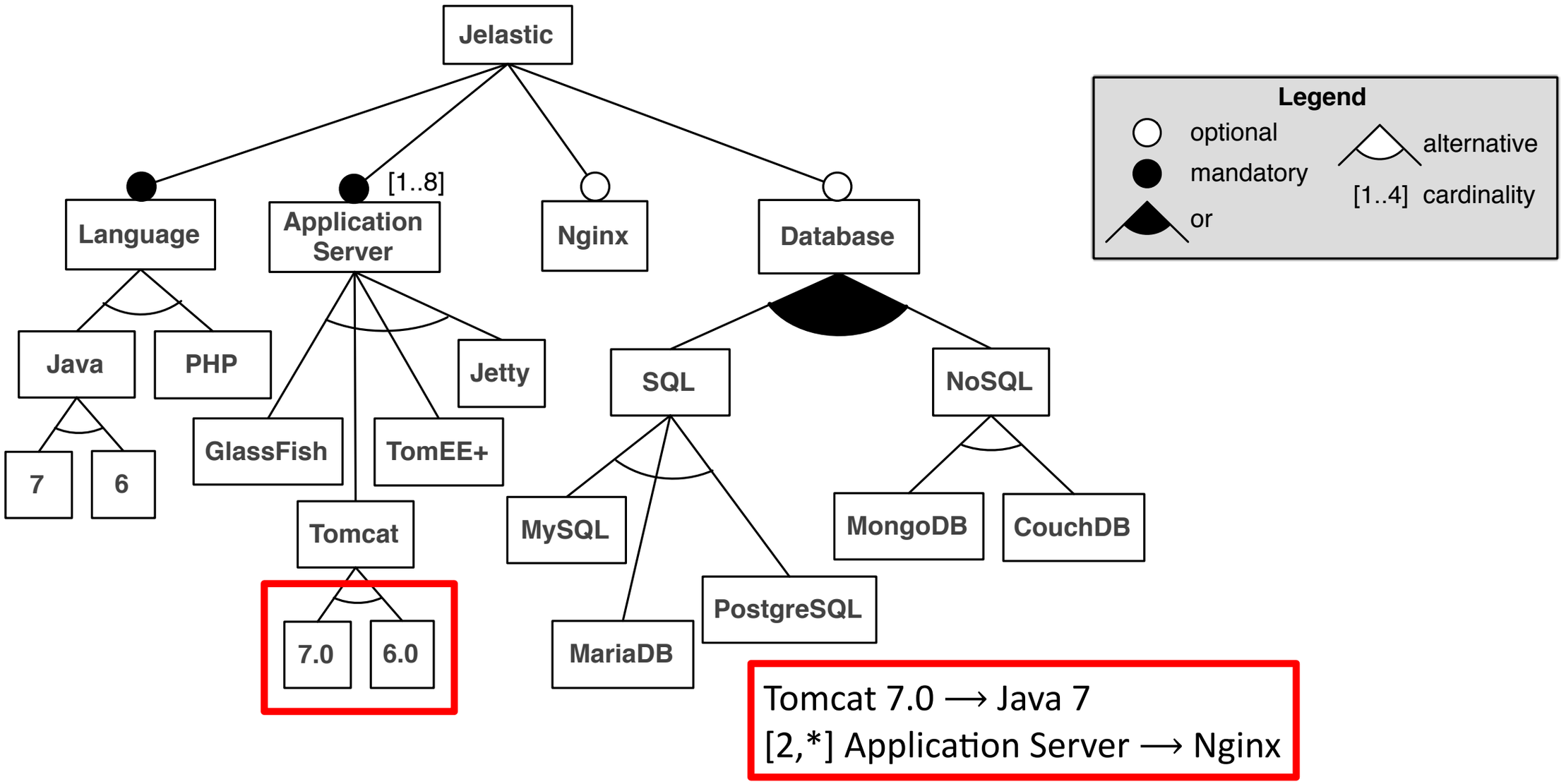


- Adaptation capabilities are modeled (boundaries!)
- Automated reasoning on (re)configurations

Why DSPL for Adaptive Systems?



- Adaptation capabilities are modeled (boundaries!)
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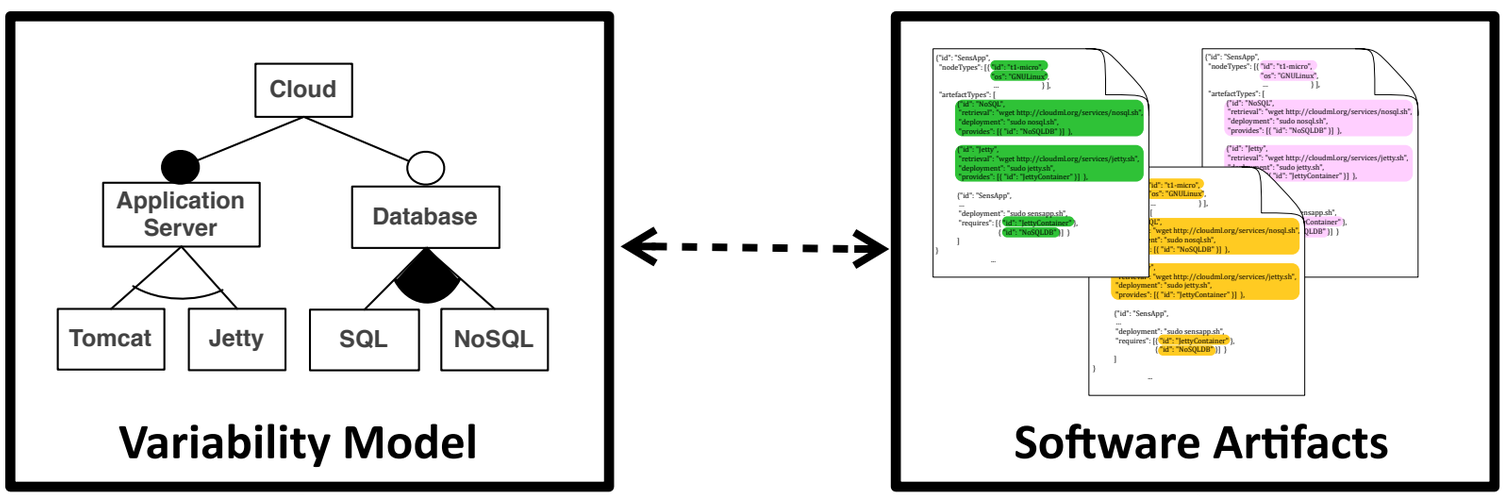
”Design evolution is absolutely inevitable“

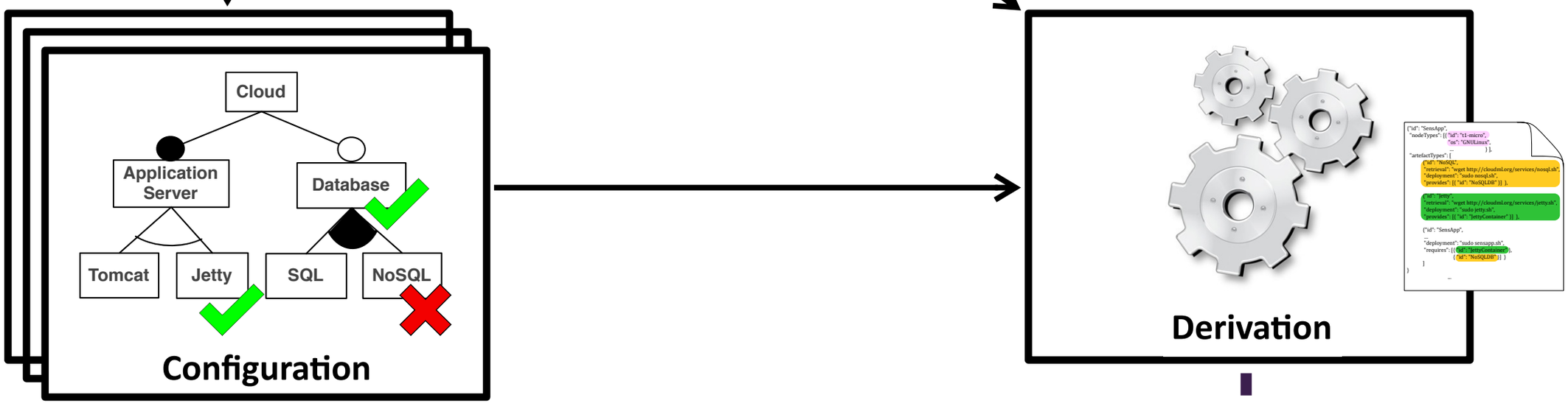
Kent Beck, *The Inevitability of Evolution*, IEEE Software, 2010

Evolution of Dynamic Software Product Lines

Domain Engineering



Application Engineering

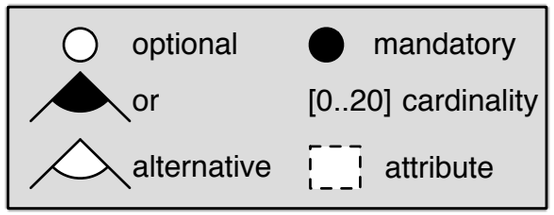


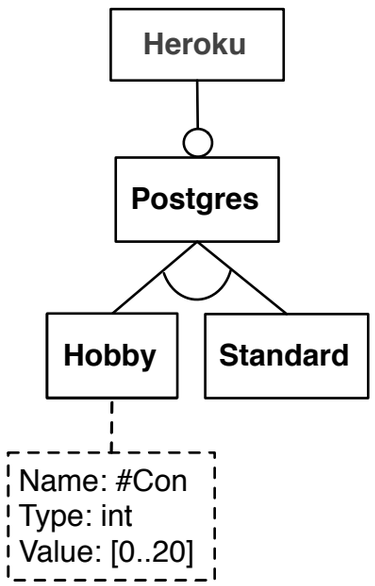
Adaptation

Reconfiguration

Design Time | Runtime

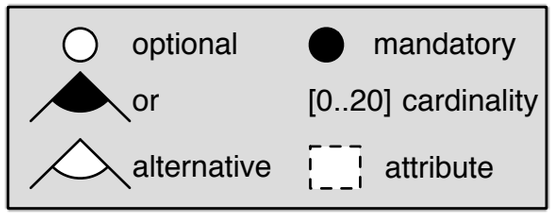
Example

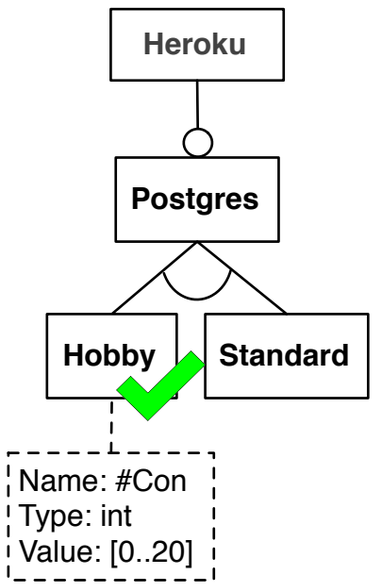


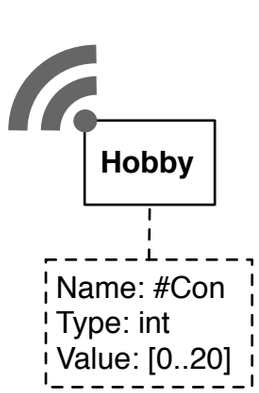


Design Time | **Runtime**

Example

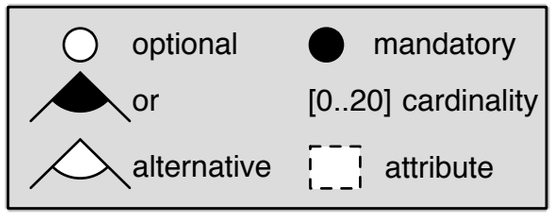


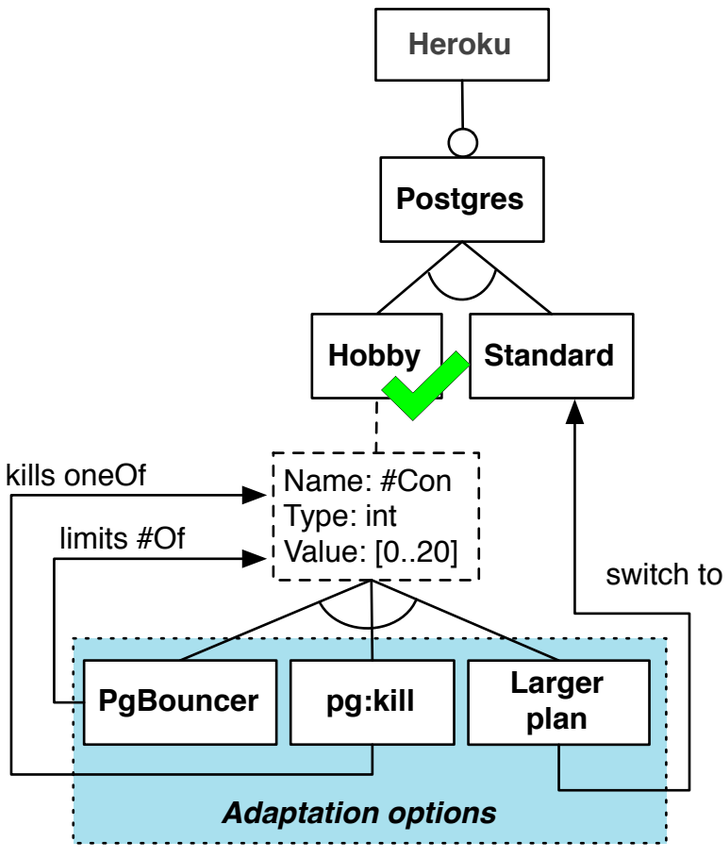


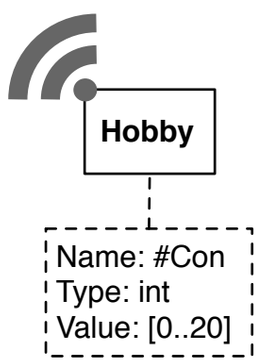


Design Time | **Runtime**

Example

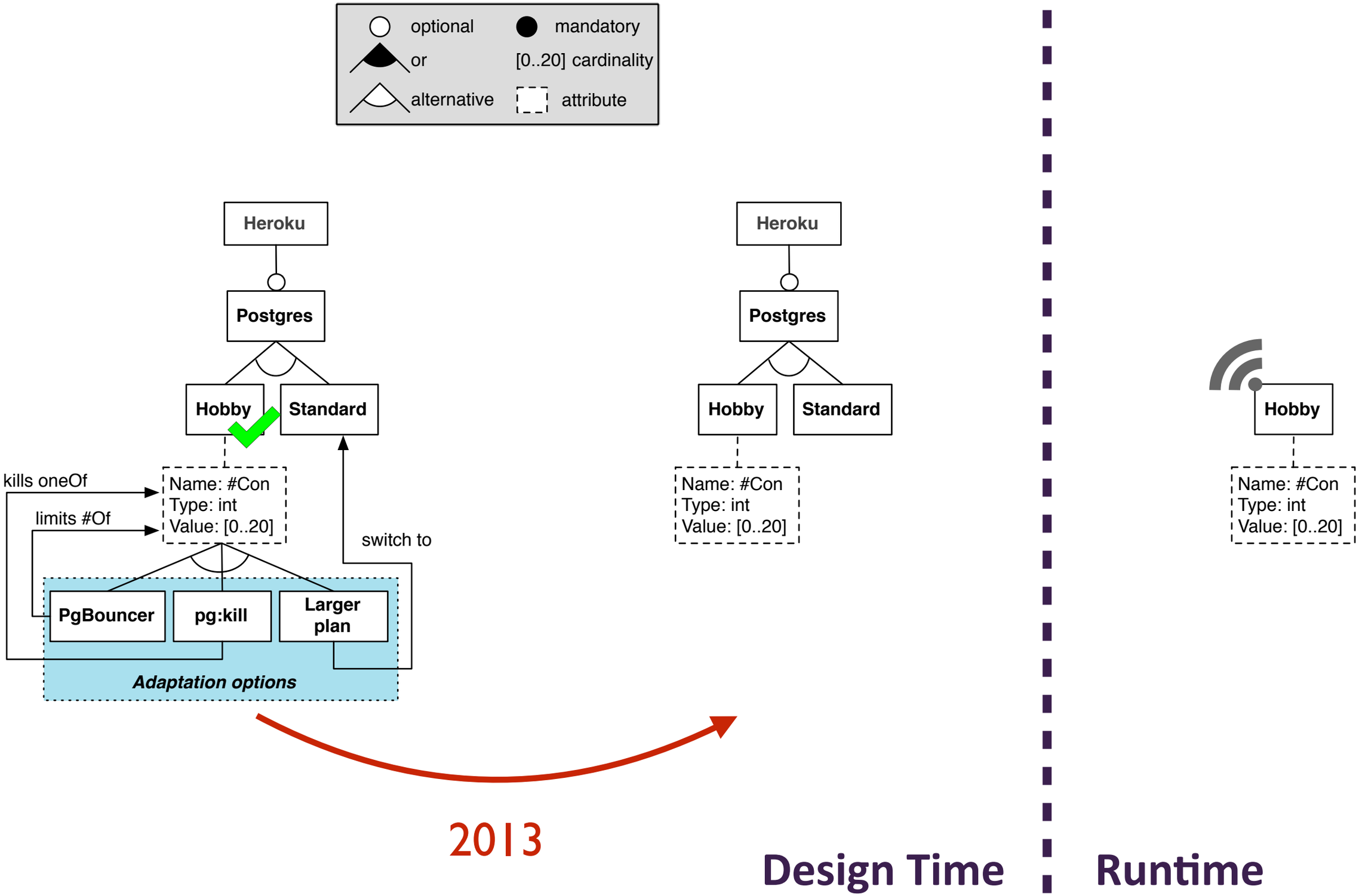






Design Time | **Runtime**

Example


optional
mandatory
or
[0..20] cardinality
alternative
attribute
Heroku
Postgres
Hobby
Standard
kills oneOf
limits #Of
Name: #Con
Type: int
Value: [0..20]
switch to
PgBouncer
pg:kill
Larger plan
Adaptation options
Heroku
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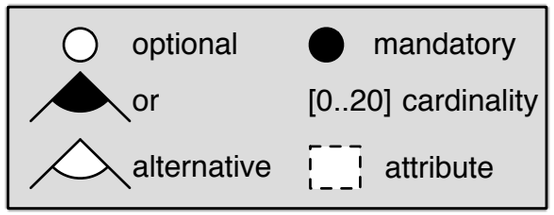
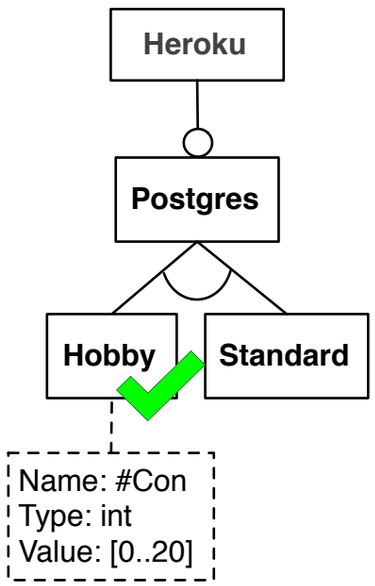
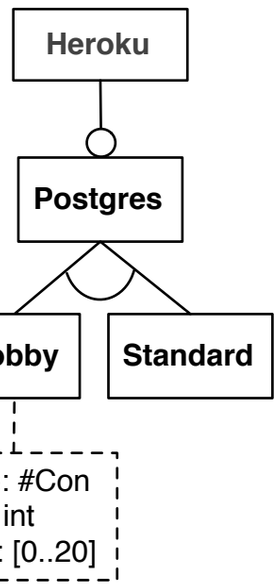
2013
Design Time
Runtime

