Autonomic Management of Component-based Services

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SCADA Workshop

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PLAN

MOTIVATION

CONTEXT

FRAMEWORK

- Problem
- Design of the solution
- Implementation
- Use Cases

PERSPECTIVES

1
MOTIVATION

Motivation

Evolution in software construction

- Monolithic, centralized, stable applications
- Close world assumption
- Software changes slowly

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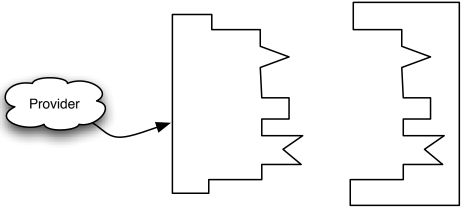

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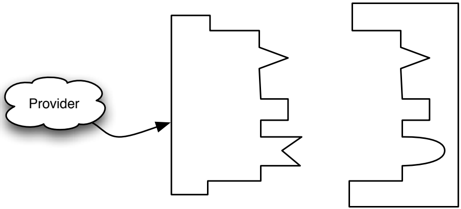

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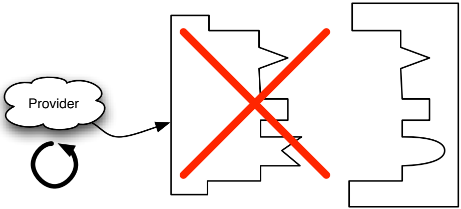

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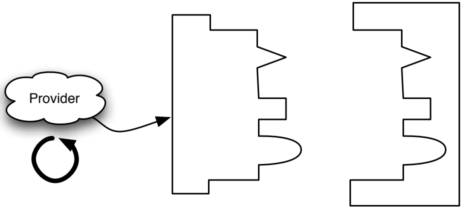

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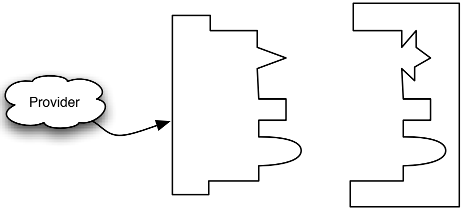

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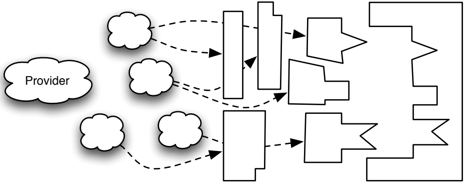

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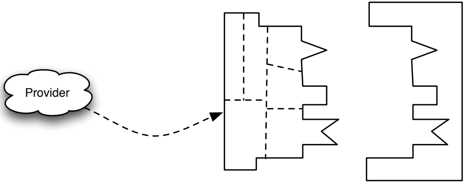

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- External conditions may change
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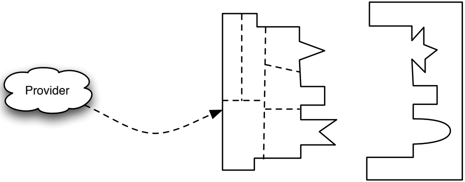

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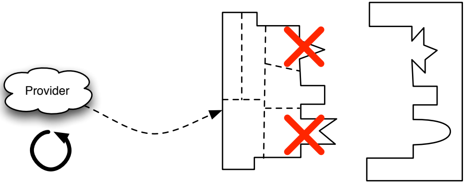

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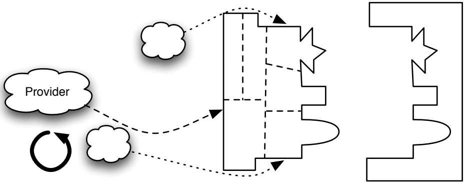

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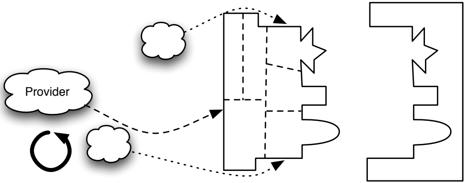