Example





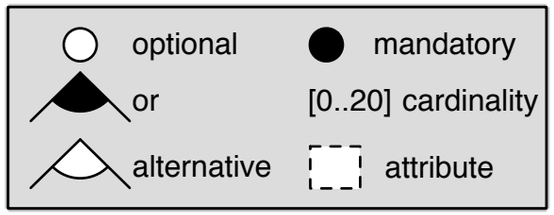


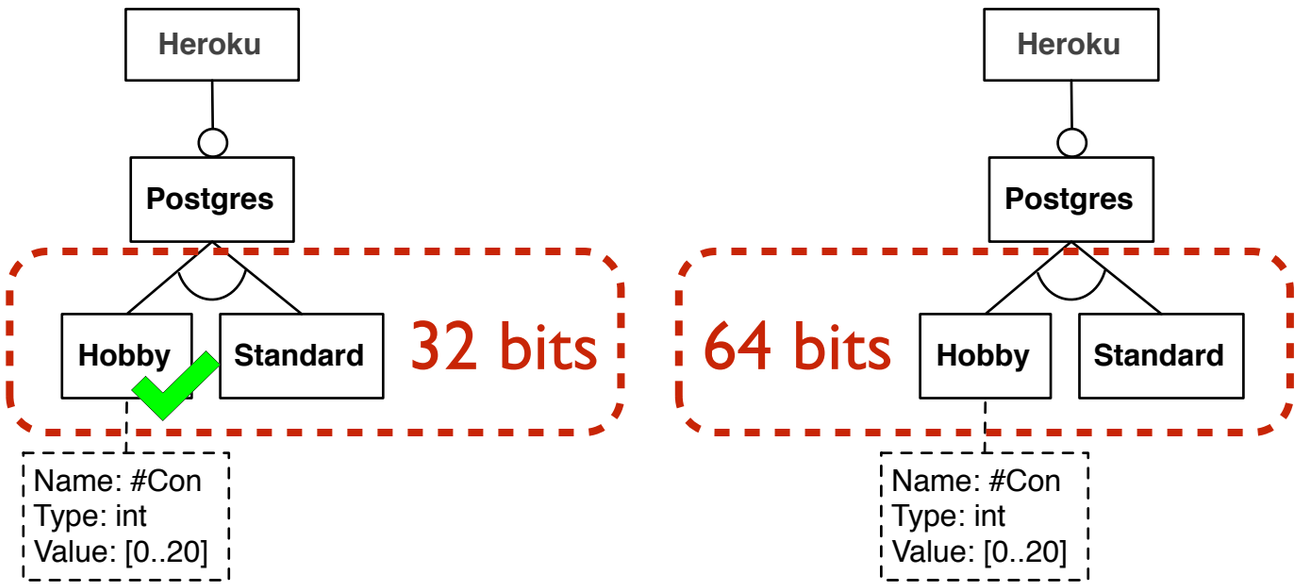
2013

Design Time

Runtime

Example



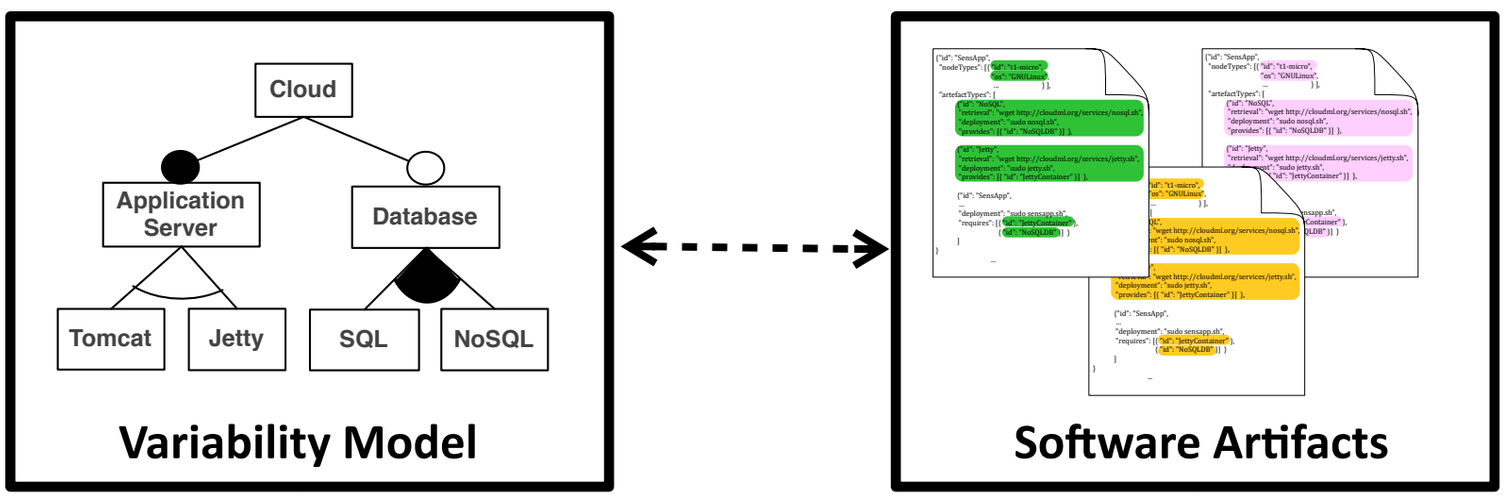


2013

Design Time **Runtime**

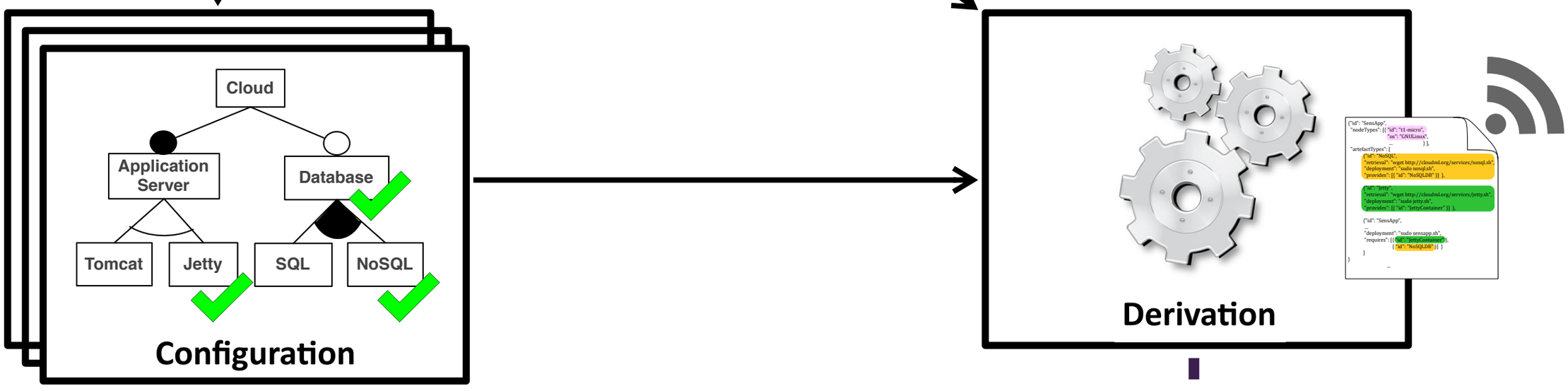
Dynamic Software Product Lines

Domain Engineering



Adaptation

Reconfiguration

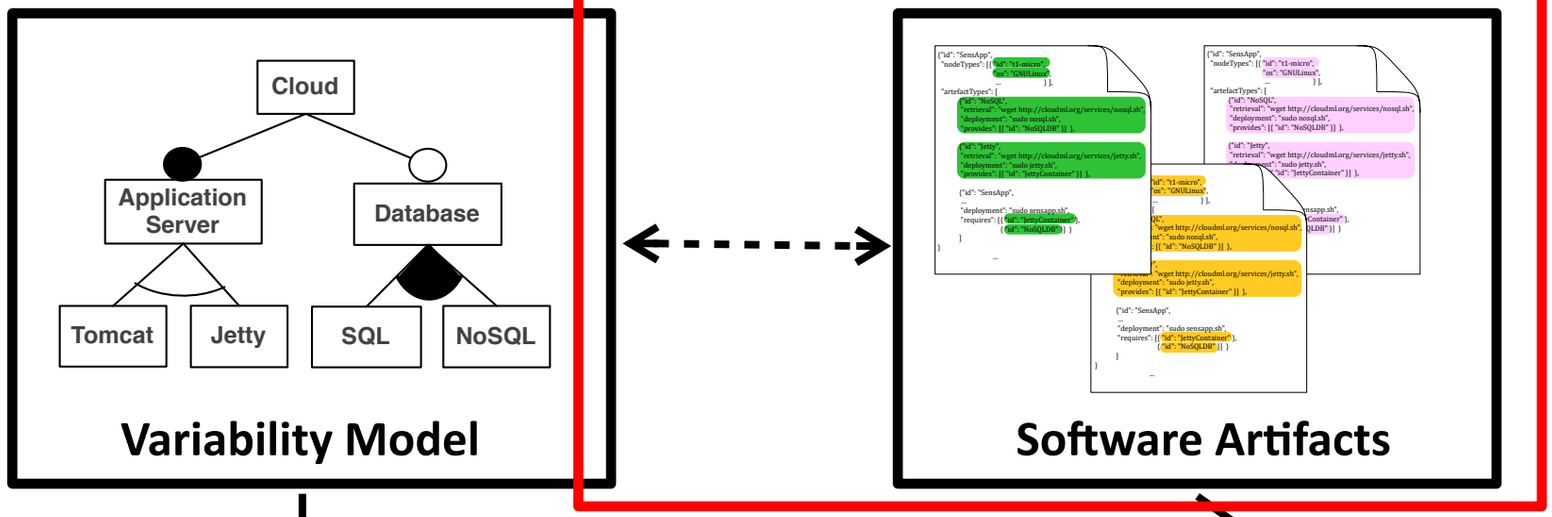


Application Engineering

Design Time | Runtime

Dynamic Software Product Lines

Domain Engineering



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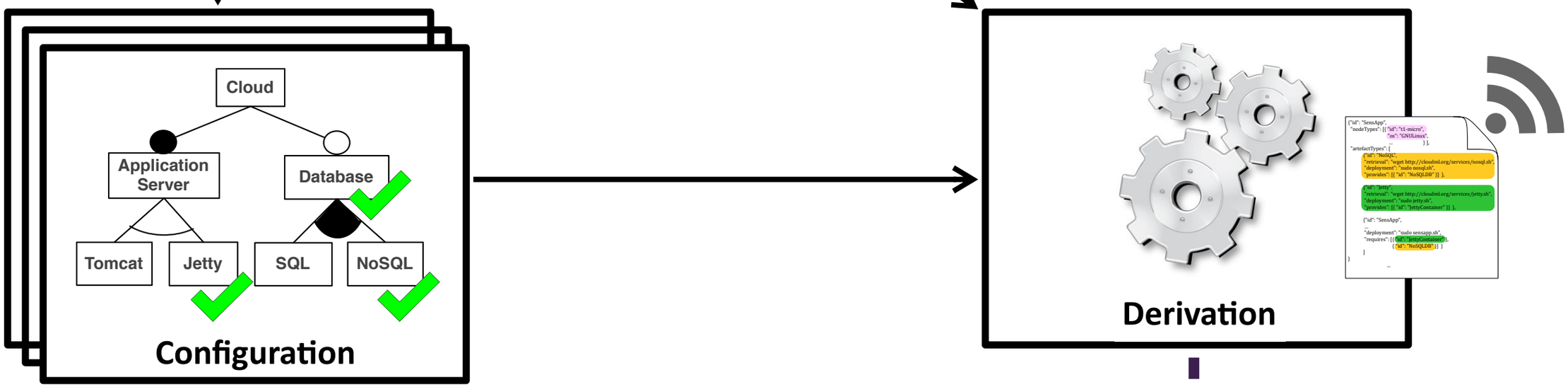
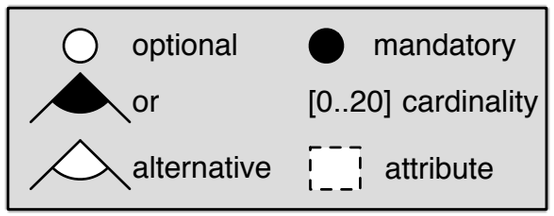
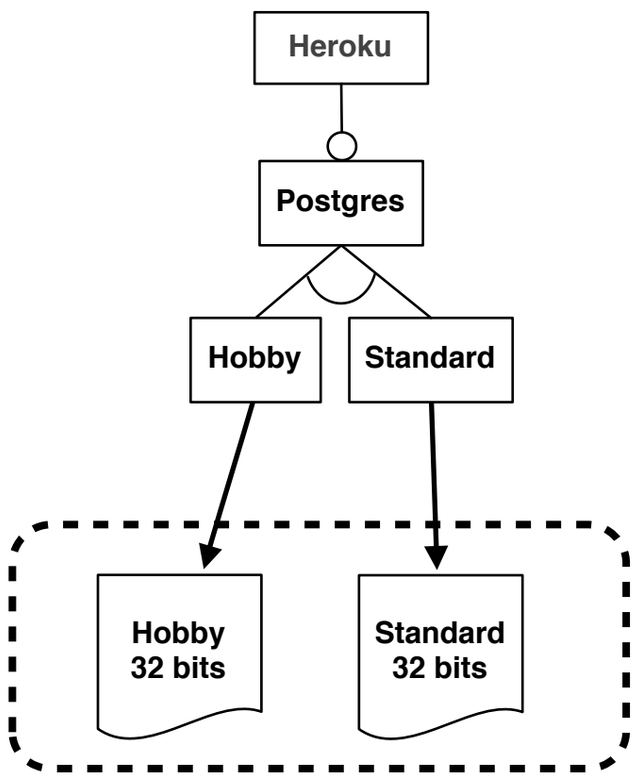


Application Engineering

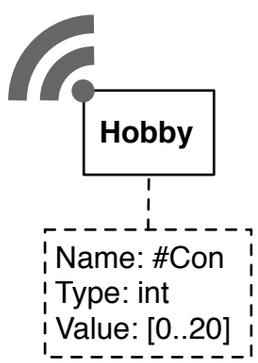
Design Time | Runtime

Example



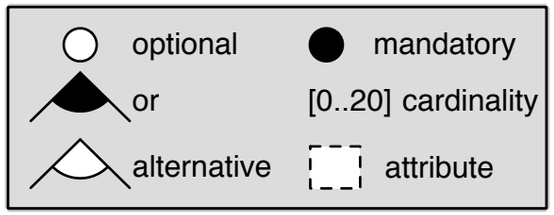


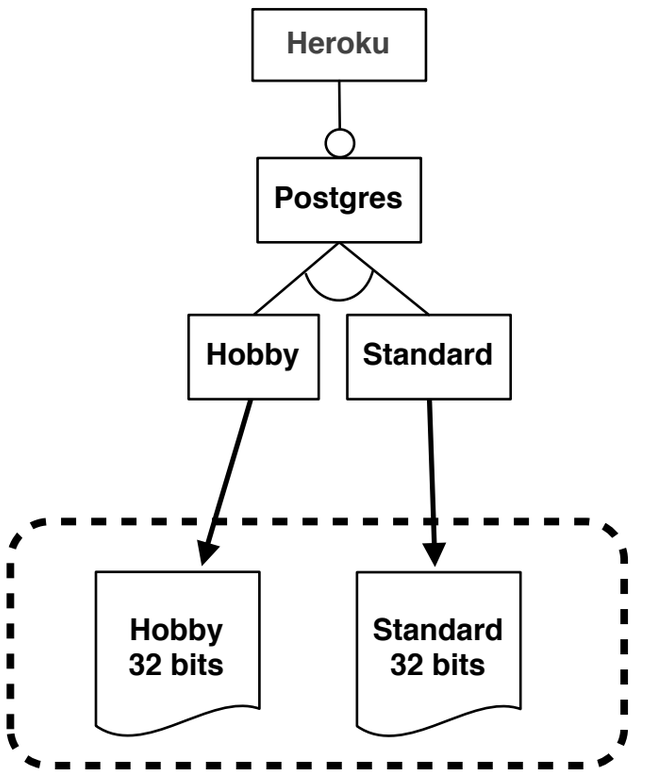
Artifacts repository



Design Time | **Runtime**

Example





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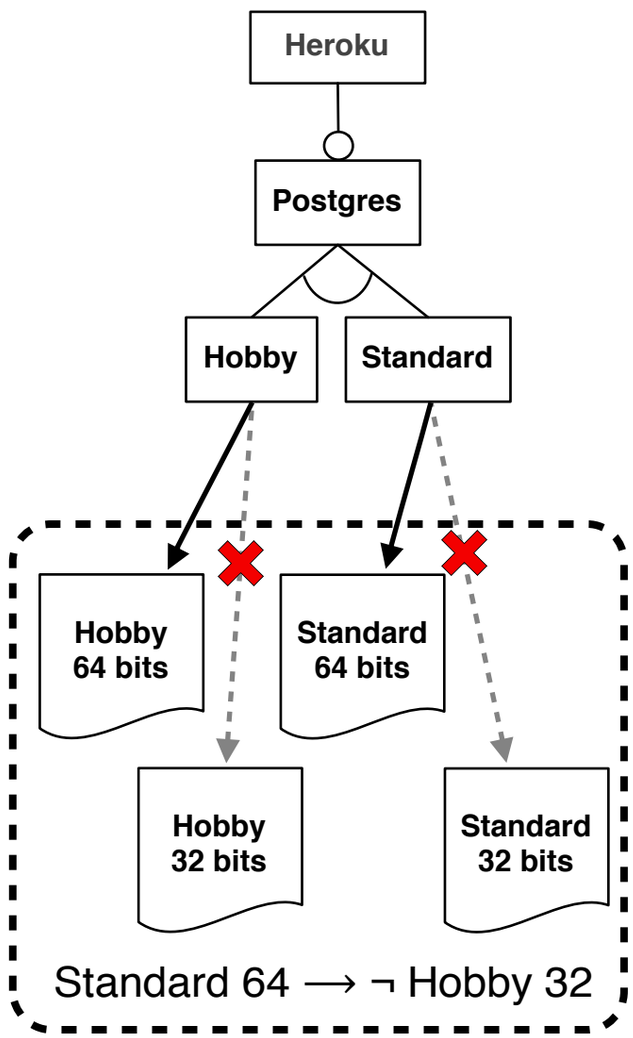

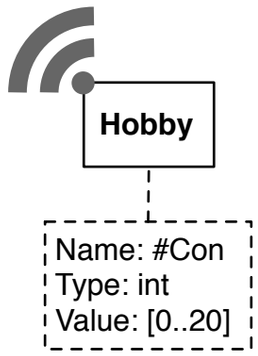

Design Time | **Runtime**

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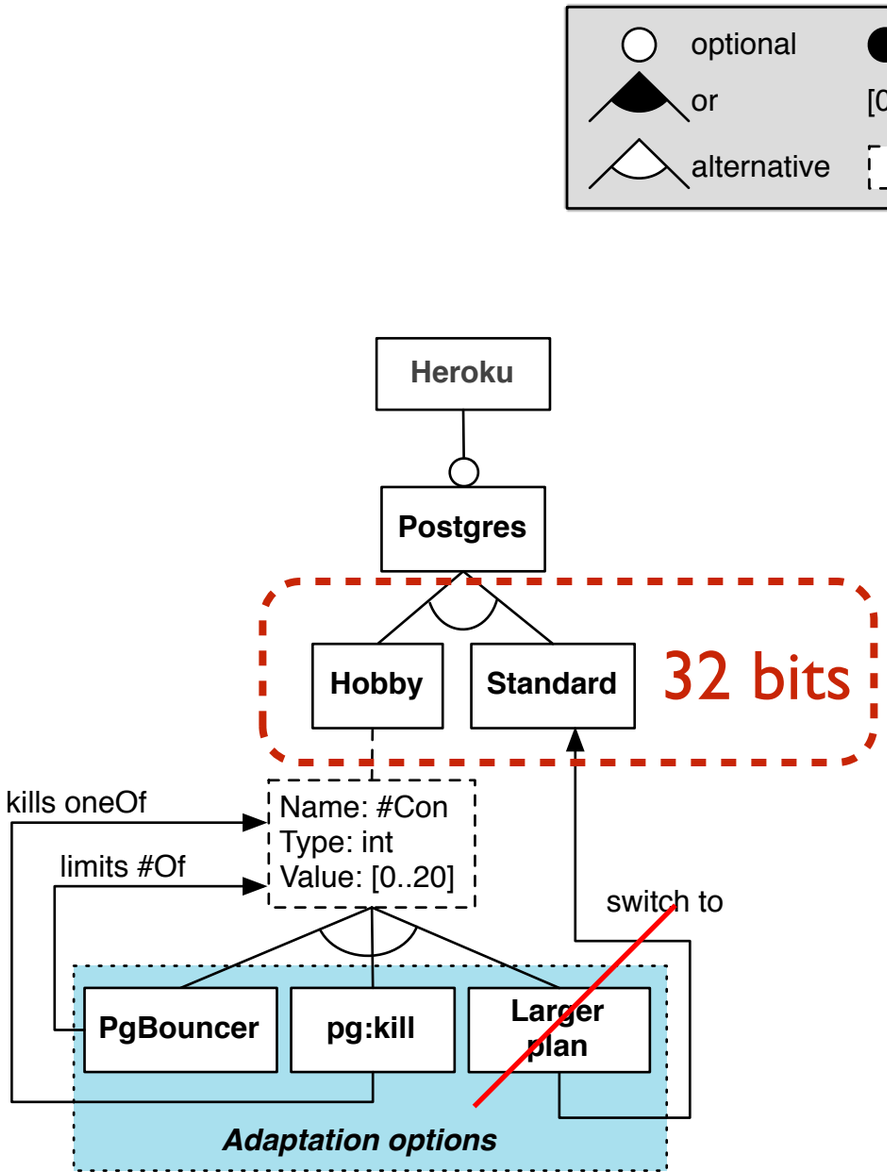
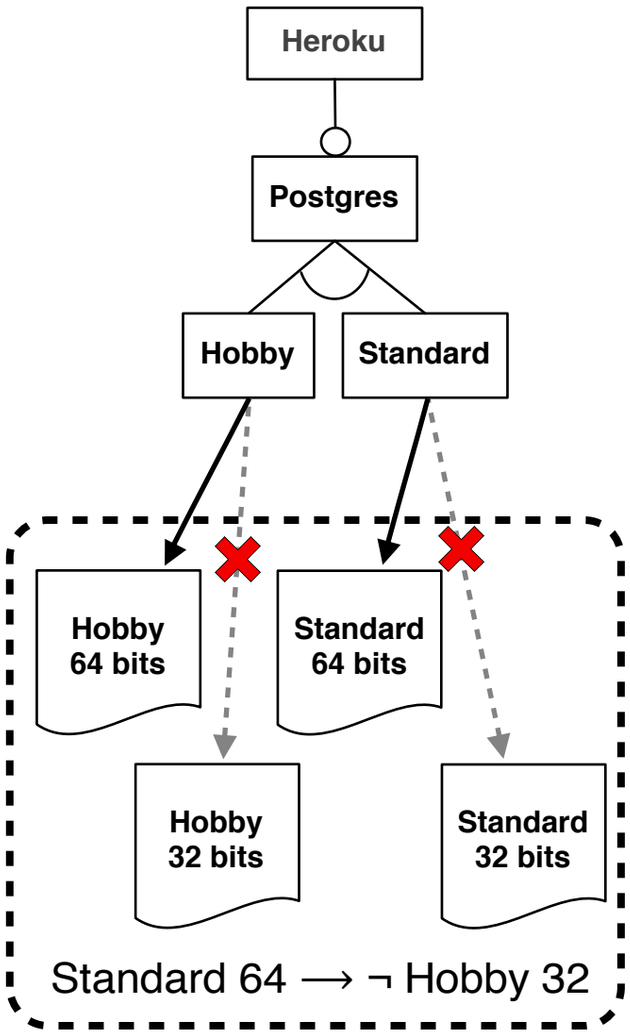
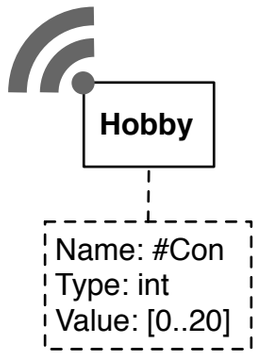






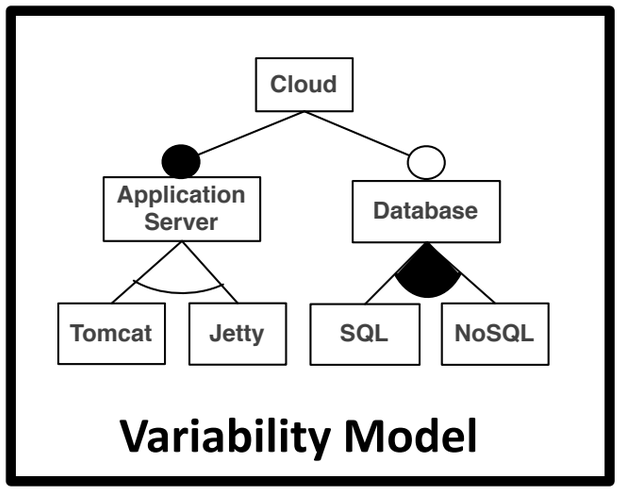
Design Time **Runtime**

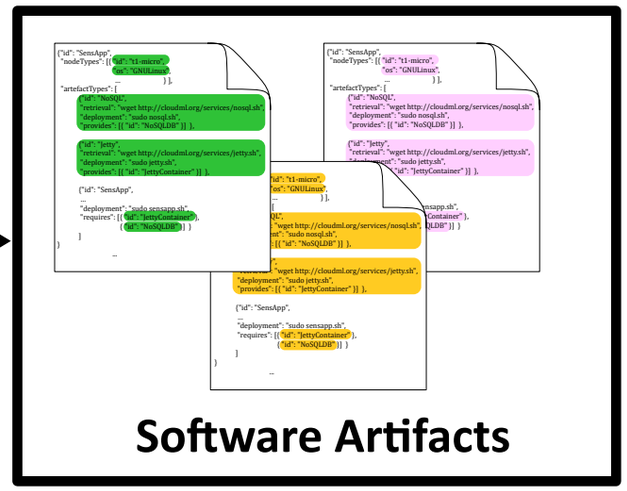
The problem: consistency

Two dimensions: Space and Time

Space

Problem Space

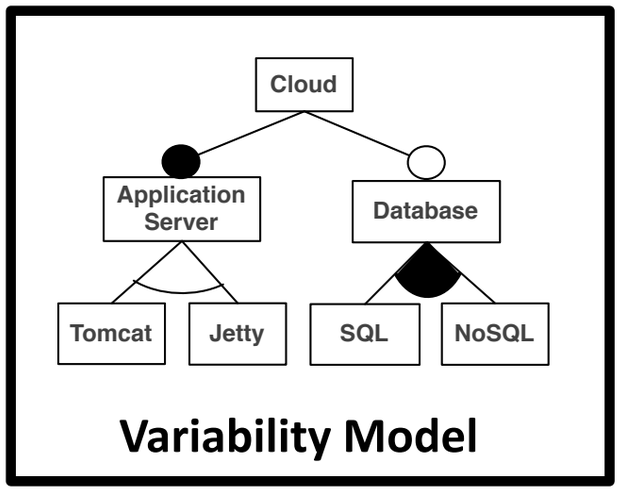


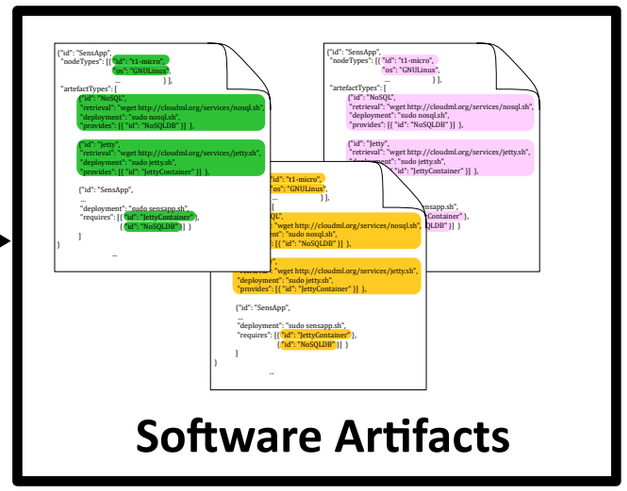


Solution Space

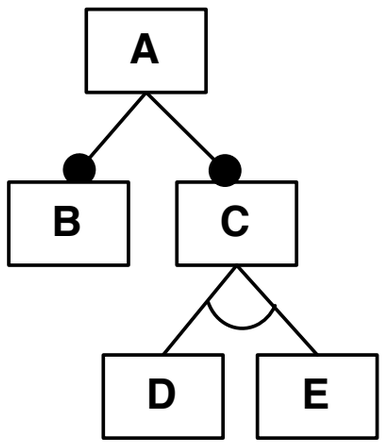
Space

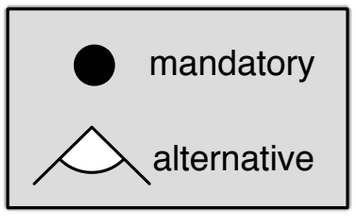
Problem Space





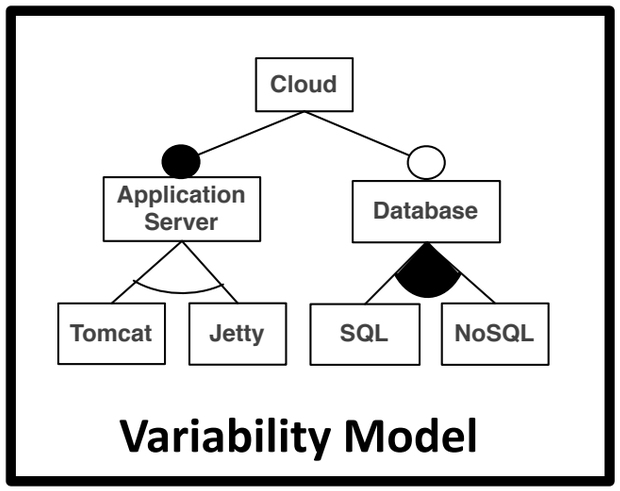
Solution Space

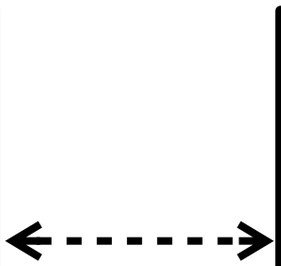


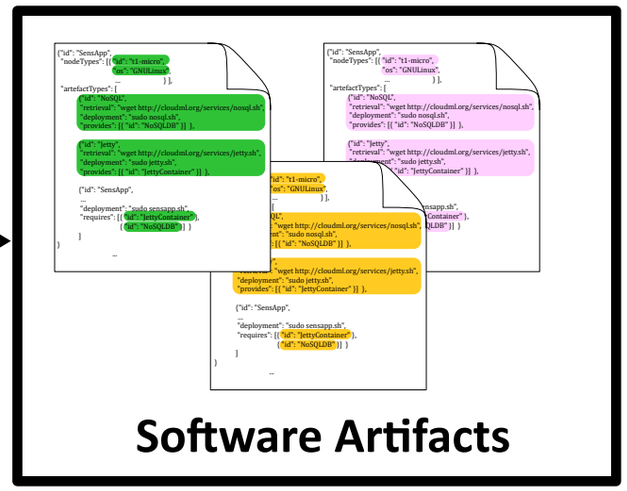


Space

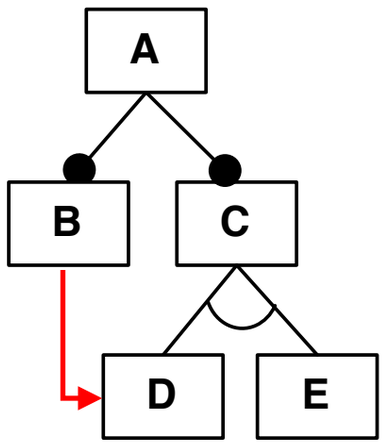
Problem Space

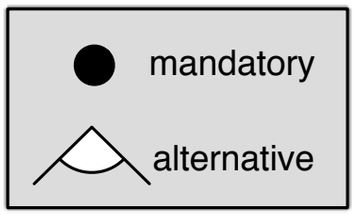






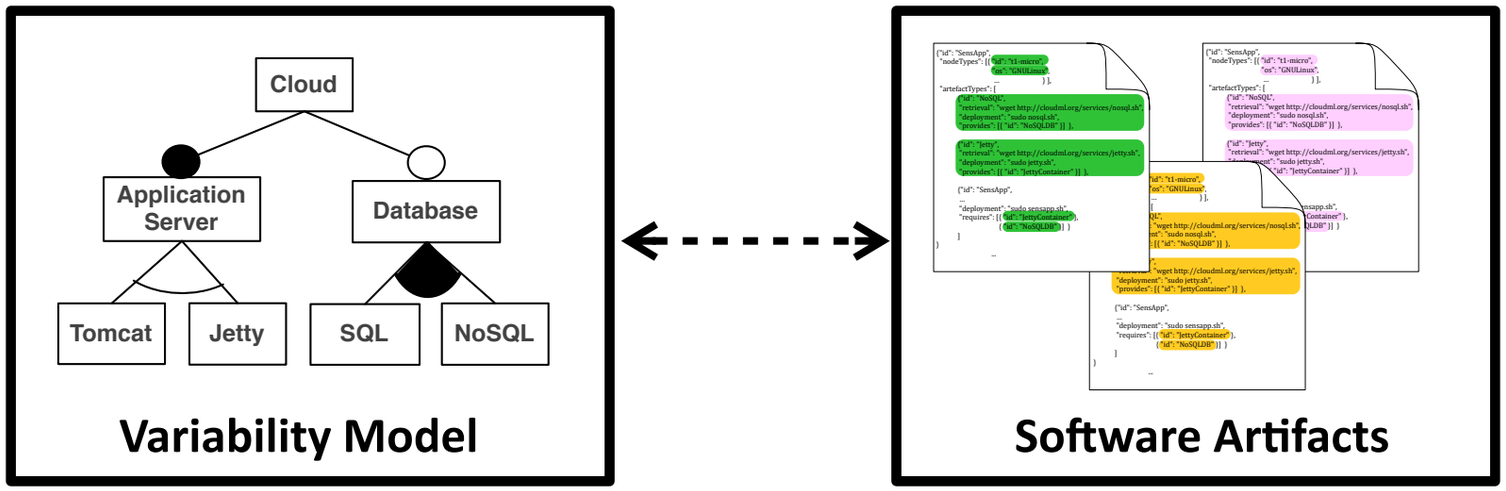
Solution Space





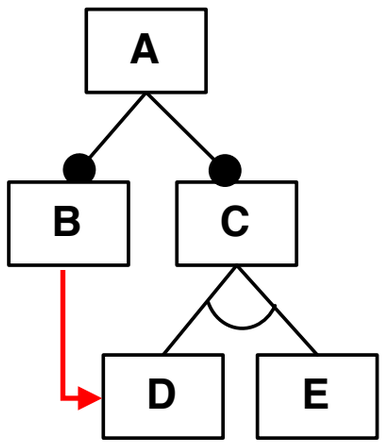
Space

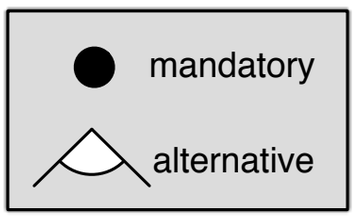
Problem Space



Solution Space

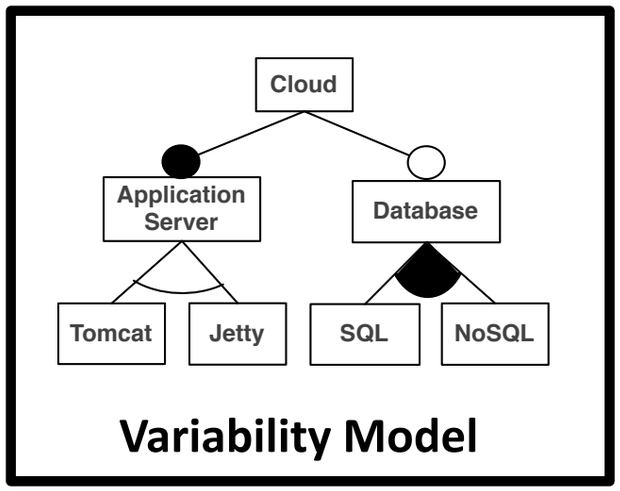
E is a dead feature

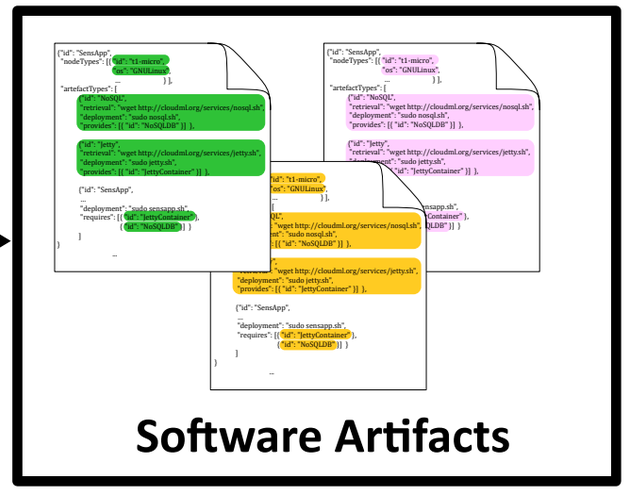




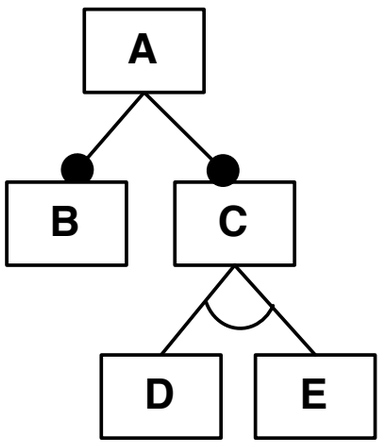
Space

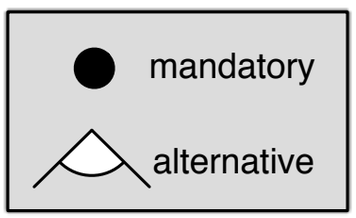
Problem Space

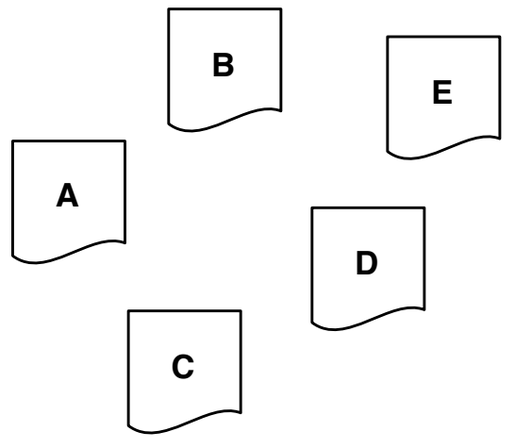




Solution Space



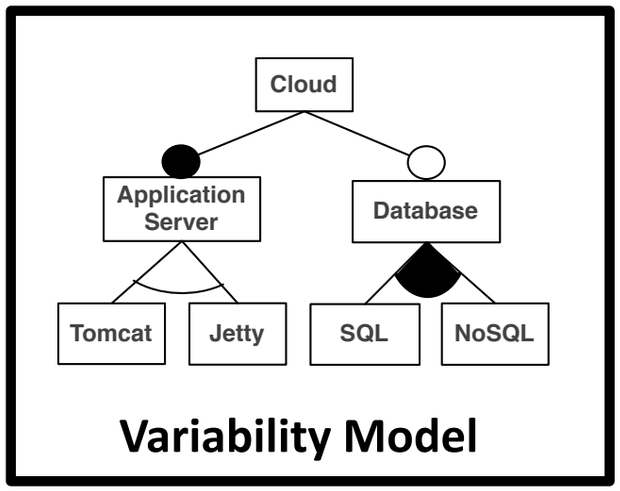


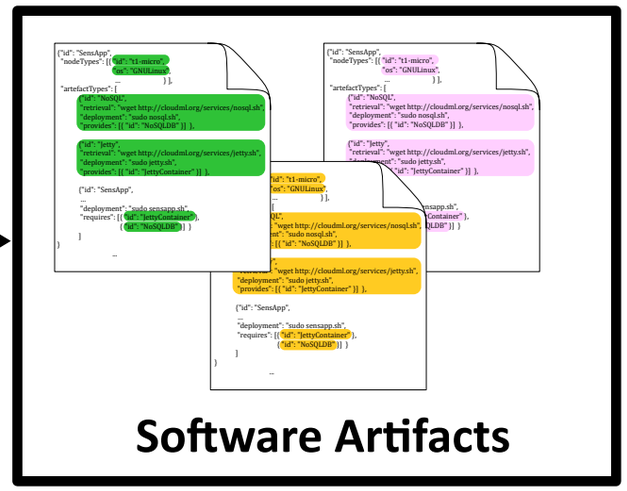


A ⟶ B
A ⟶ C
C ⟶ D
C ⟶ E

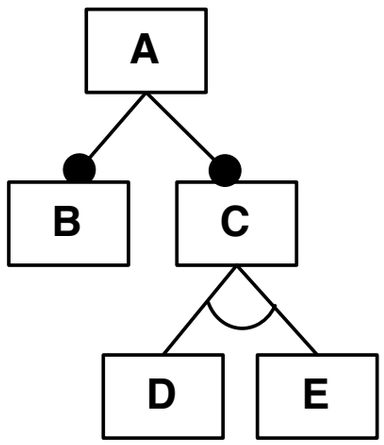
Space

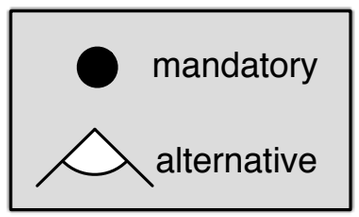
Problem Space

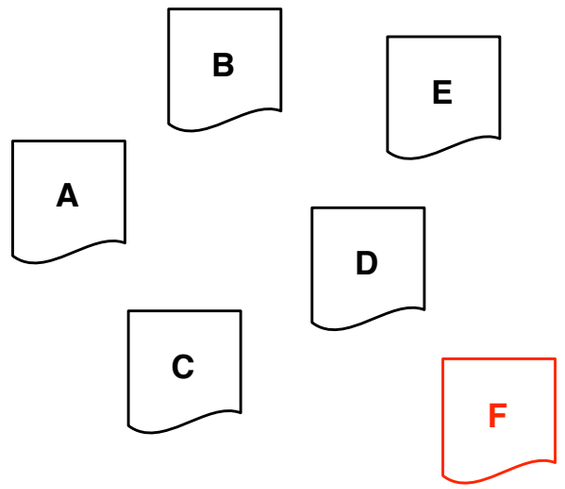




Solution Space



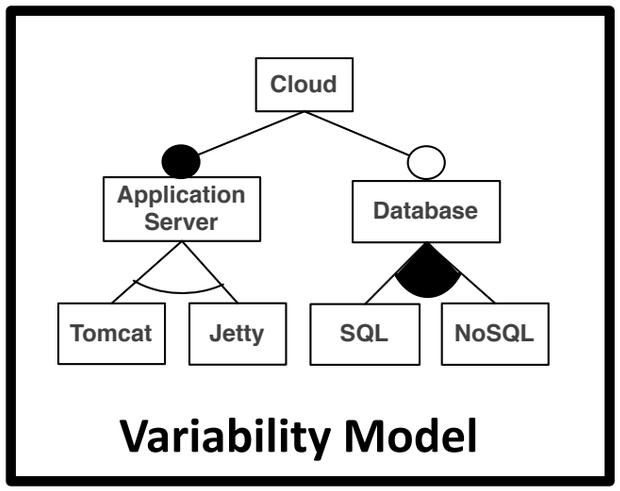


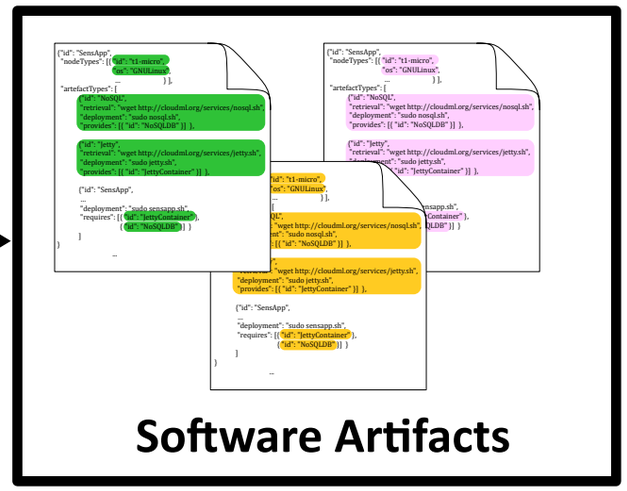


$A \longrightarrow B$
$A \longrightarrow C$
$C \longrightarrow D$
$C \longrightarrow E$
$F \longrightarrow C$
$F \longrightarrow \neg E$

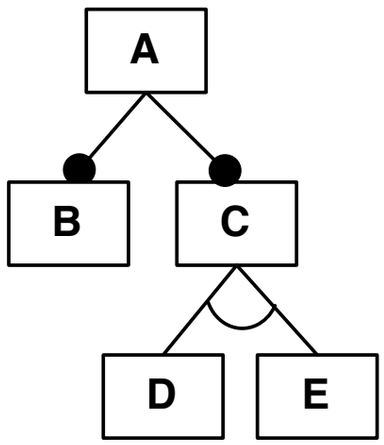
Space

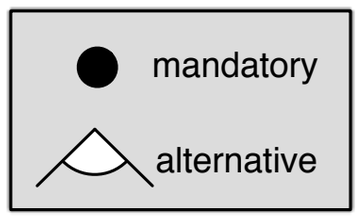
Problem Space

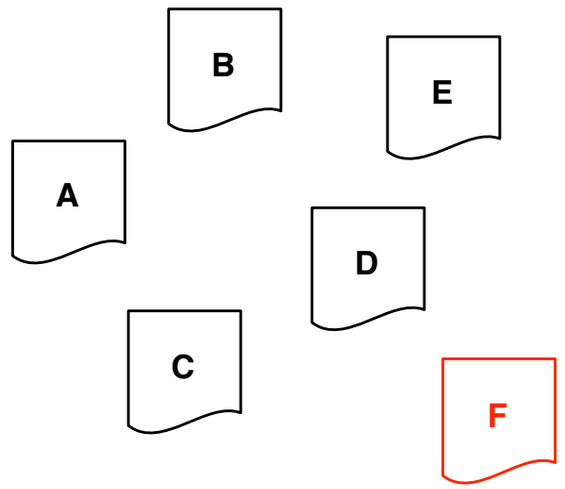




Solution Space



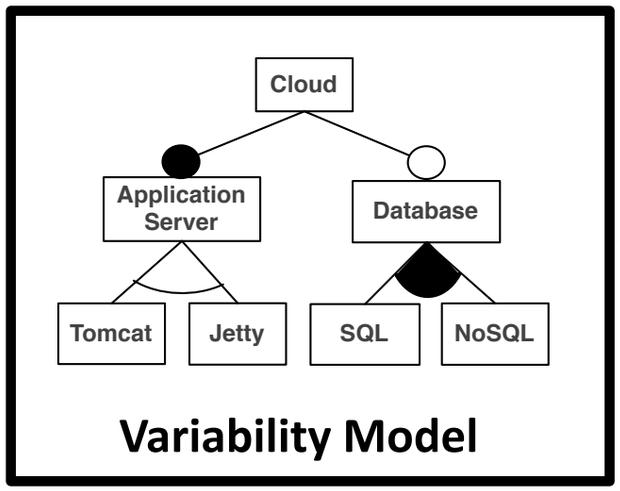


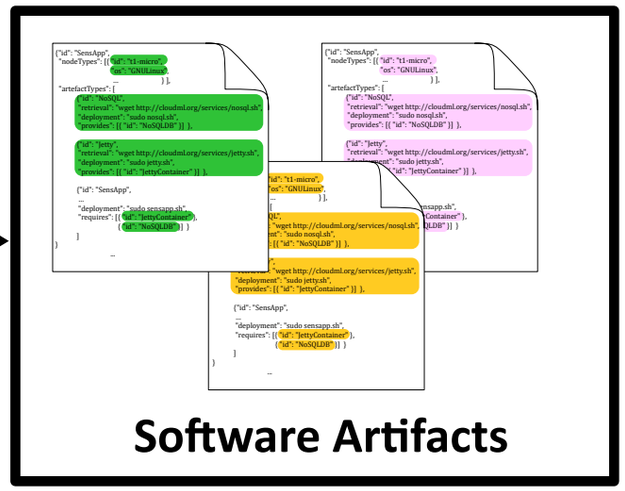


$A \longrightarrow B$
$A \longrightarrow C$
$C \longrightarrow D$
$C \longrightarrow E$
$F \longrightarrow C$
$F \longrightarrow \neg E$