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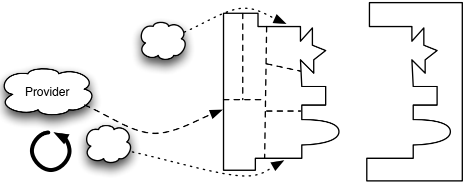

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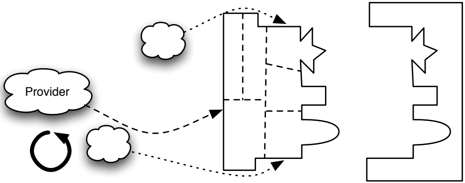

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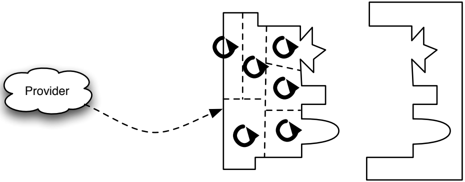
  - Complexity not easy for a human manager
  - Autonomic adaptation
- Heterogeneity and distribution
  - **Transfer autonomic adaptation task to each element**

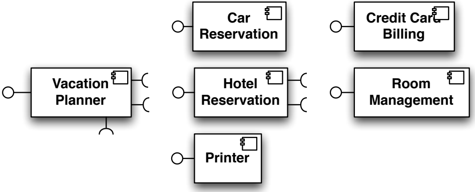


2
CONTEXT

Developing dynamic adaptable software

Component-based Software Development

Service-orientation

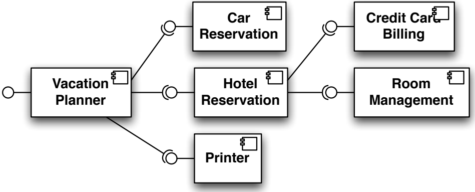


Developing dynamic adaptable software

Component-based Software Development

- Development of independent pieces of code
- Encapsulated, reusable units
- Better adaptation to changing requirements

Service-orientation



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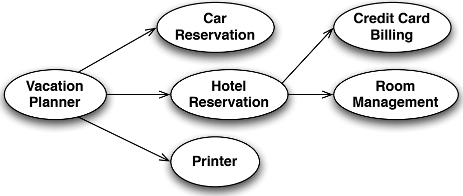
Service-orientation

- Providers offers specific functionalities *as a service*
- Services are composable using standard means
- Facilitate the construction of new added-value applications



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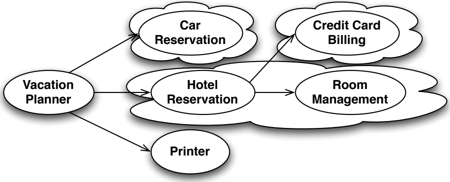
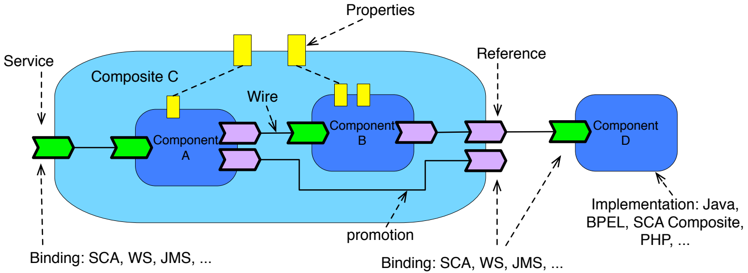
- Services are composable using standard means
- Facilitate the construction of new added-value applications
- Loosely coupled compositions of heterogeneous services



Service Component Architecture (SCA)

Designing services using a component-based approach

- Design-time model for building service-based systems
- Technologically agnostic
- Multiple runtime implementations: IBM Websphere App Server, Fabric3, Apache Tuscany, Paremus, FraSCAti
- Specification does not consider dynamic evolution