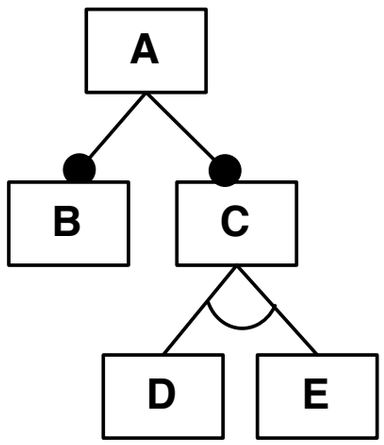
Space

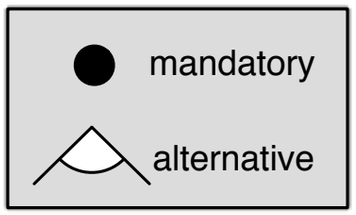
Problem Space

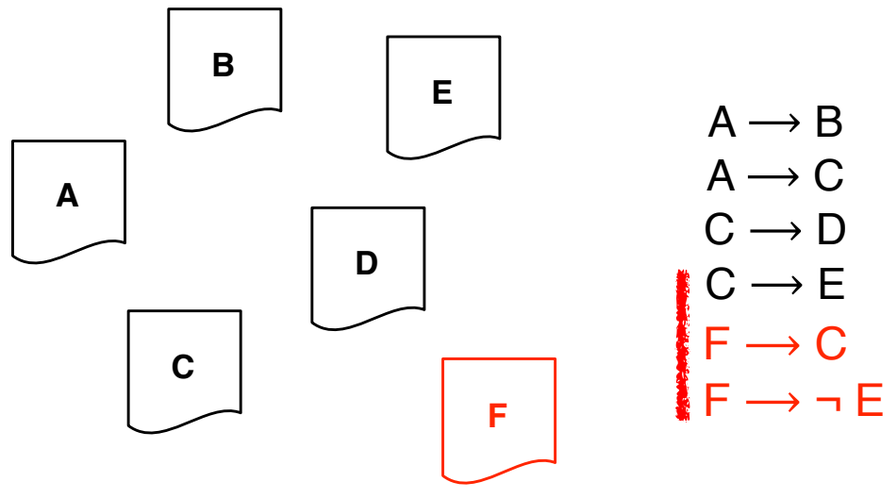




Solution Space



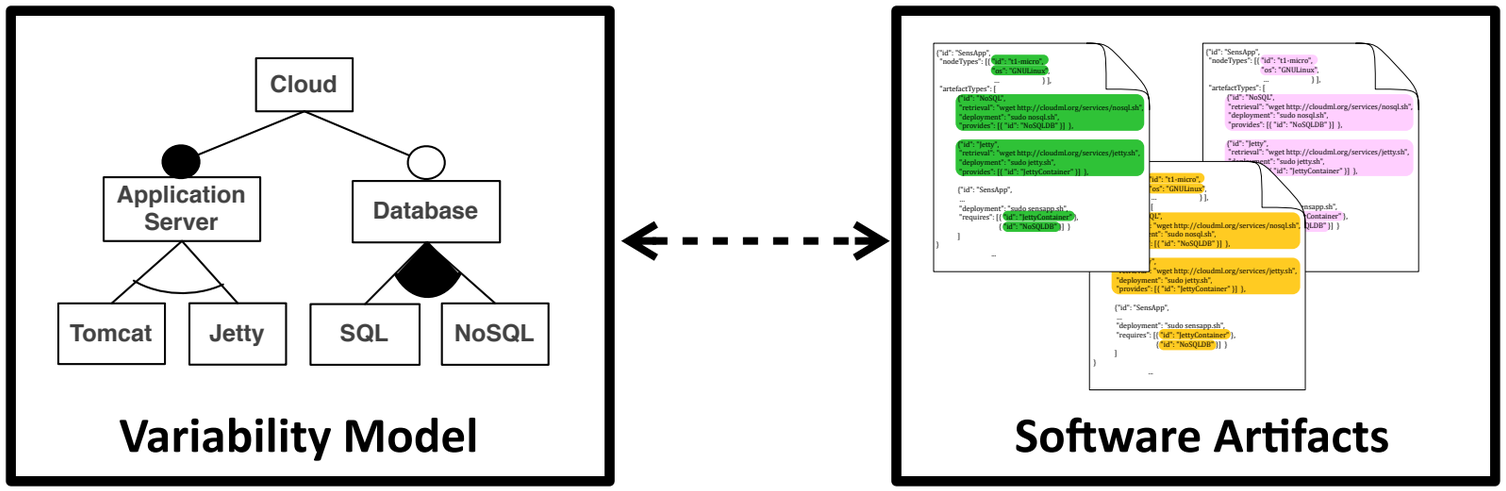




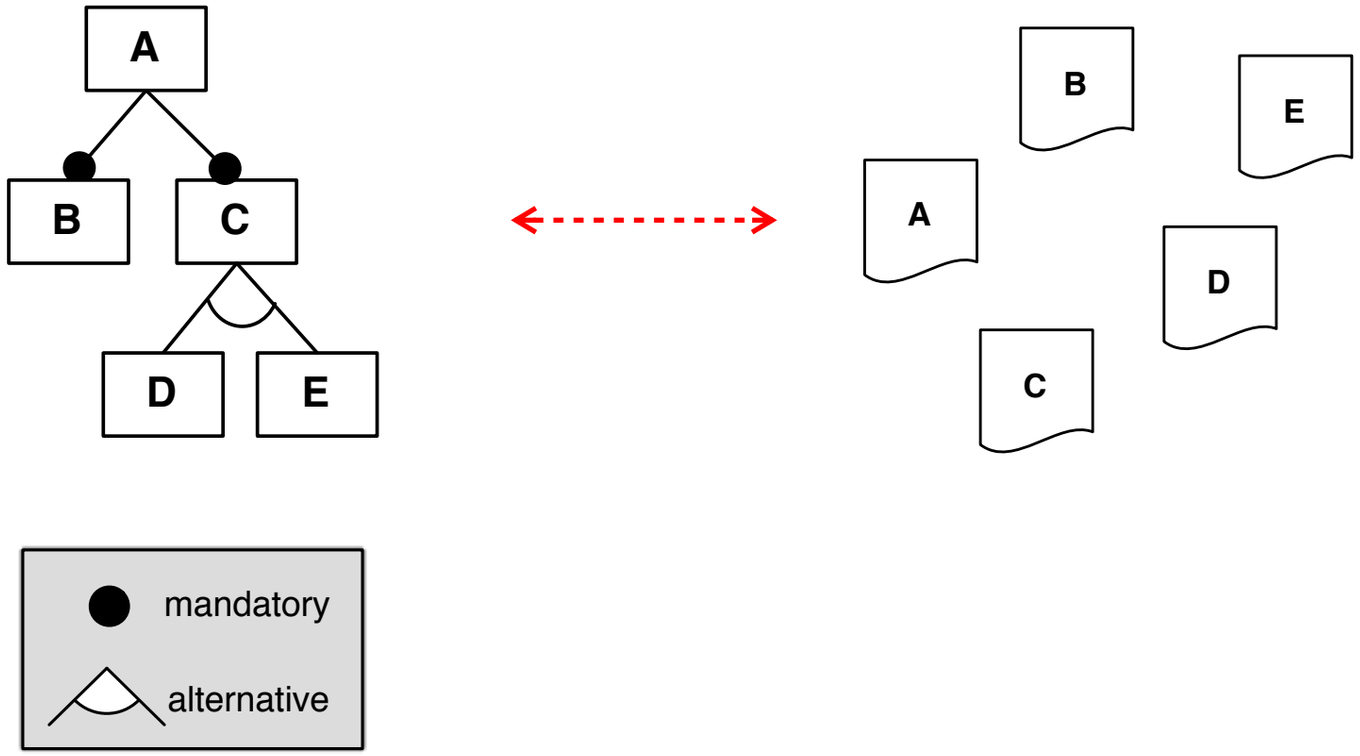
Incompatibilities between
- packages (e.g. Linux)
- plugins (e.g. Eclipse)