Properties
Service
Composite C
Wire
Reference
Component A
Component B
Component D
promotion
Implementation: Java, BPEL, SCA Composite, PHP, ...
Binding: SCA, WS, JMS, ...
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Advantages . . . and challenges

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- Growing ecosystem of services and compositions
- Easier to modify an application dynamically and quickly adapt

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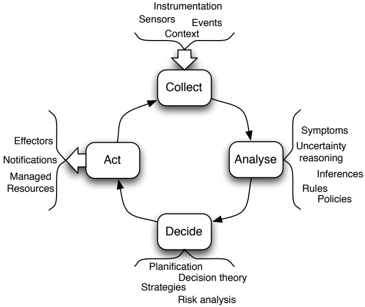
Challenges

- Proper management of complex compositions
- Maintenance depends on different providers
- Several characteristics are less controllable (QoS)
- Need to timely react to unforeseen conditions, and with minimal perturbation

Autonomic Computing

Response to the increasing complexity in the maintenance of systems, exceeding the capacity of human beings

- Based on the idea of self-governing systems
- Context-awareness, and self-* properties
  - Self-{configuring, healing, optimizing, protecting, . . . }
- Activities represented in a *feedback control loop*



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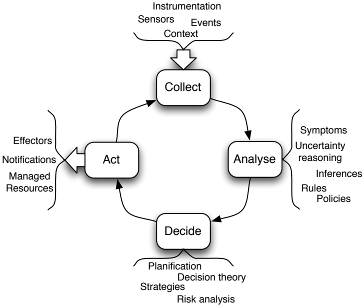
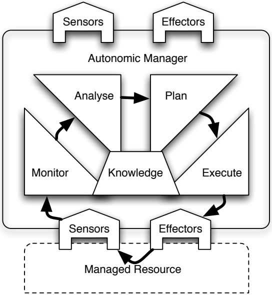
- Activities represented in a *feedback control loop*
- Phases in the *MAPE* autonomic control loop





3
FRAMEWORK

Problem

How to implement dynamic adaptations?

- Lack of uniformity and flexibility
- Impossibility of foreseeing all situations
- Complexity of developing effective autonomic tasks

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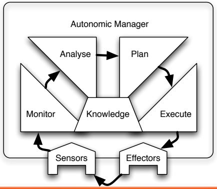
Goal: **Improve the adaptability of service-based applications**

Solution Overview

Flexible Monitoring and Management Framework

- **Implementing an *autonomic* control loop**



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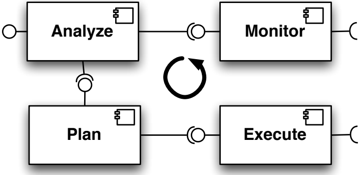
Flexible Monitoring and Management Framework

- **Implementing an *autonomic* control loop**
- **Encapsulating each MAPE phase as a component**
  - Use components to **extend** the behaviour of the control loop



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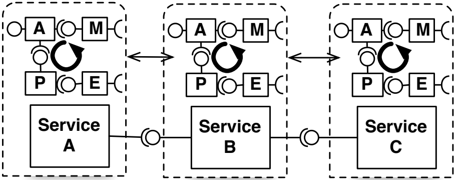
  - Take timely decisions, close to services (**efficiency**)



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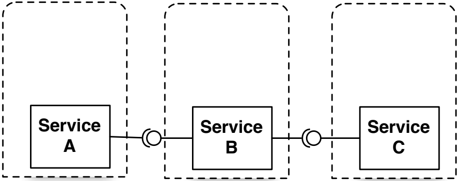
  - Add/remove components at runtime as needed (**flexibility**)



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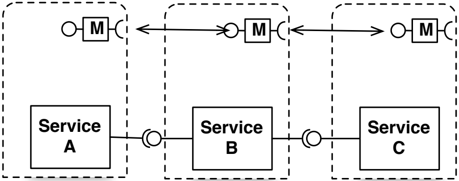