Space

Problem Space

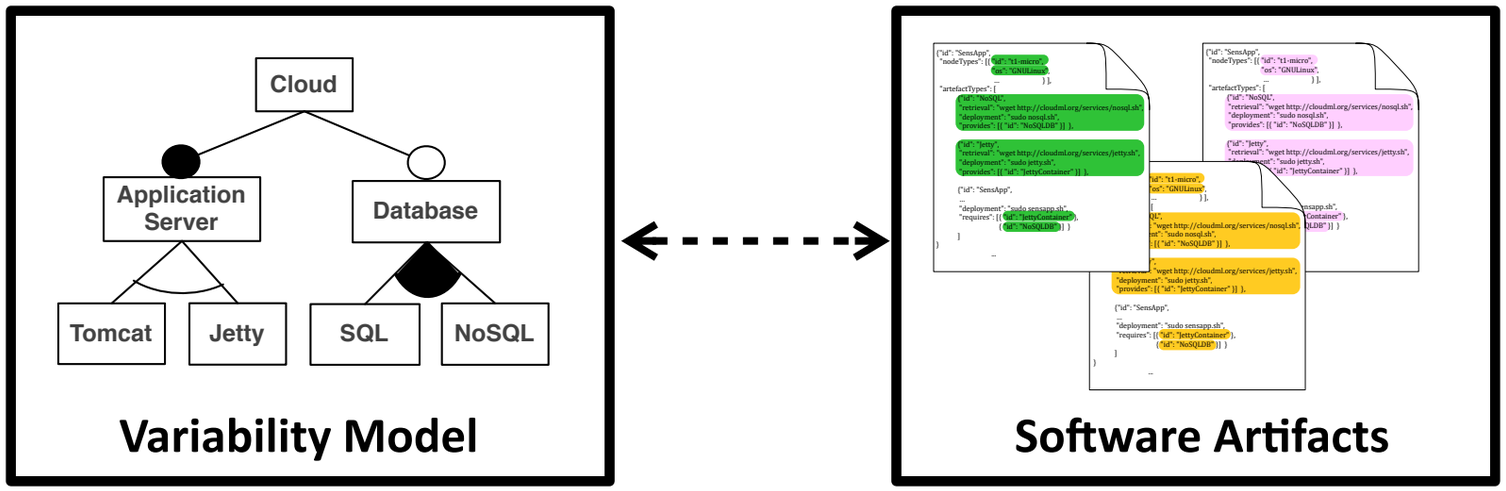


Solution Space

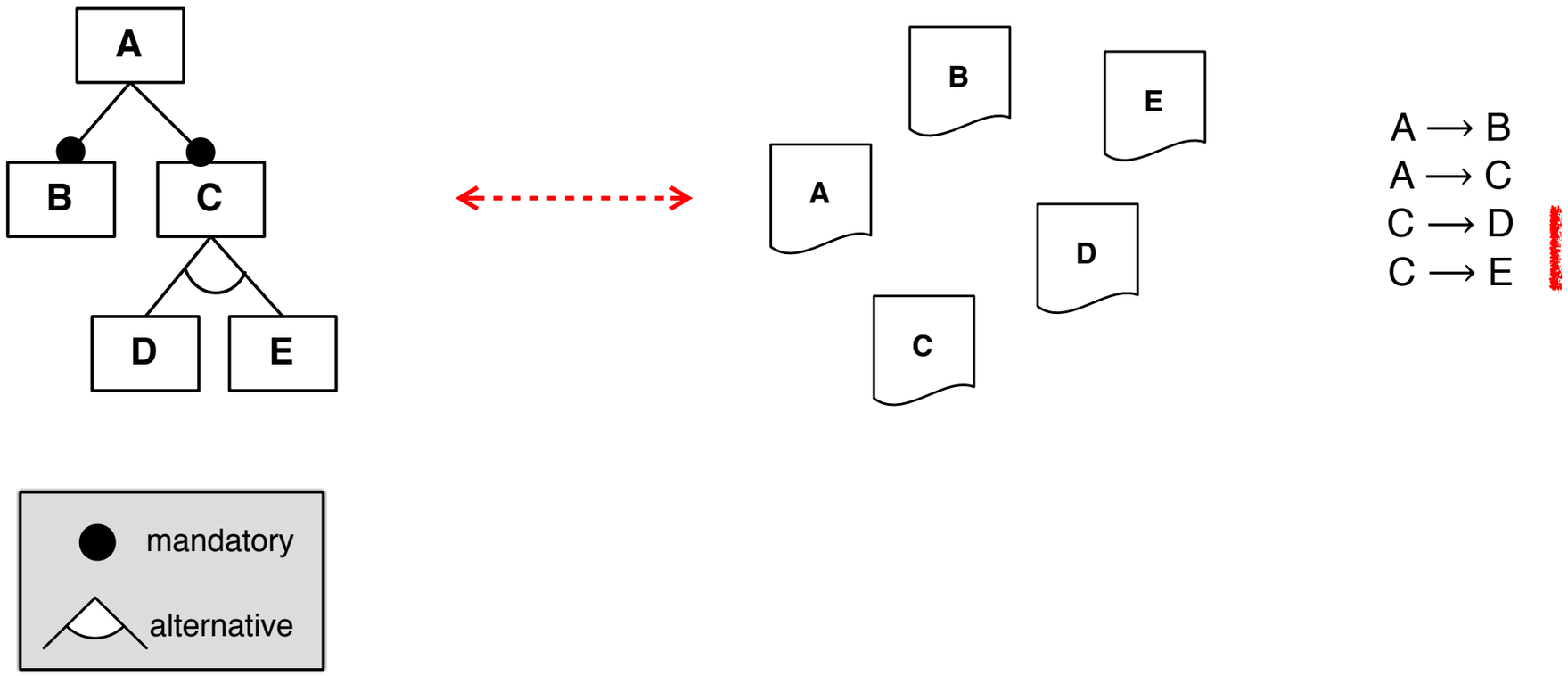


Space

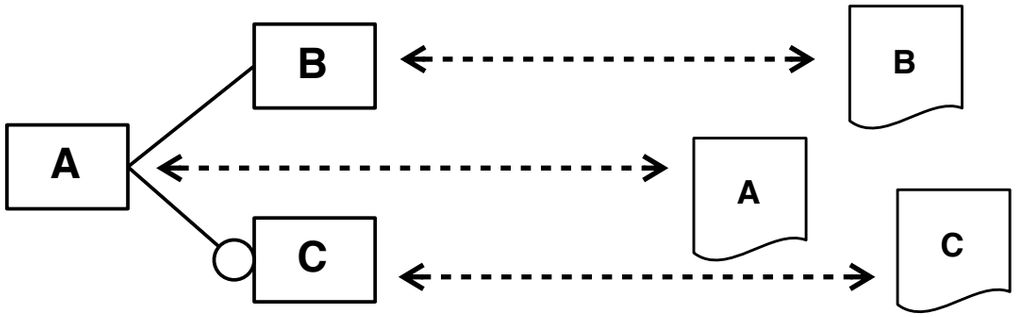
Problem Space



Solution Space



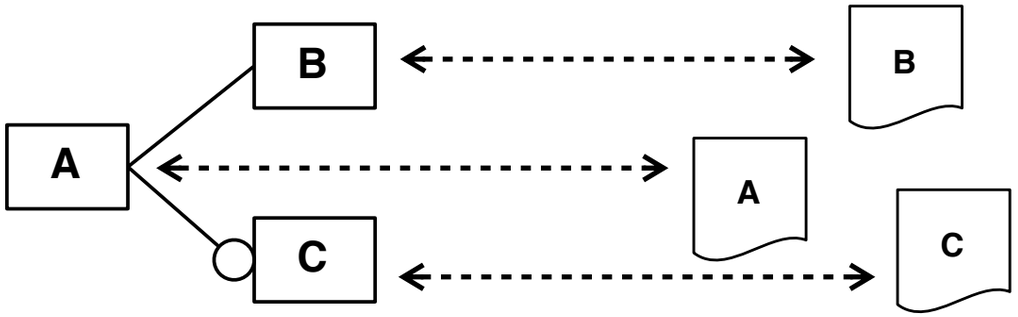
Time



○ optional

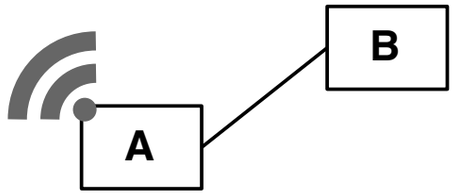
Design Time | **Runtime**

Time



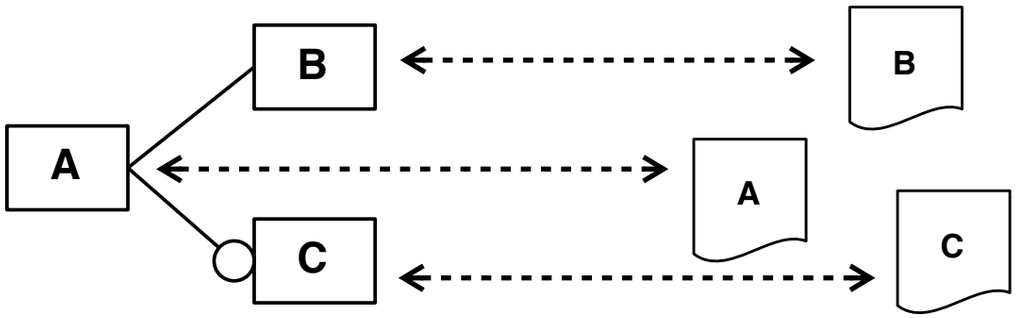
optional

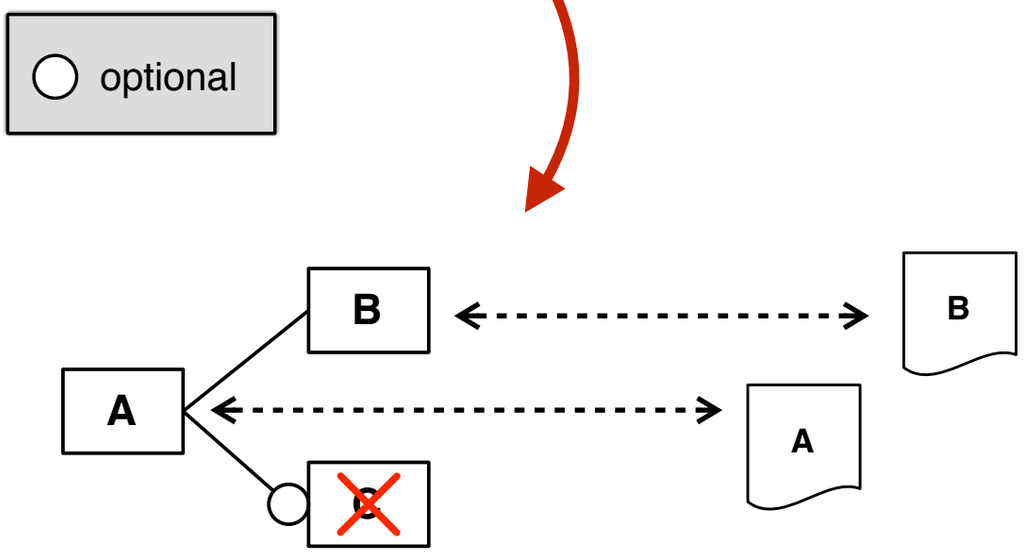
Adaptation rule
if *condition* then C



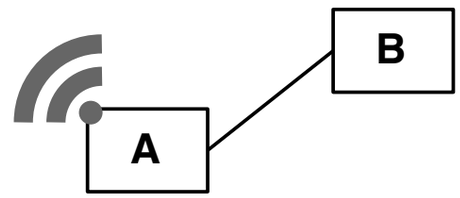
Design Time | **Runtime**

Time



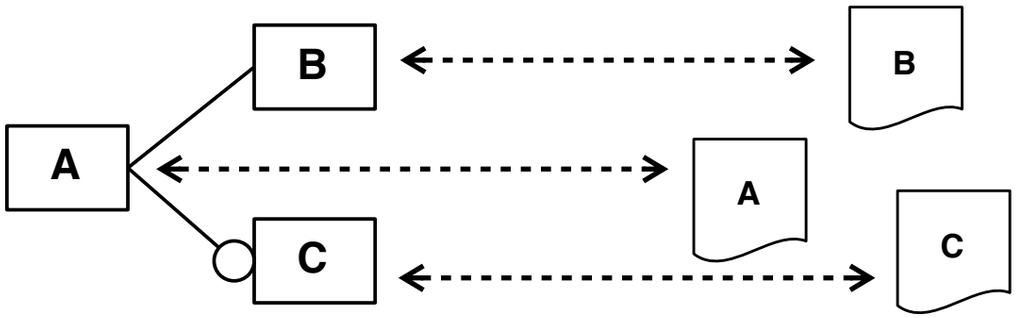


Adaptation rule
if *condition* then C

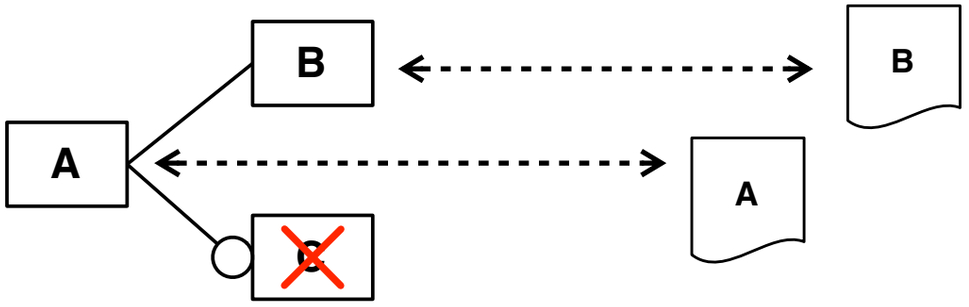


Design Time | **Runtime**

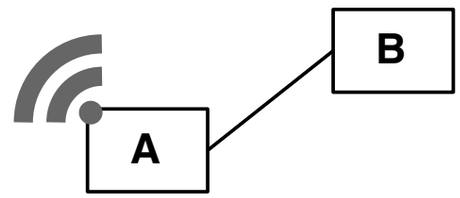
Time



optional



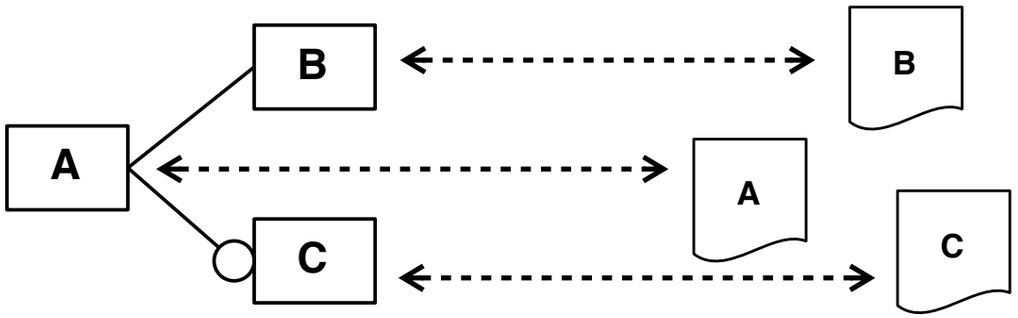
Adaptation rule
if *condition* then C

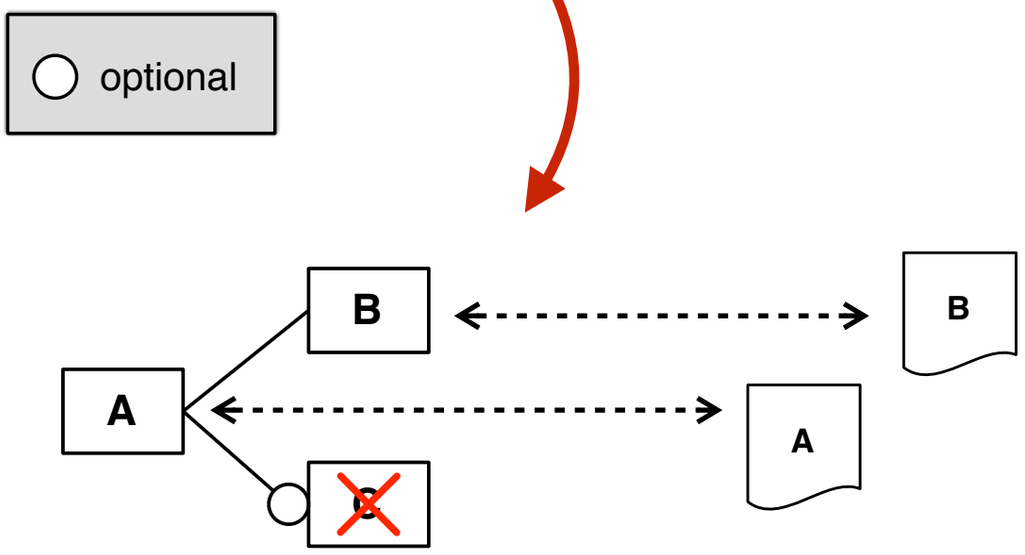


condition is met

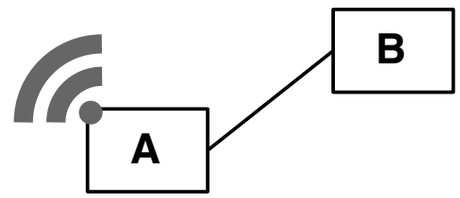
Design Time **Runtime**

Time





Adaptation rule
if *condition* then C

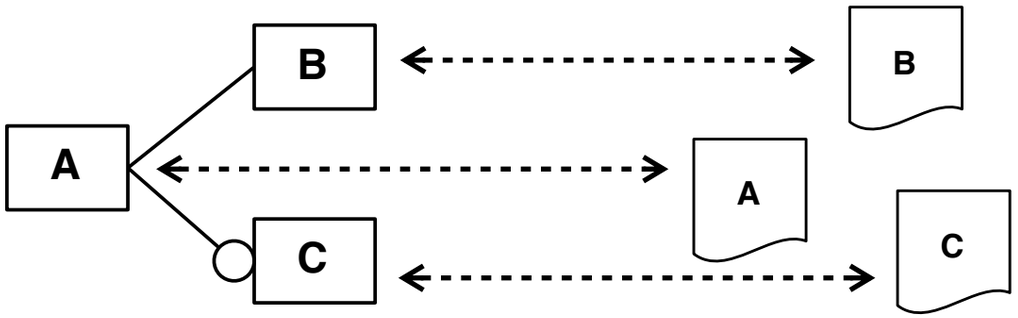


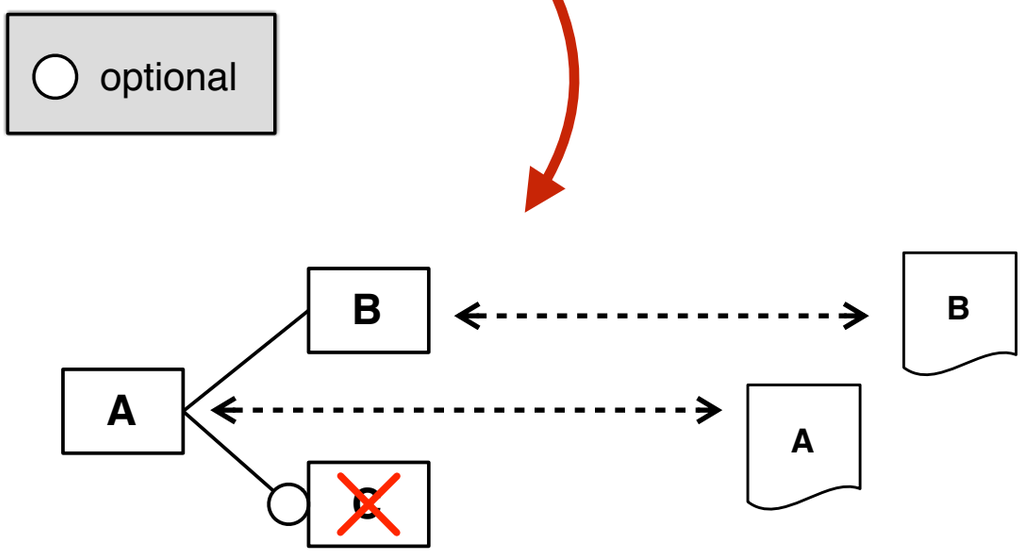
condition is met
then

?

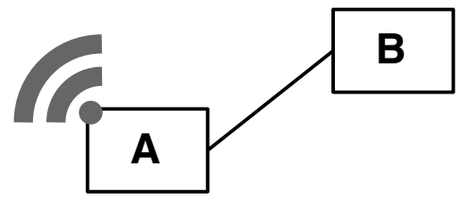
Design Time **Runtime**

Time





Adaptation rule
if *condition* then C



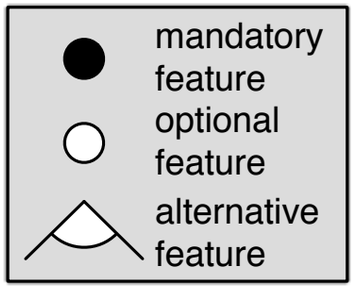
condition is met
then
- nothing
- something else

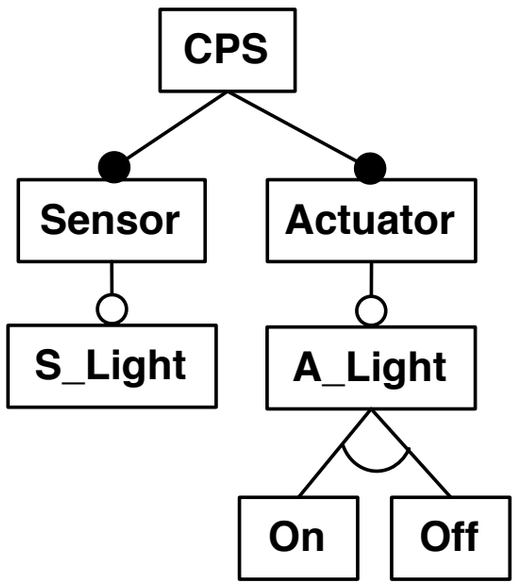
?

Design Time **Runtime**

It depends

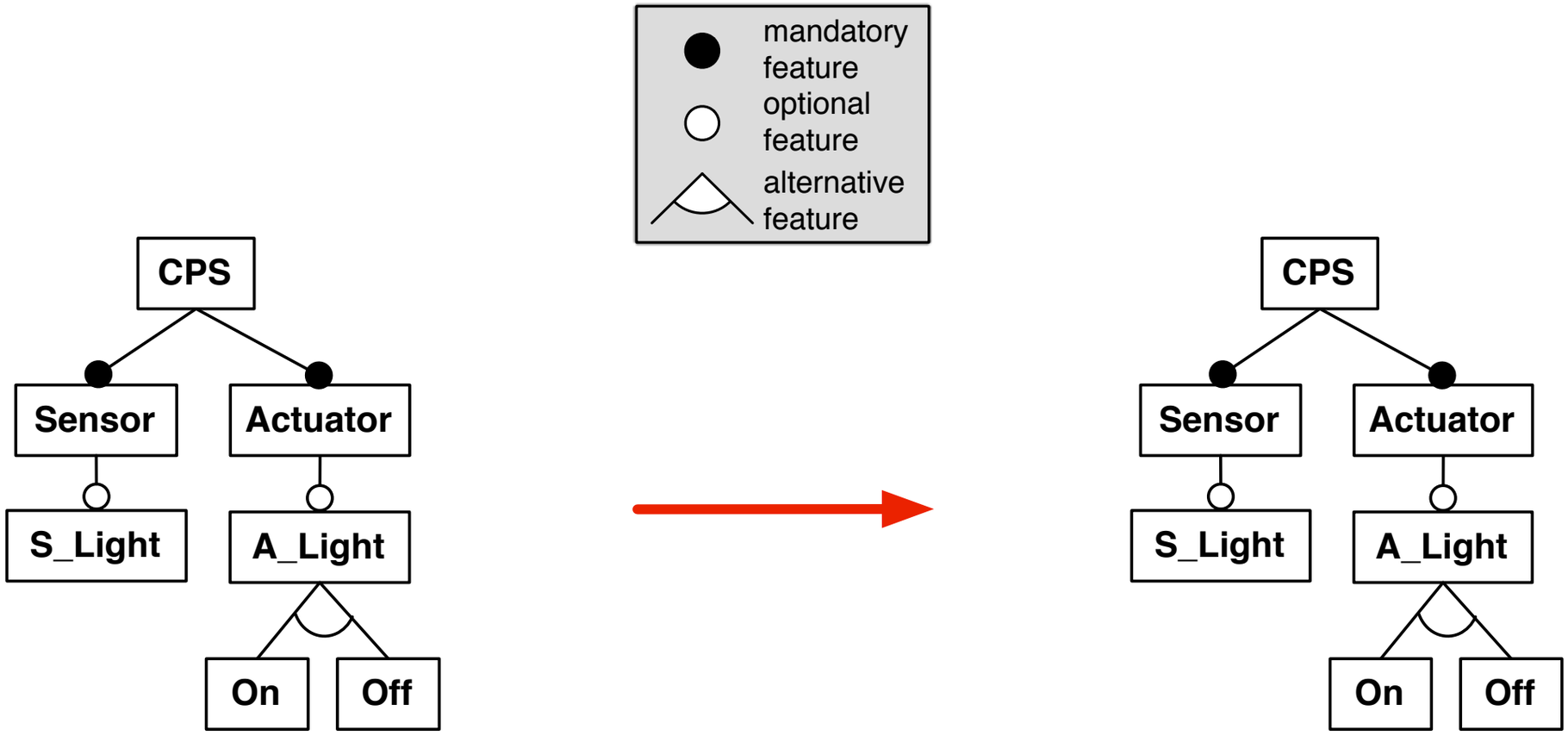
It depends





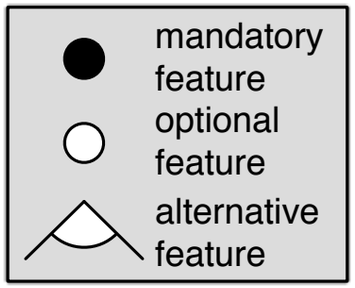
luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

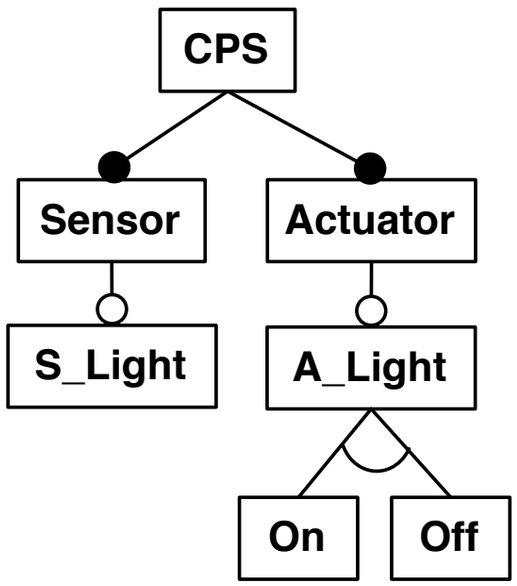
It depends

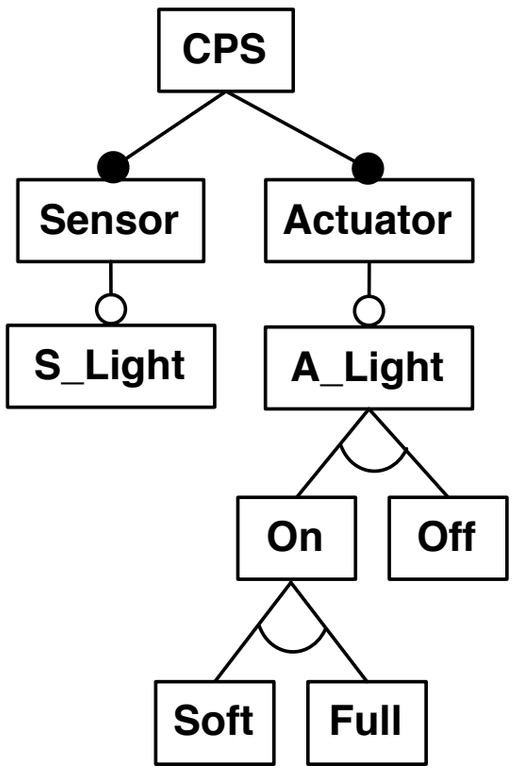


luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

It depends

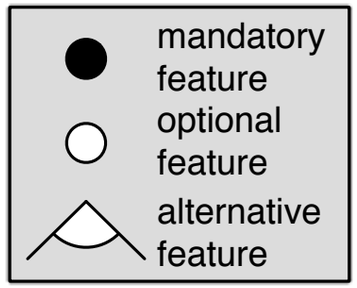


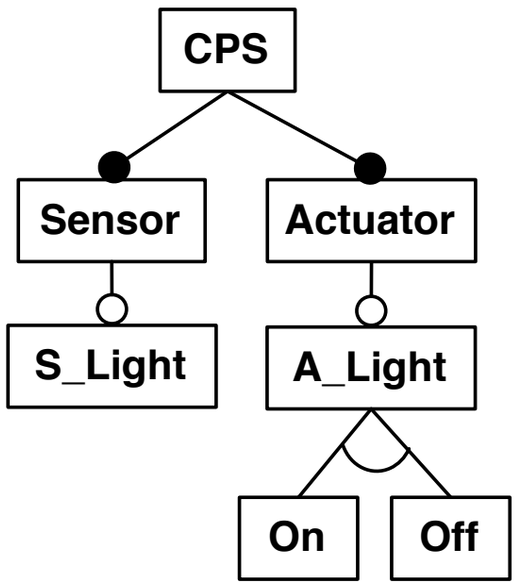


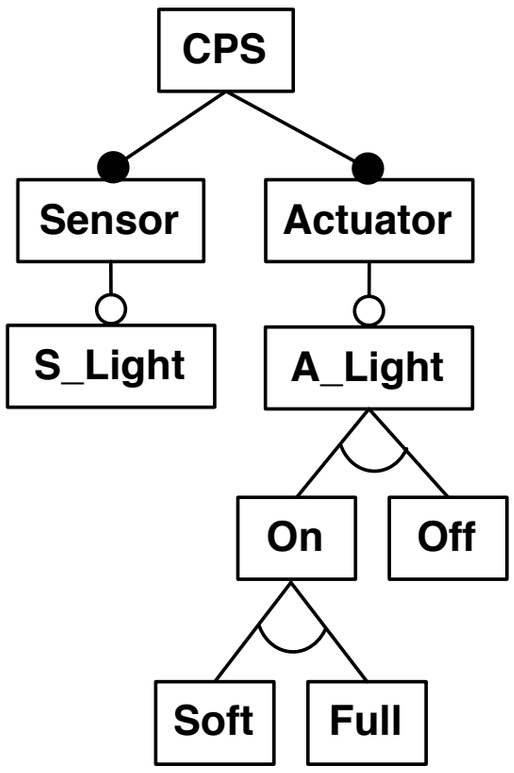


luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

It depends



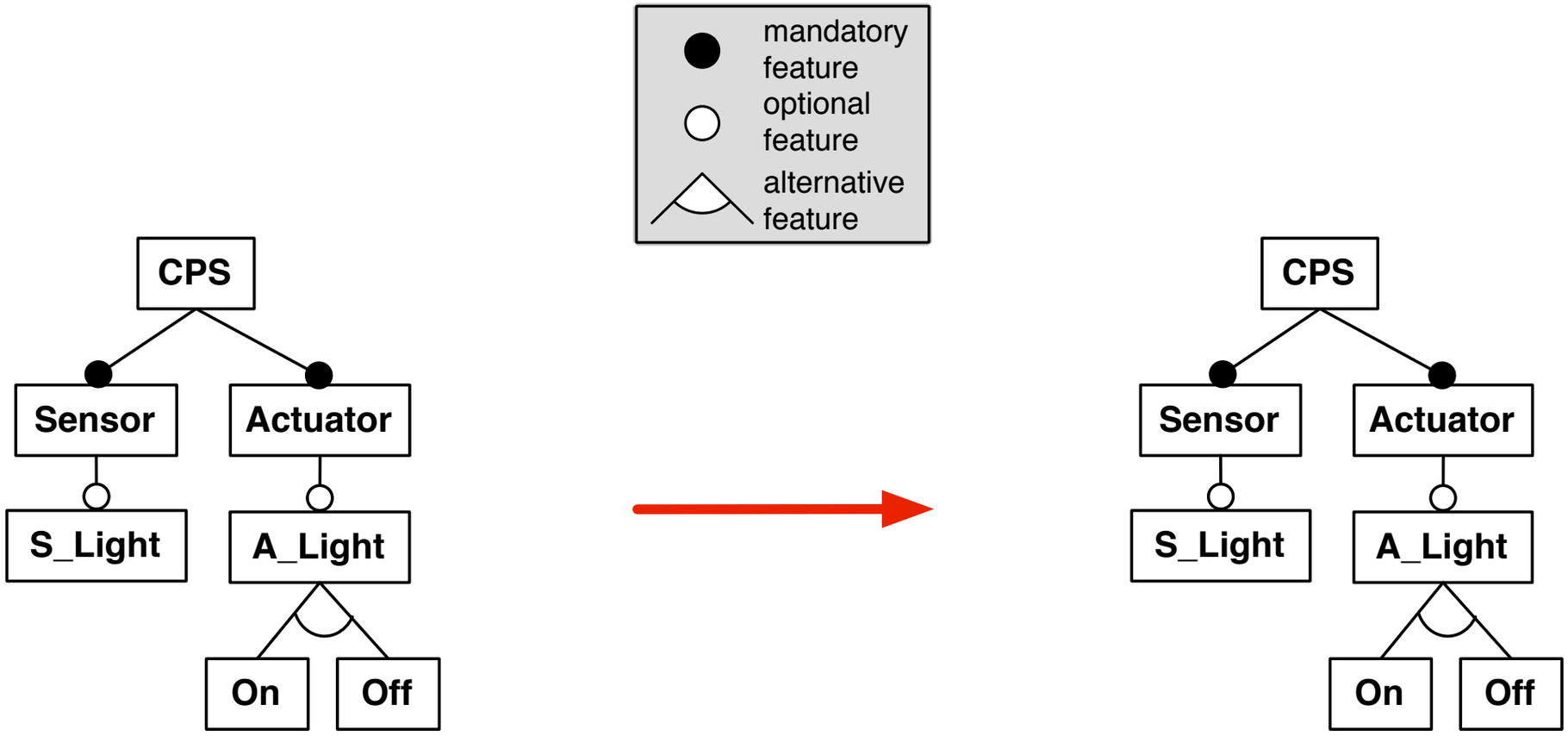




luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

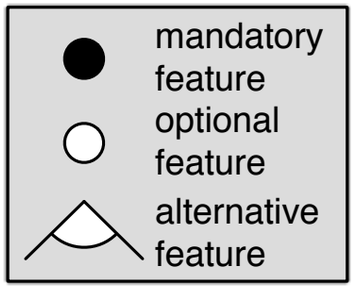
Automated evolution (based on rules, default solver choice)
Manual evolution (user choice)