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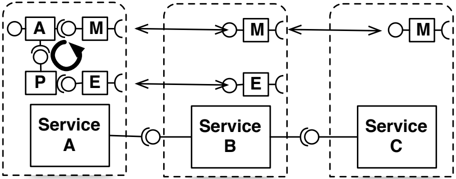

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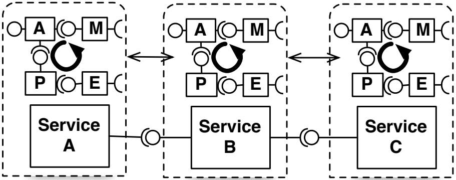

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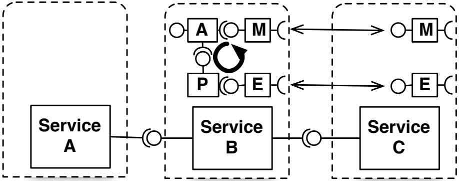
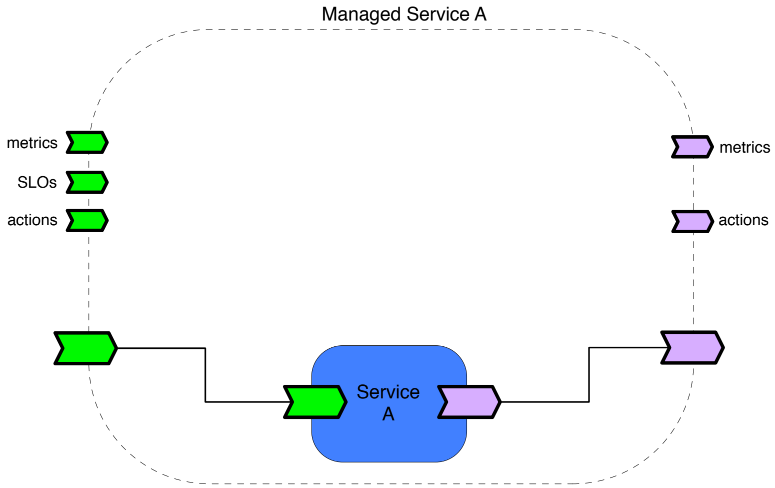


Inside a *Managed Service*

The *framework* itself is component-based application.



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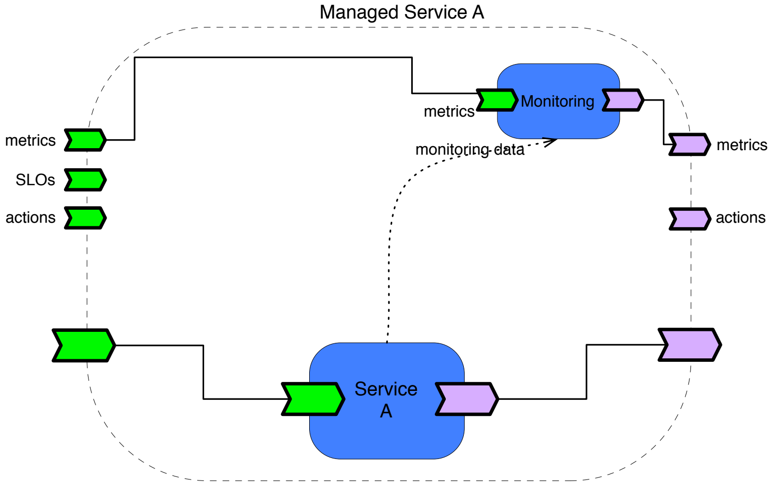

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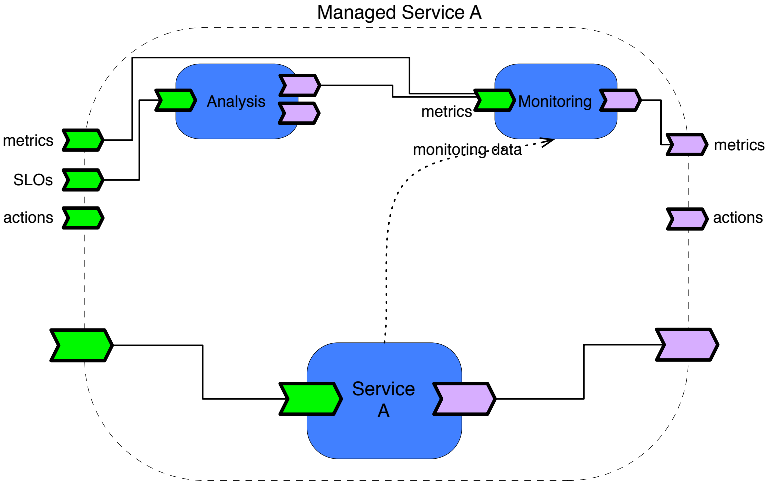

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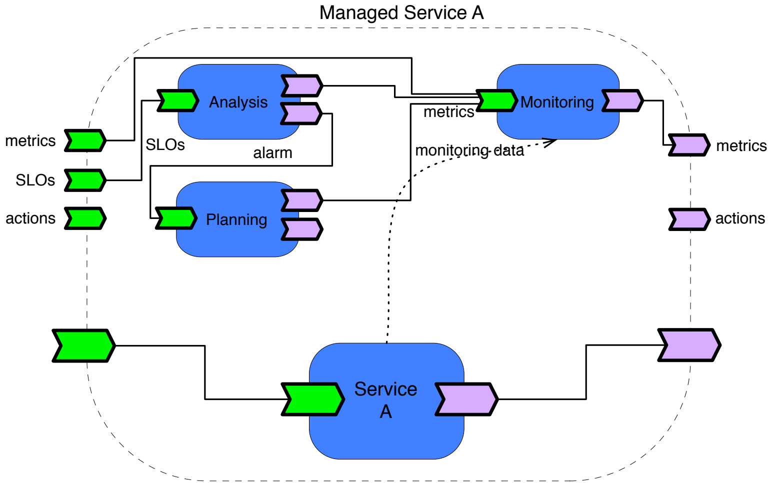

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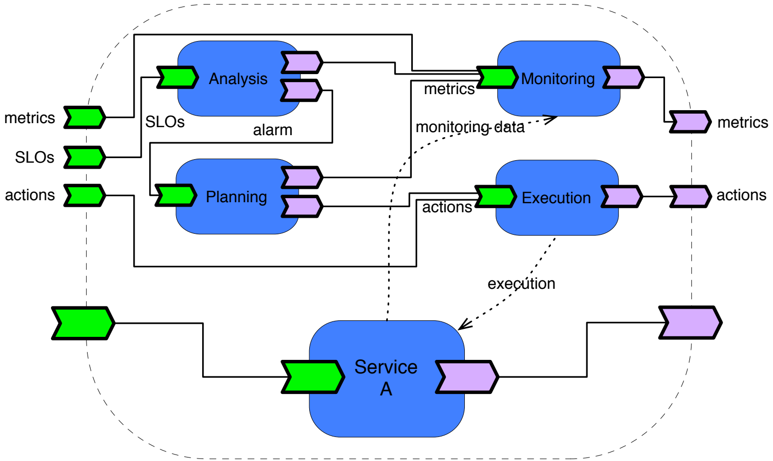
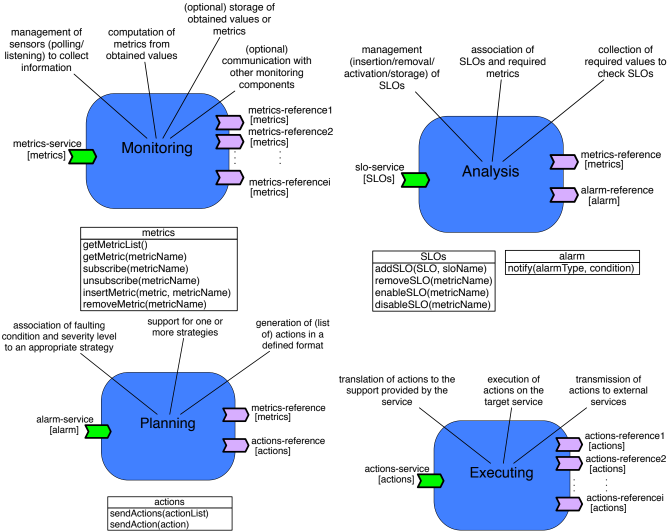