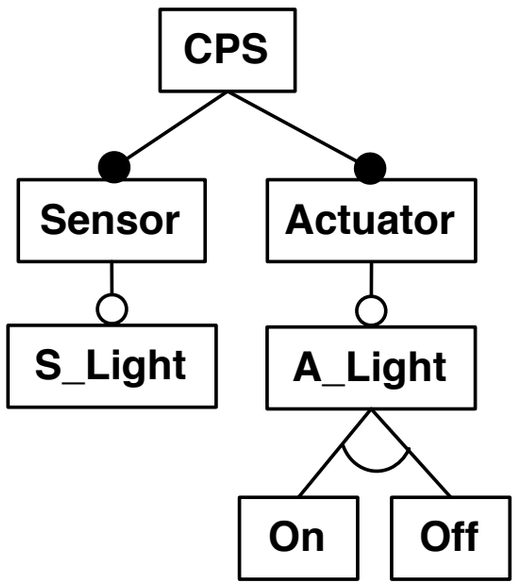
It depends

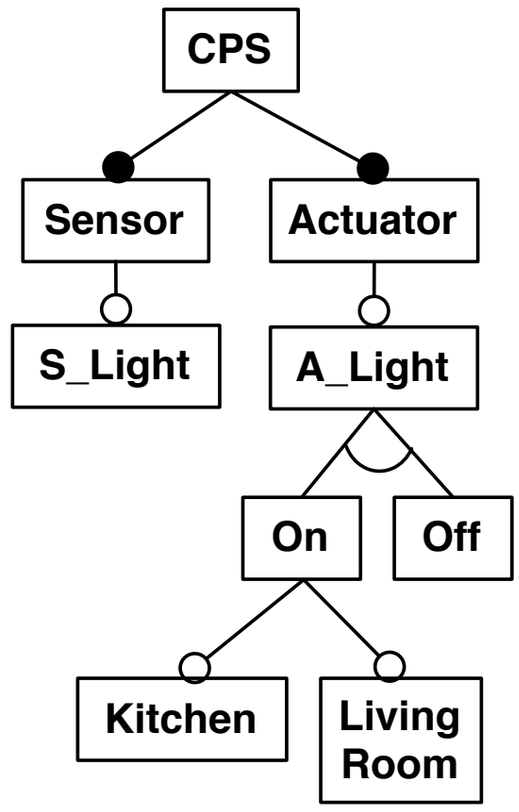


luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

It depends

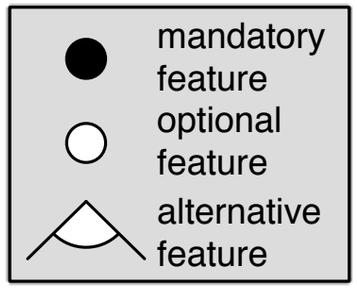


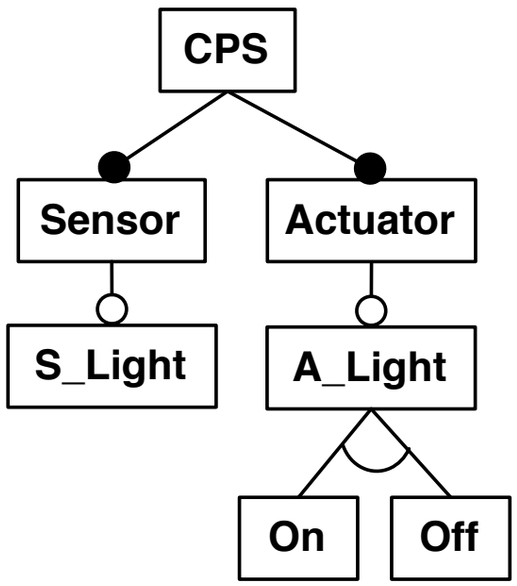




luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

It depends





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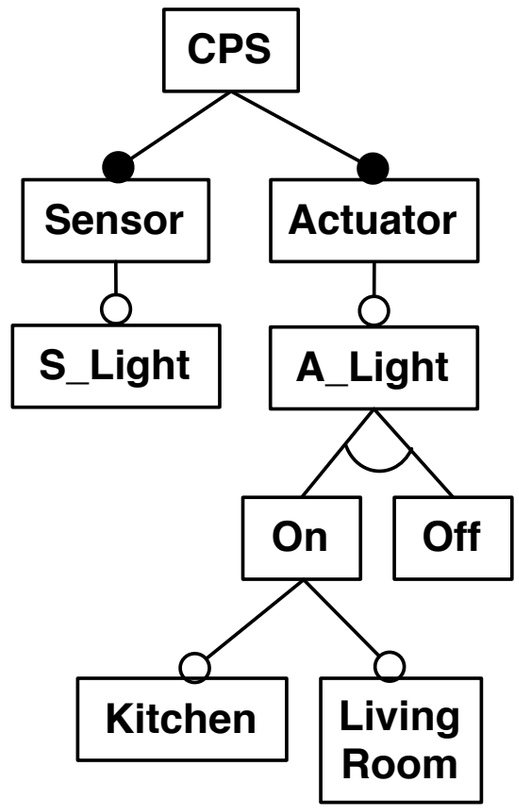
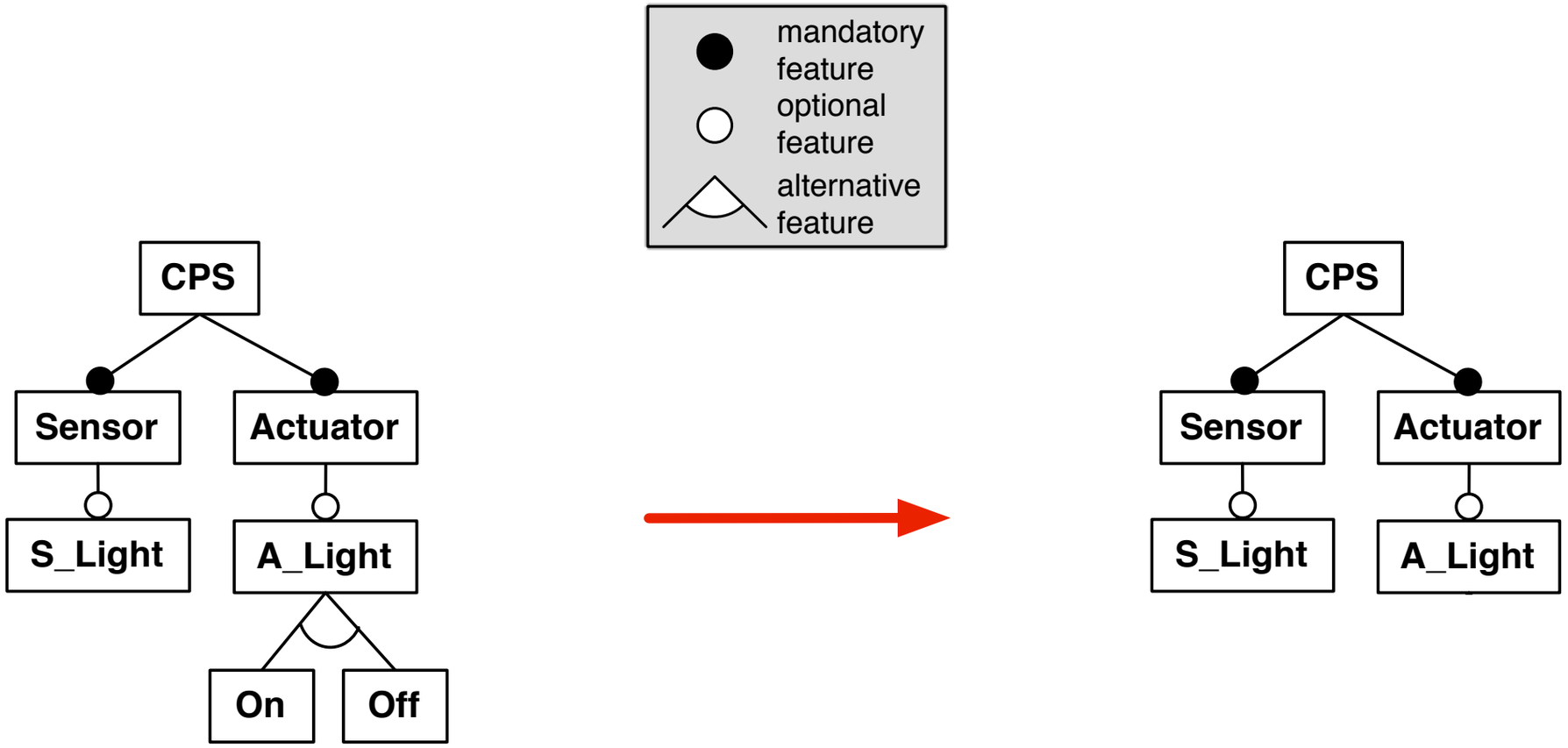


Automated evolution (based on rules, default solver choice)
Manual evolution (user choice)

It depends



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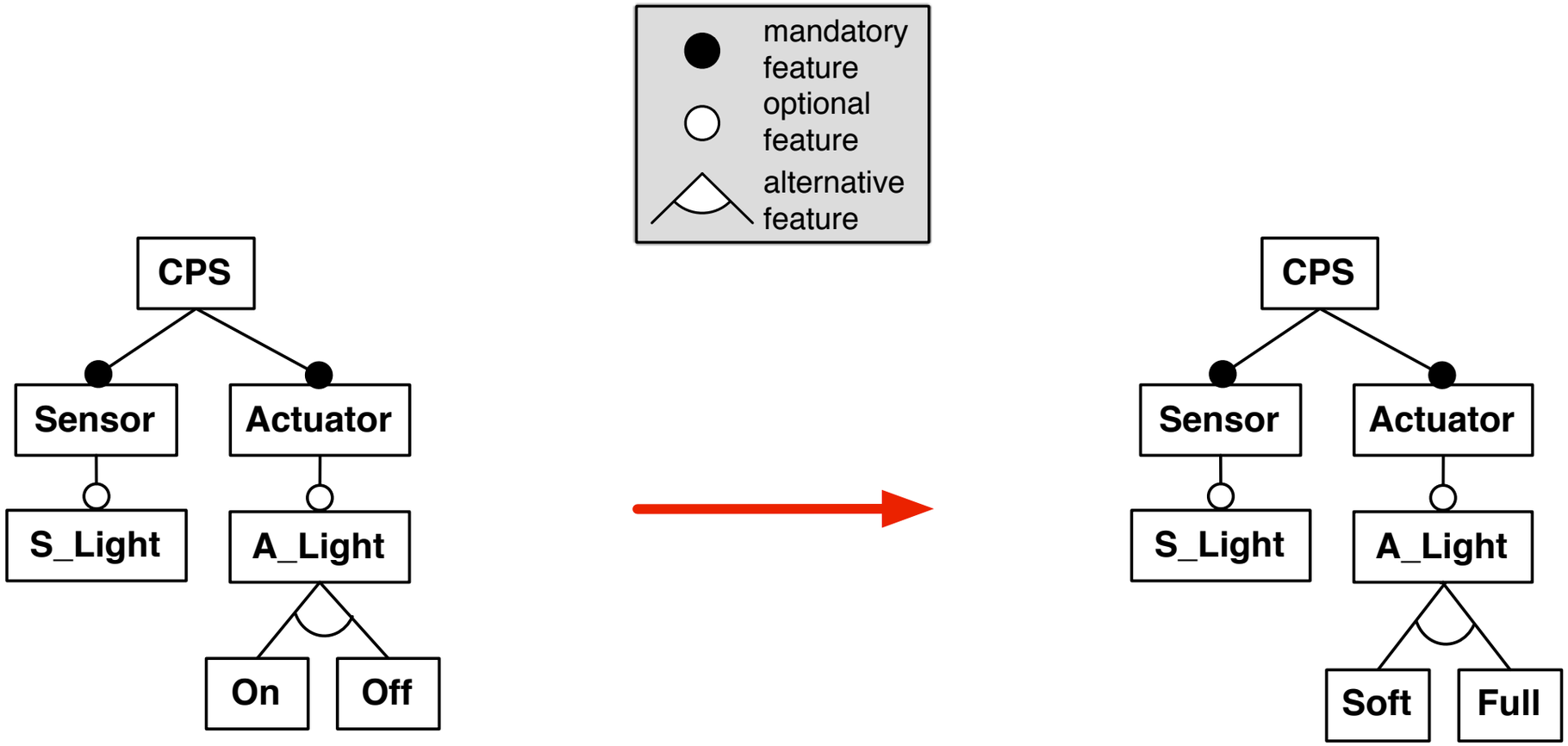
It depends



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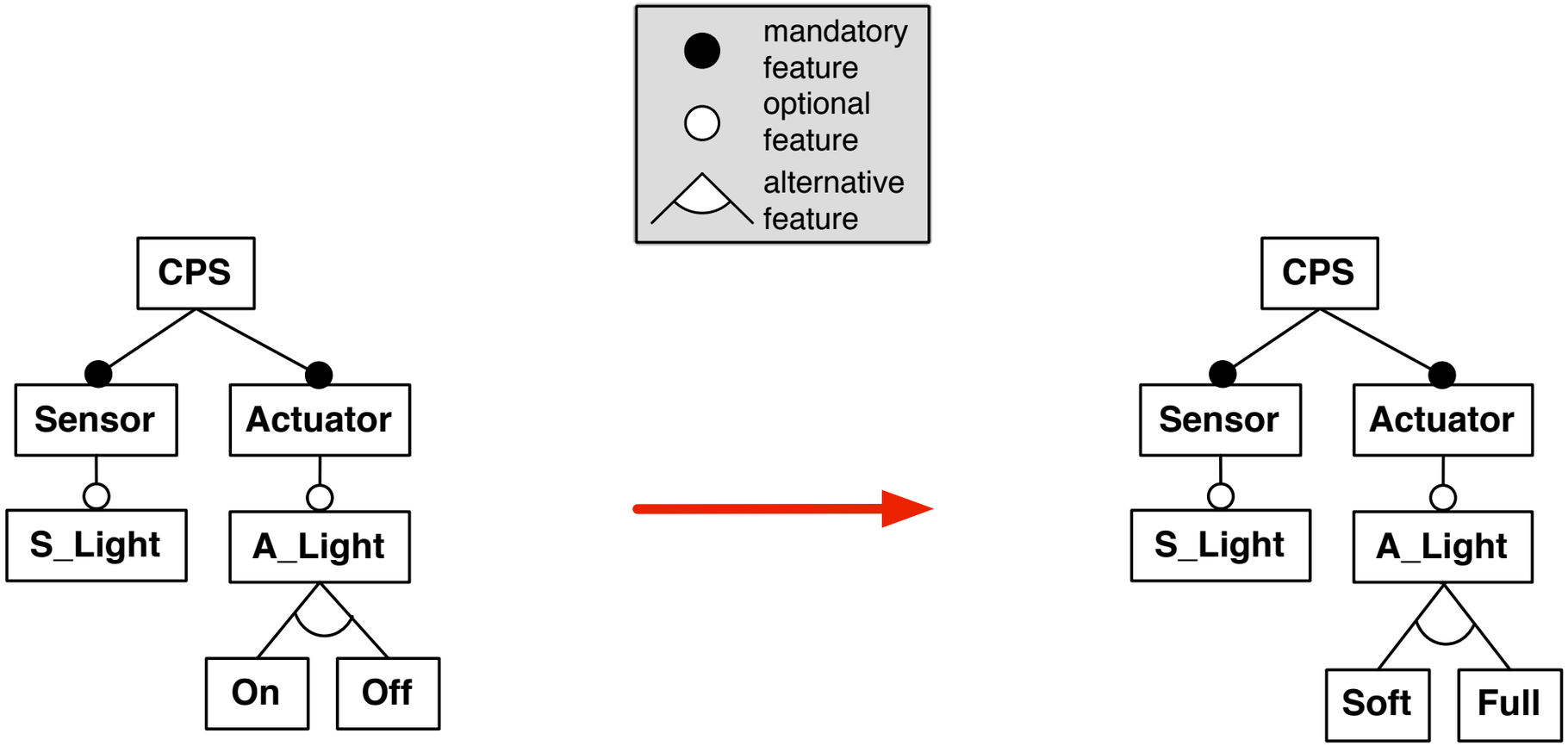

luminosity < 40 lumens —> turnLightOn()
(activates the *On* feature)

Manual evolution only

To sum up

The adaptation rules must evolve to maintain the DSPL consistency

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But it’s not an easy task!

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```
/* Adaptation rules for functionalities */

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

rule StopDA : // Stop being a DA
  condition (LowBatt or not ElectedDA) and DA
  effect not DA

rule BecomeUA : // Become a User Agent
  condition  SrvReq=UA and not UA
  effect UA and not SA

rule BecomeSA : // Become a Service Agent
  condition SrvReq=SA and not SA
  effect not UA and SA
```

Modeling and Validating Dynamic Adaptation, MODELS 2009

To sum up

The adaptation rules must evolve to maintain the DSPL consistency

But it's not an easy task!

```
/* Adaptation rules for functionalities */

rule BecomeDA : // Becomes a DA
  condition ElectedDA and not LowBatt and not DA
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rule BecomeUA : // Become a User Agent
  condition  SrvReq=UA and not UA
  effect UA and not SA