MAPE Components

Basic API for each component



Monitoring

management of sensors (polling/ listening) to collect information

computation of metrics from obtained values

(optional) storage of obtained values or metrics

(optional) communication with other monitoring components

metrics-service [metrics]

metrics-reference1 [metrics]

metrics-reference2 [metrics]

⋮

metrics-referencei [metrics]

metrics
getMetricList()
getMetric(metricName)
subscribe(metricName)
unsubscribe(metricName)
insertMetric(metric, metricName)
removeMetric(metricName)

Analysis

management (insertion/removal/ activation/storage) of SLOs

association of SLOs and required metrics

collection of required values to check SLOs

slo-service [SLOs]

metrics-reference [metrics]

alarm-reference [alarm]

SLOs
addSLO(SLO, sloName)
removeSLO(metricName)
enableSLO(metricName)
disableSLO(metricName)

alarm
notify(alarmType, condition)

Planning

association of faulting condition and severity level to an appropriate strategy

support for one or more strategies

generation of (list of) actions in a defined format

alarm-service [alarm]

metrics-reference [metrics]

actions-reference [actions]

actions
sendActions(actionList)
sendAction(action)

Executing

translation of actions to the support provided by the service

execution of actions on the target service

transmission of actions to external services

actions-service [actions]

actions-reference1 [actions]

actions-reference2 [actions]

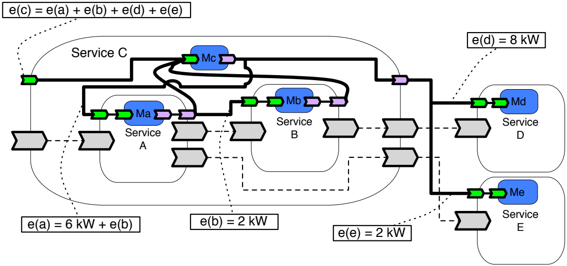
⋮

actions-referencei [actions]

Monitoring: Example

Monitoring components connected through the application

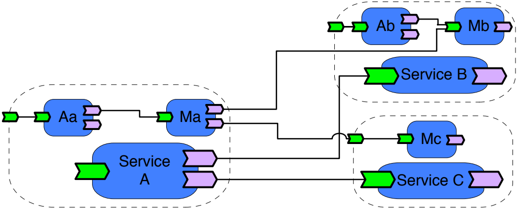
- *Monitoring backbone* through the application
- Components collaborate to compute metrics
- Each component may implement the computation logic differently



Analysis: Example

Analysis components use the *monitoring backbone* to obtain the metrics they need to perform SLO checking

- Different Analyzers may check different conditions without interferring with others