rule BecomeSA : // Become a Service Agent
  condition SrvReq=SA and not SA
  effect not UA and SA
```
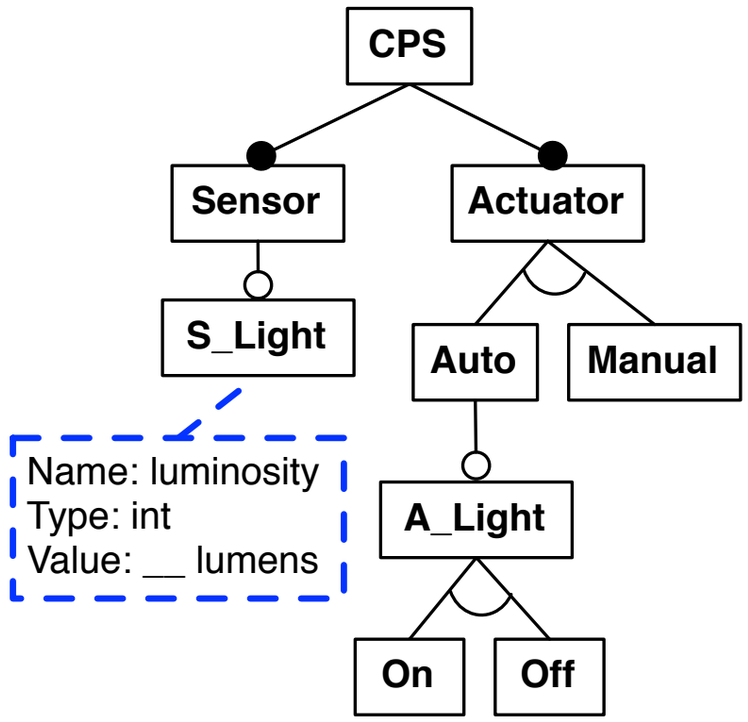

How to detect?

Modeling and Validating Dynamic Adaptation, MODELS 2009

Our idea



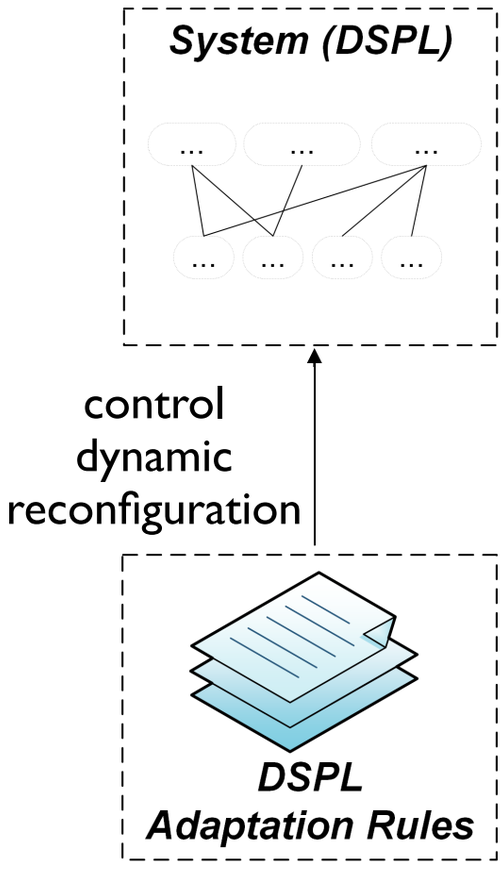
Configuration: A_Light ⟶ S_Light

Adaptation: S_Light.luminosity < 40 ⟶ On

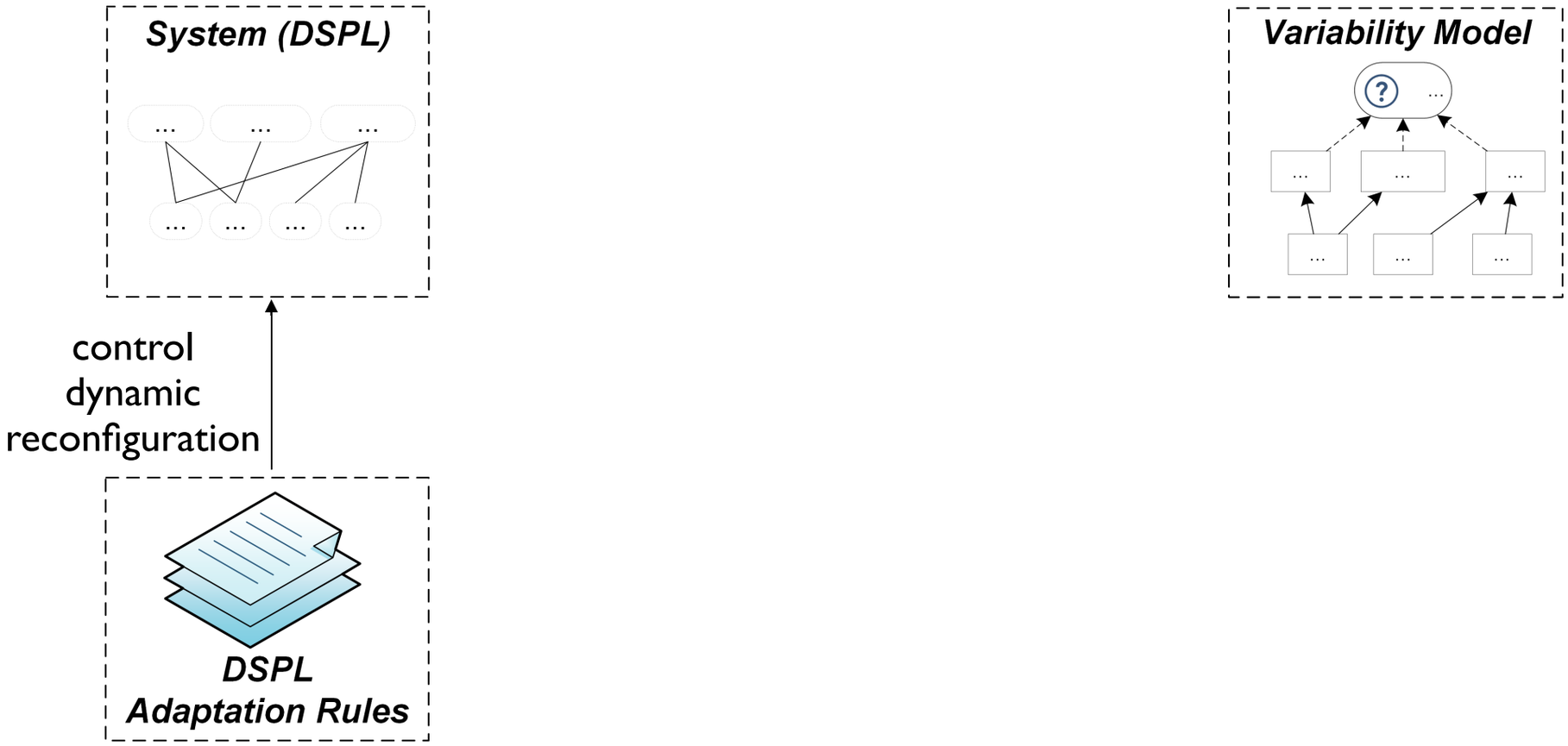
Runtime elements

Current and Future Work

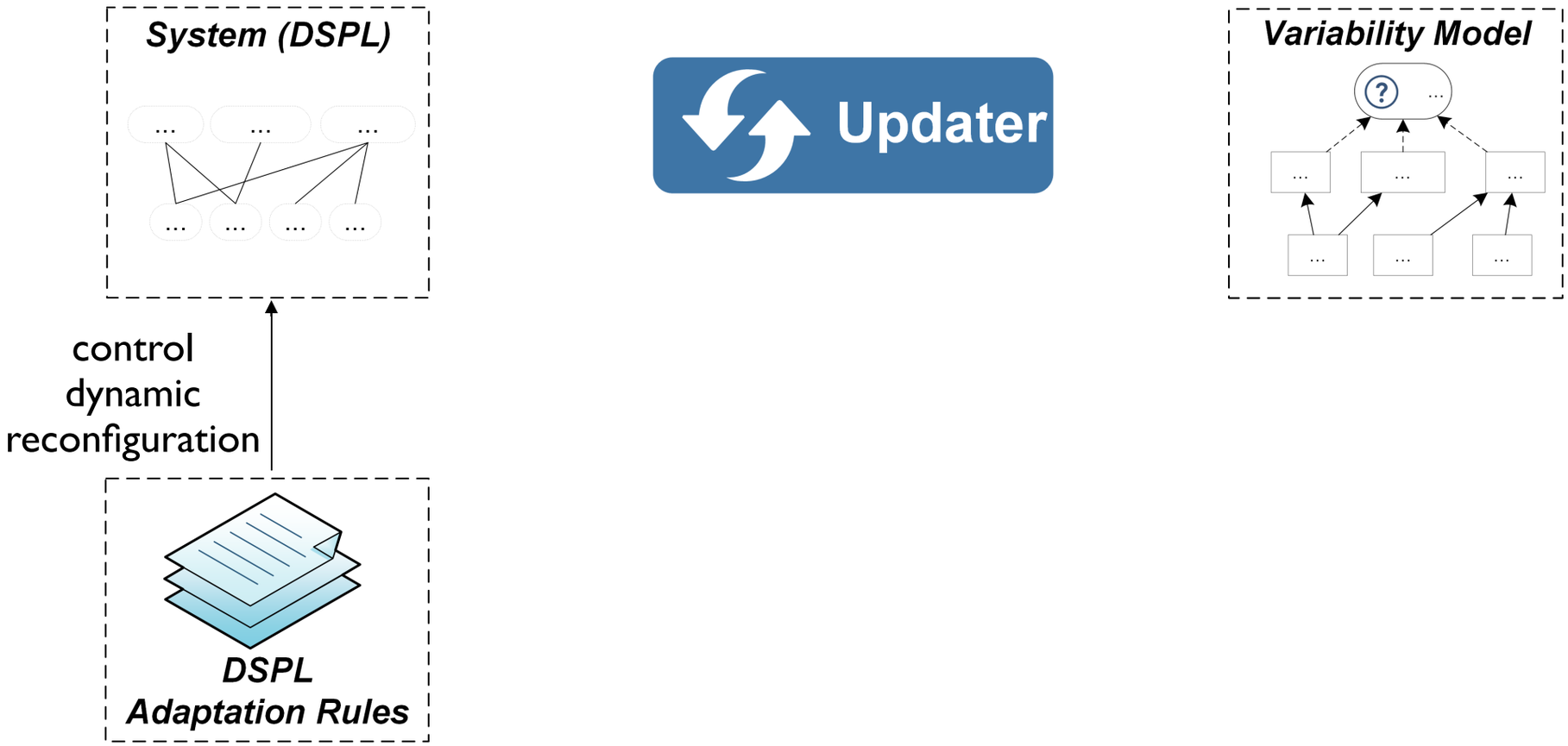
Current and Future Work



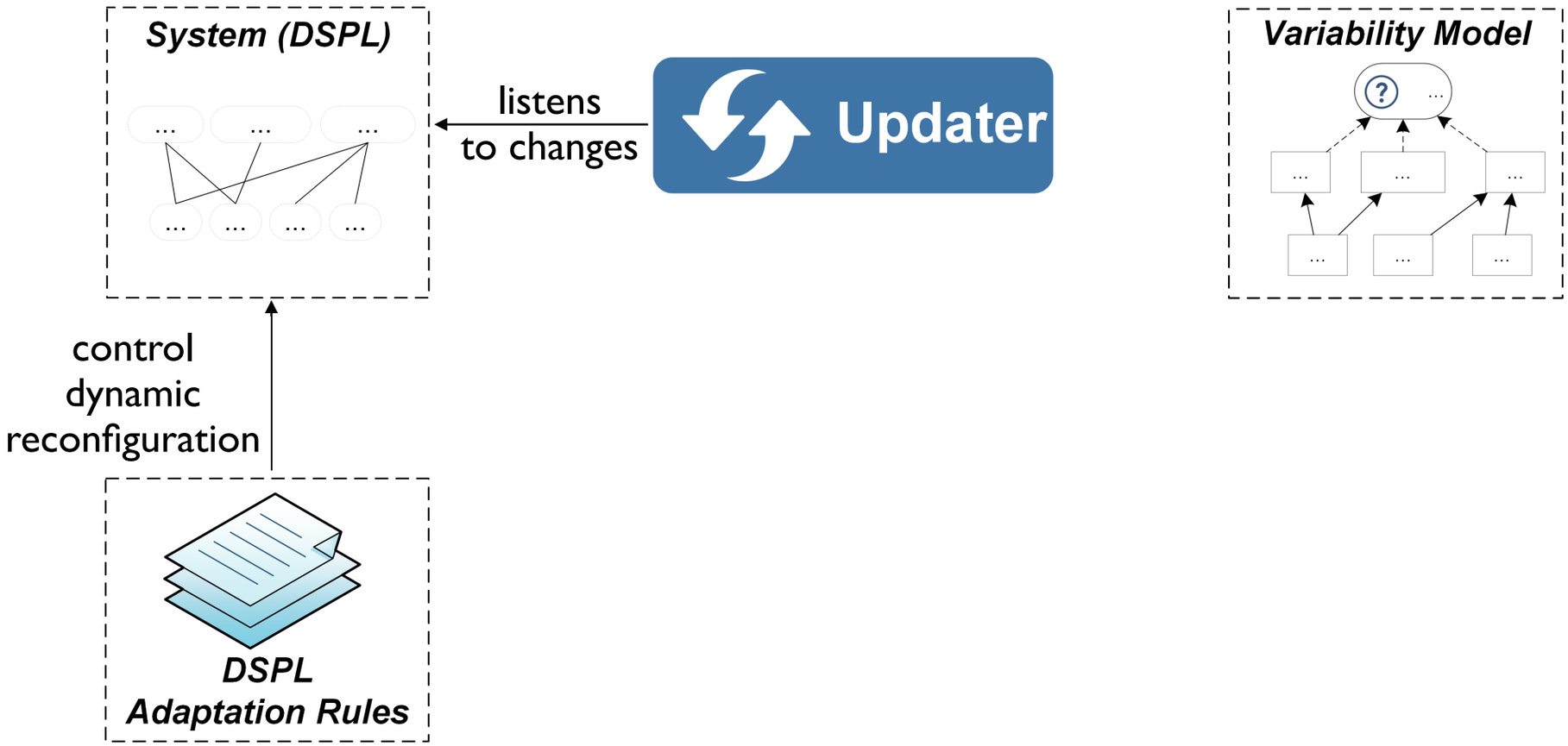
Current and Future Work



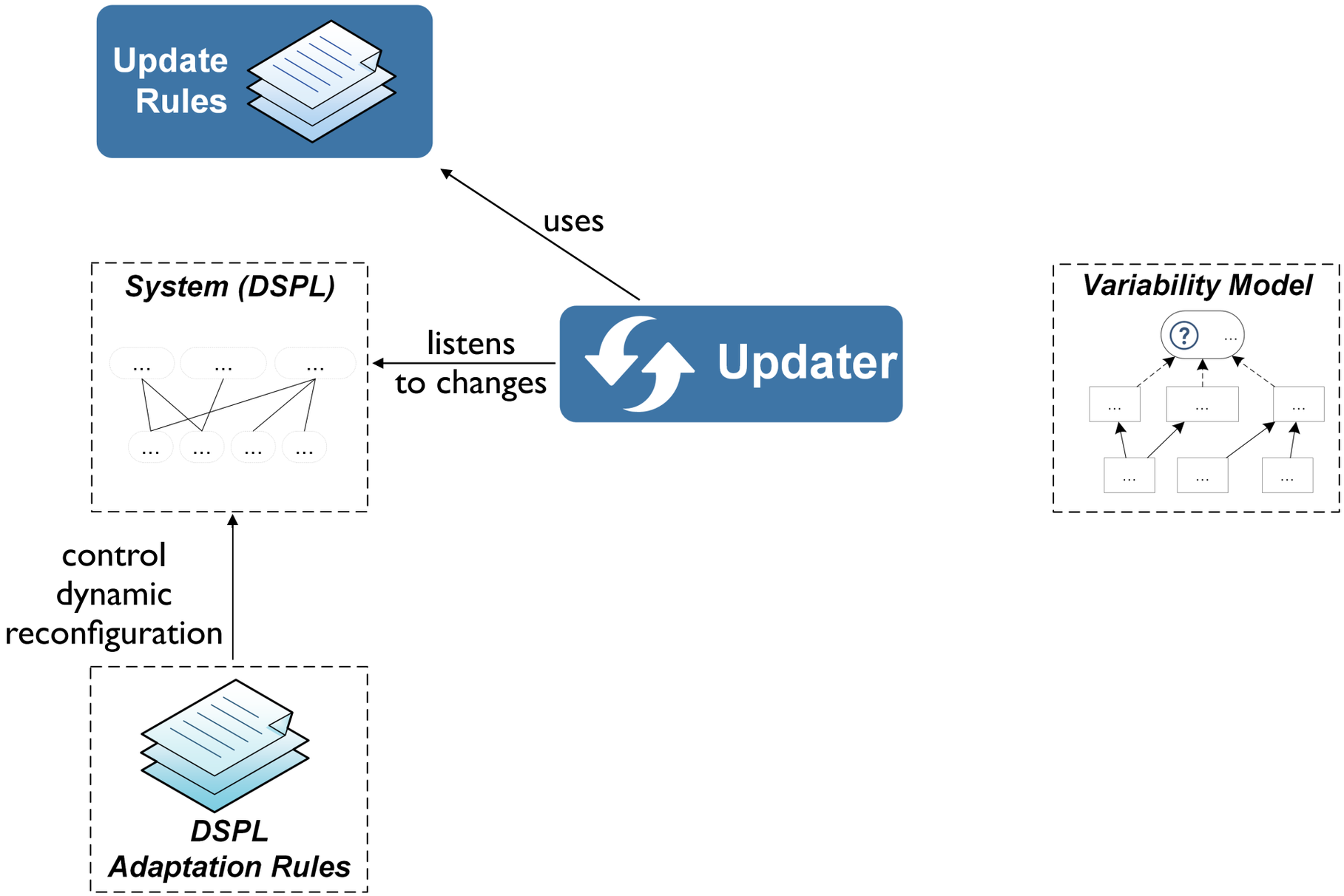
Current and Future Work



Current and Future Work



Current and Future Work



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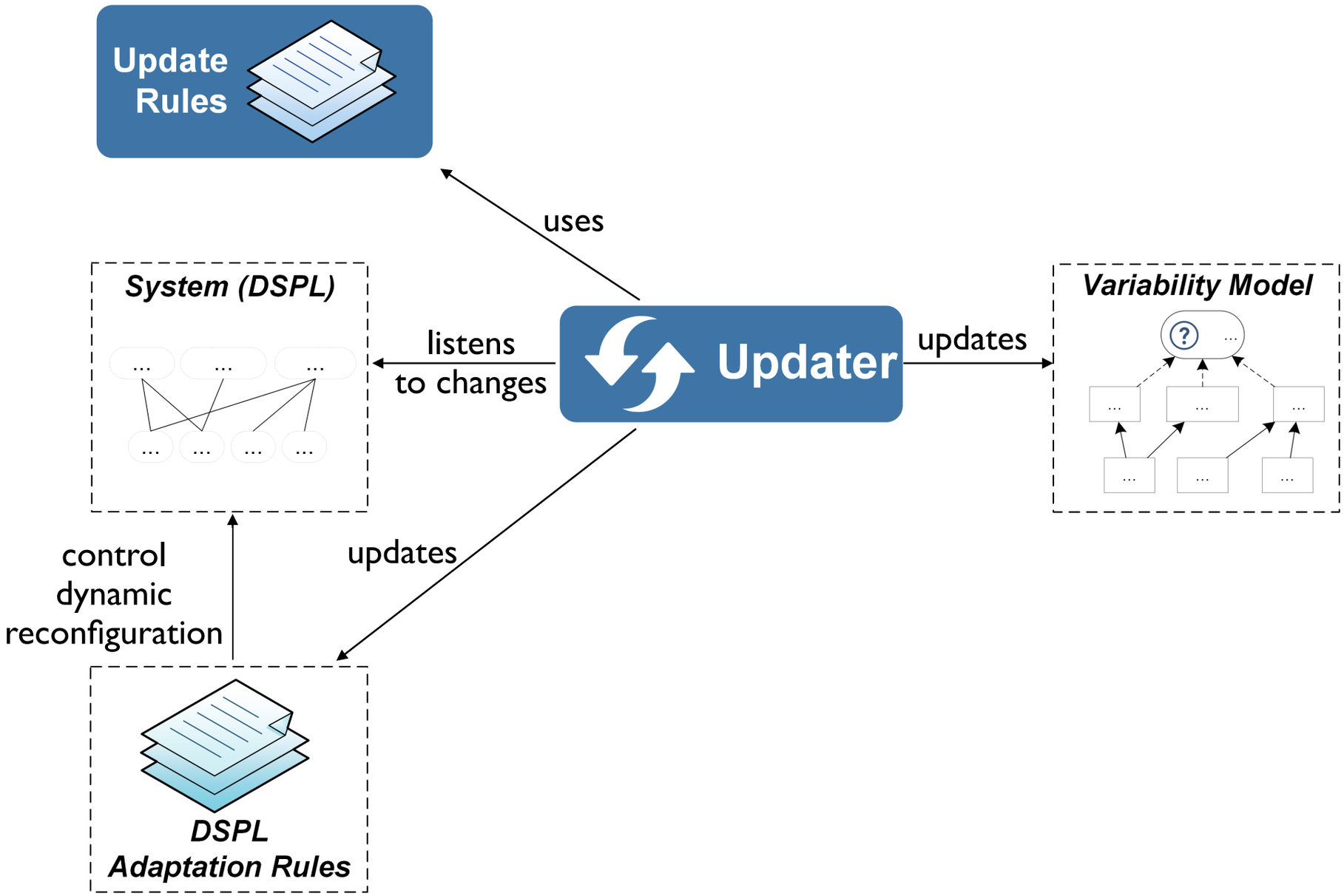
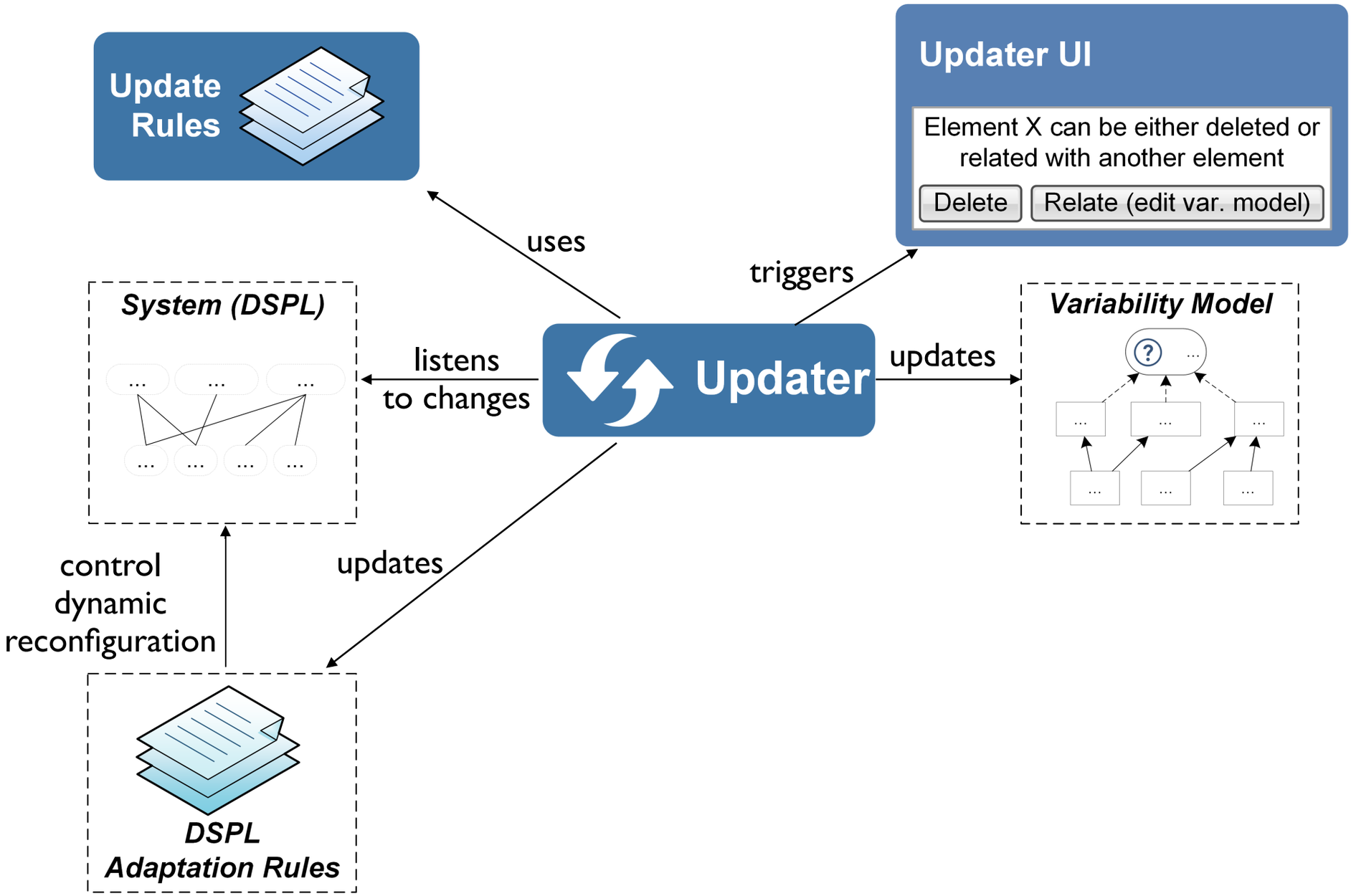


Current and Future Work



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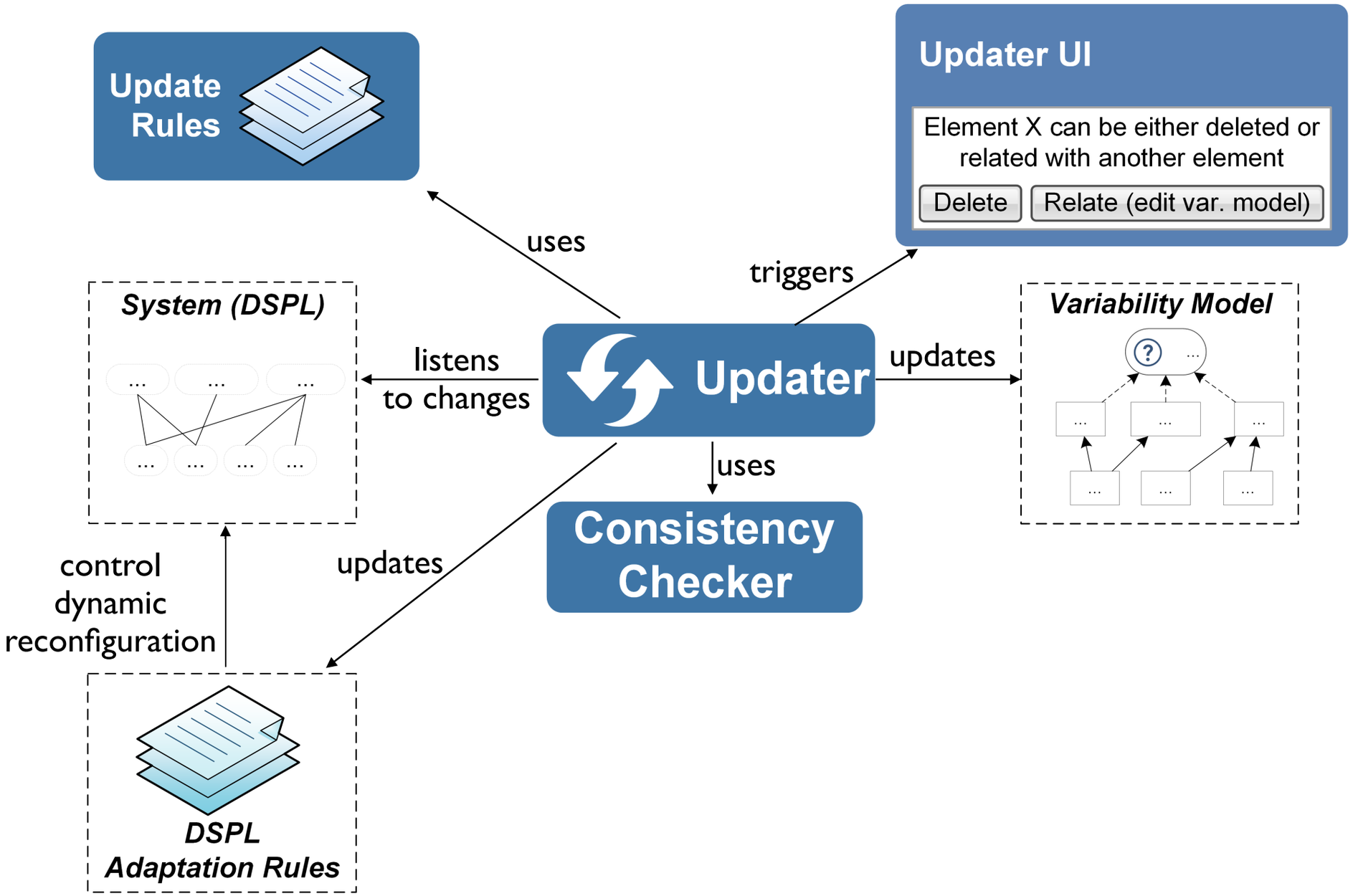
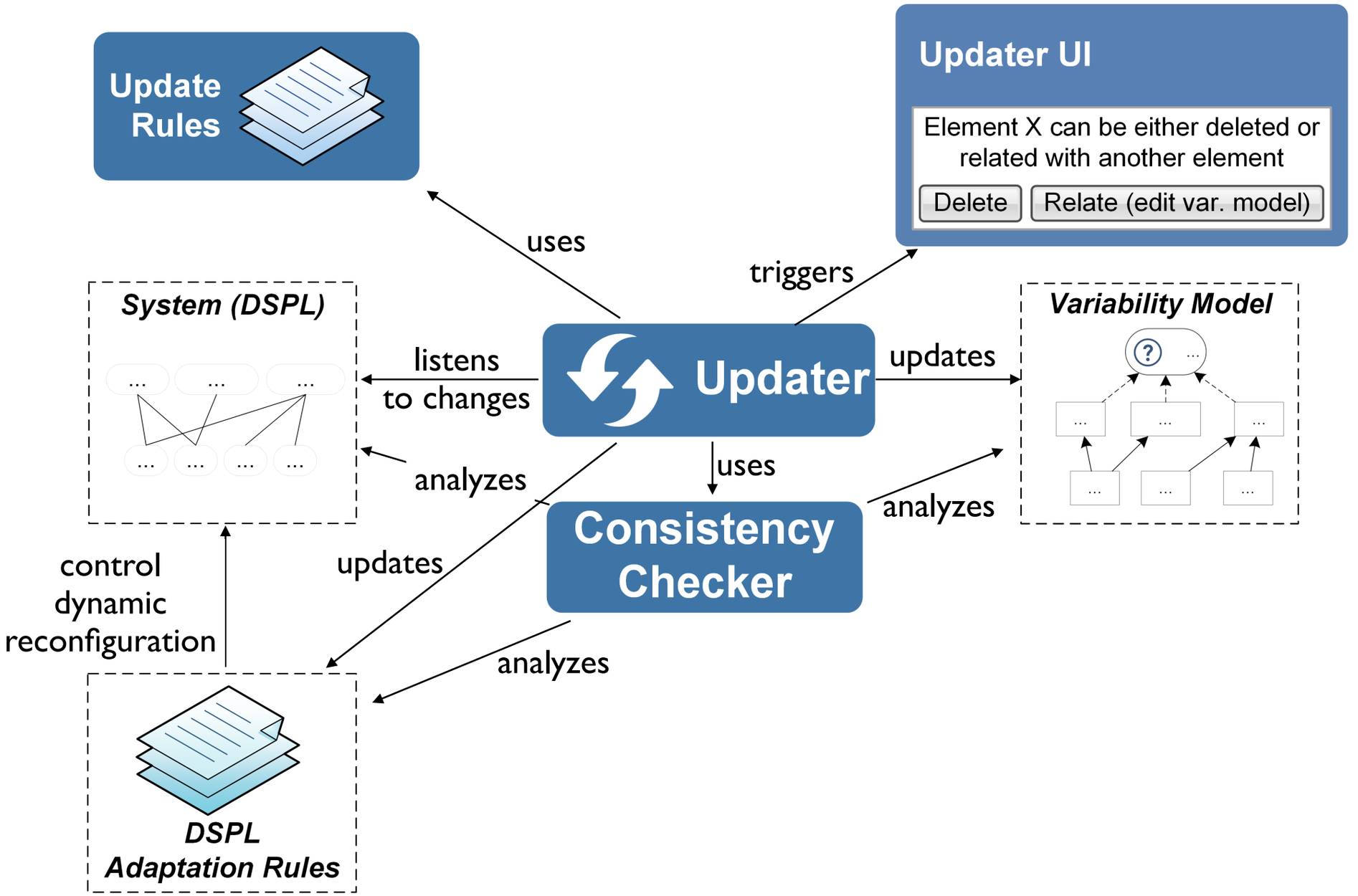
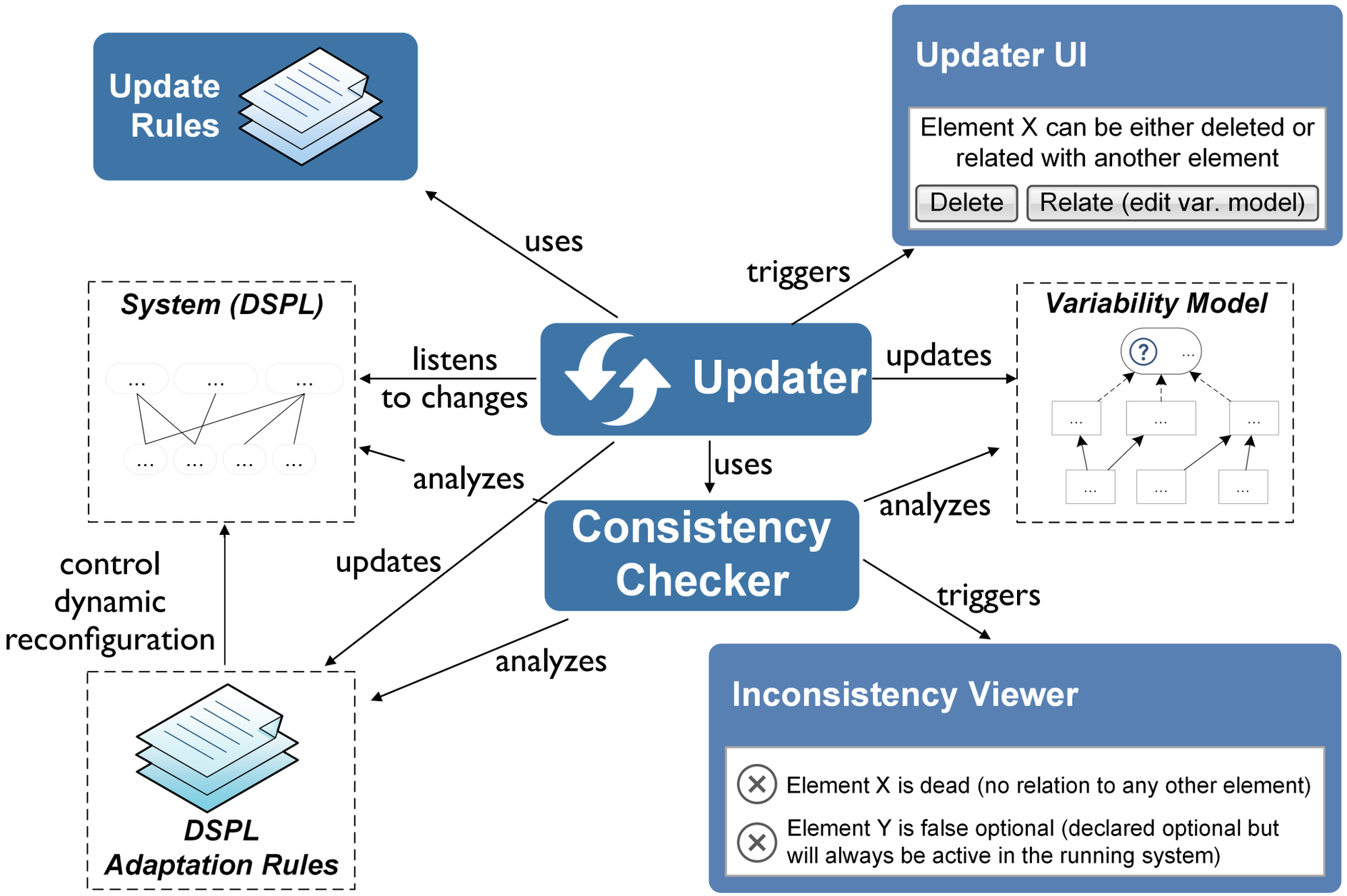


Current and Future Work



Current and Future Work



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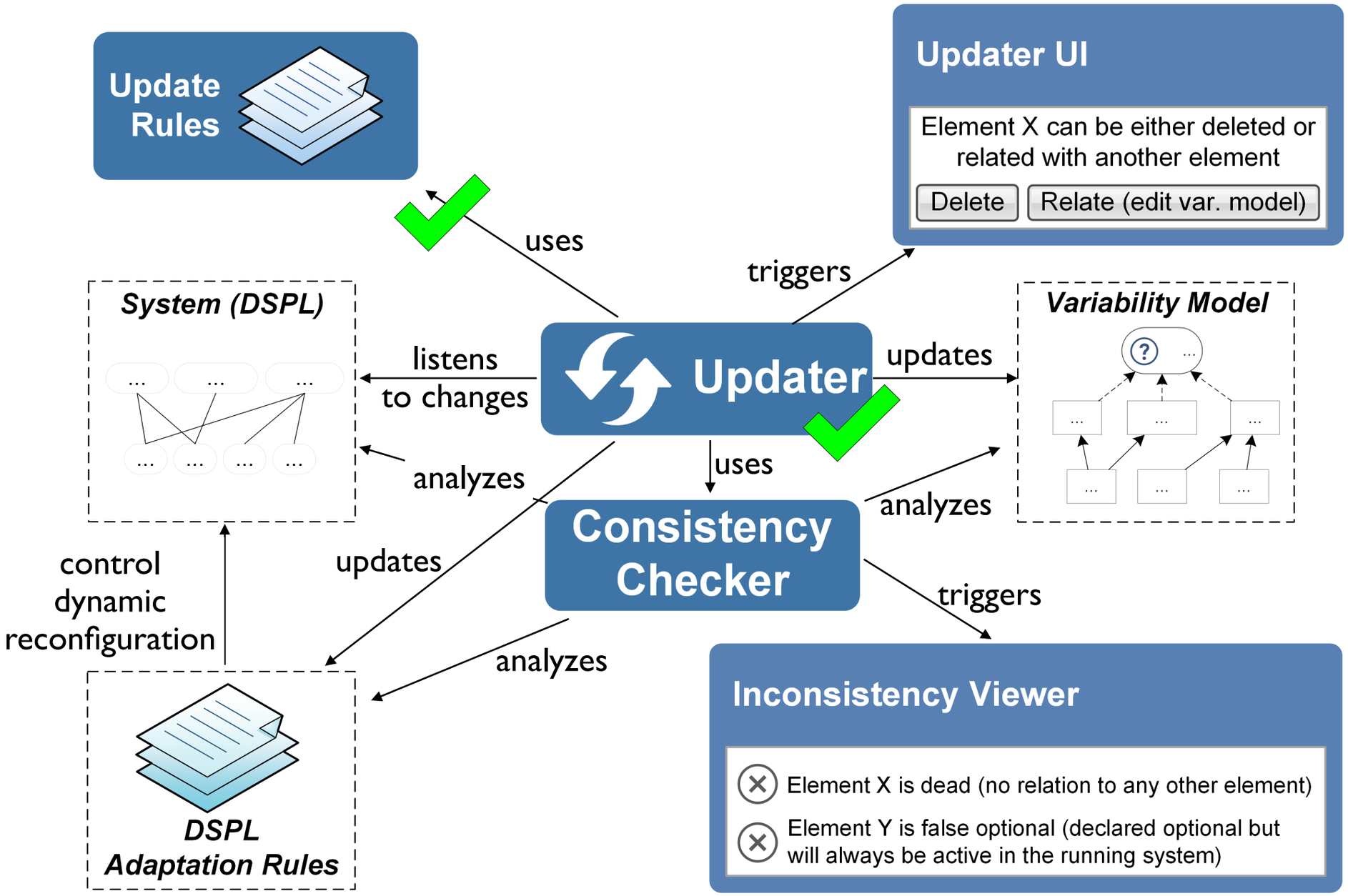
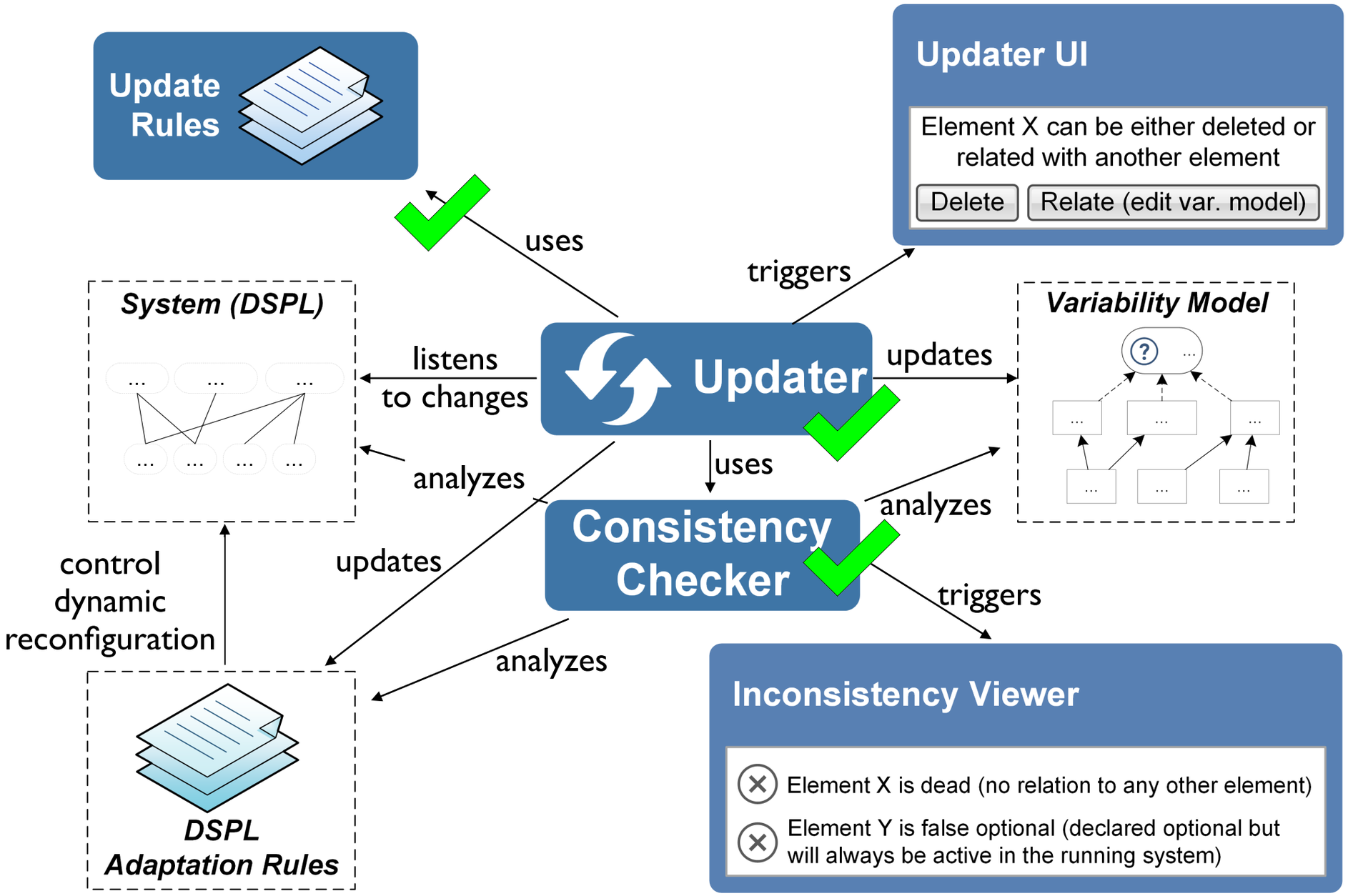


Current and Future Work



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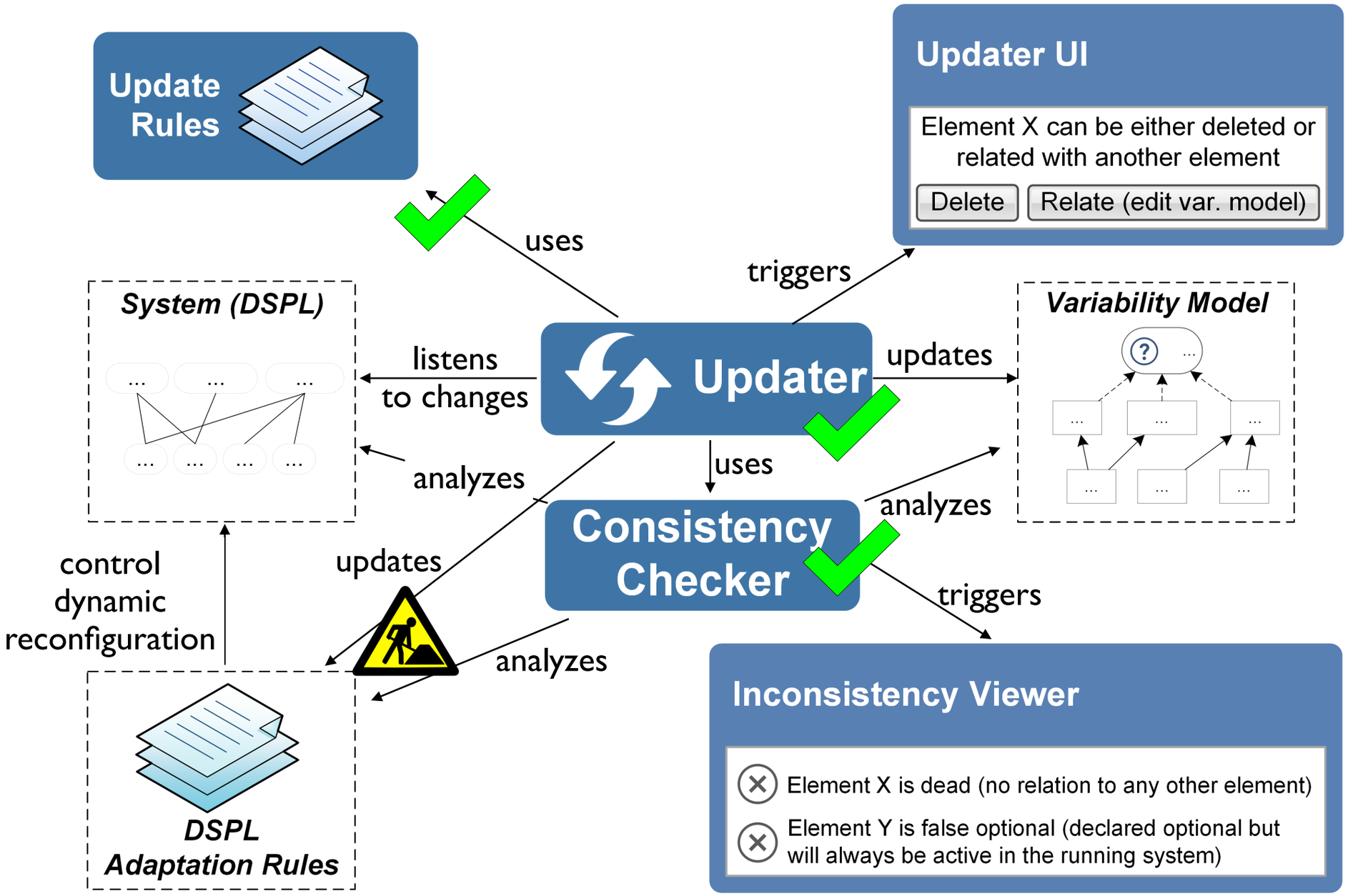

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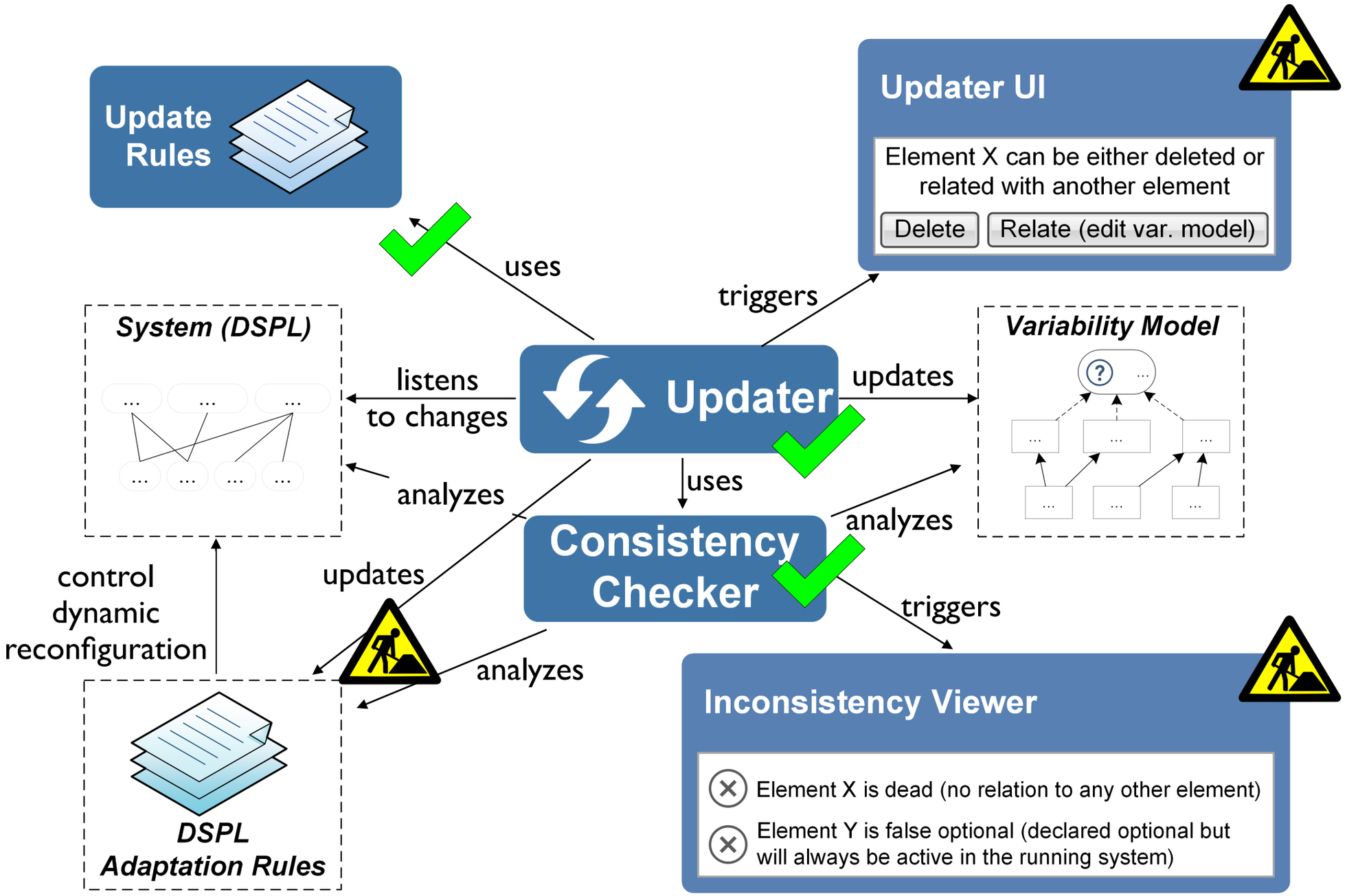
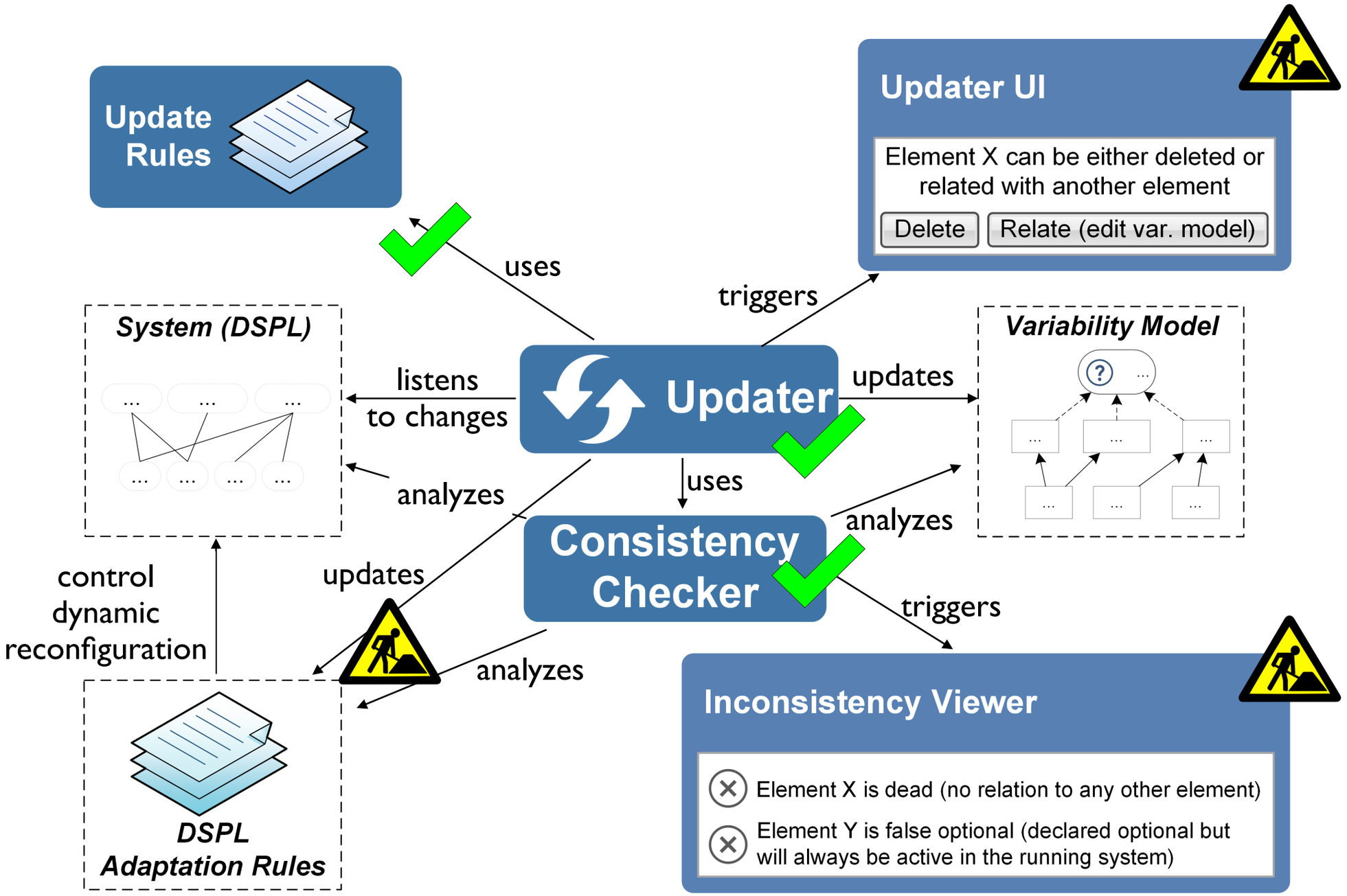


Current and Future Work



Human in the loop!

Conclusion

- DSPL must evolve while systems are running
  - Systems cannot be stopped
- Need for tools/approaches dealing with
  - Consistency maintenance
  - Uncertainty
  - History
  - Proactive adaptations

Questions / Comments ?

Thank you!