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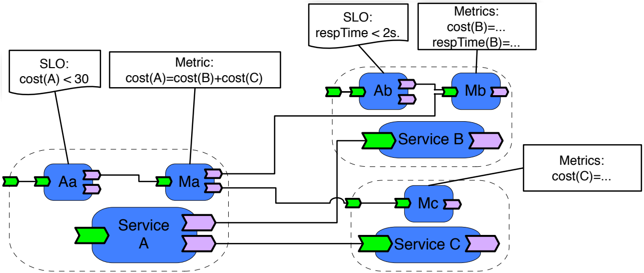
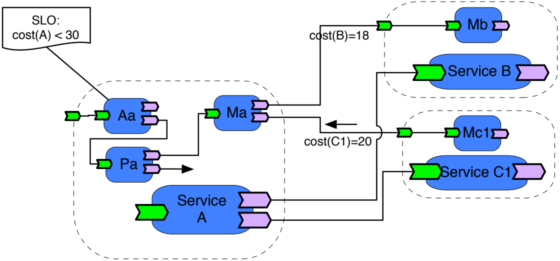


Planning: Example

Implementation of strategies of decision algorithms



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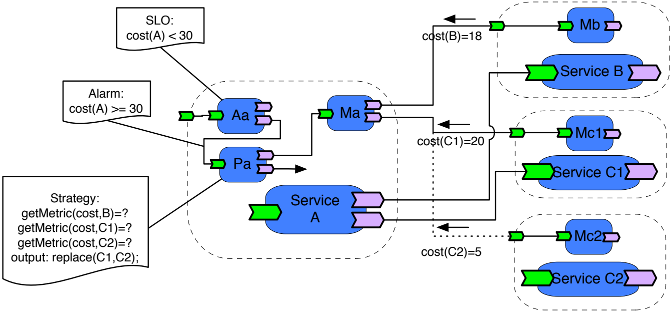

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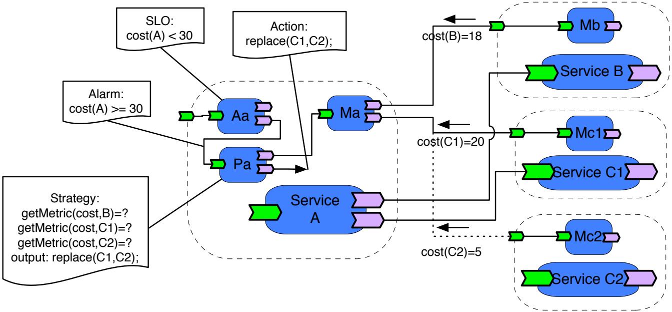
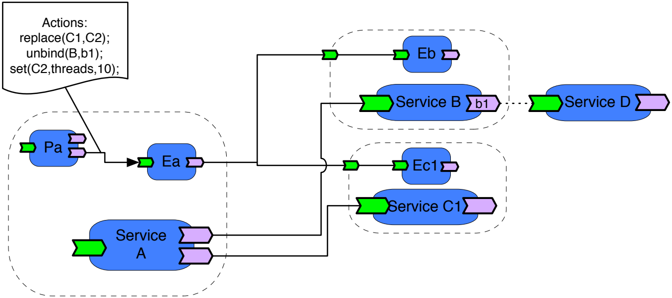


Execution: Example

Actions may be propagated to the appropiate service

- Execute actions on the service according to the specific means allowed



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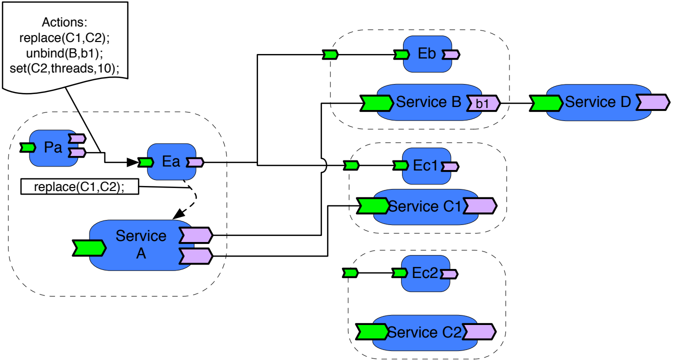

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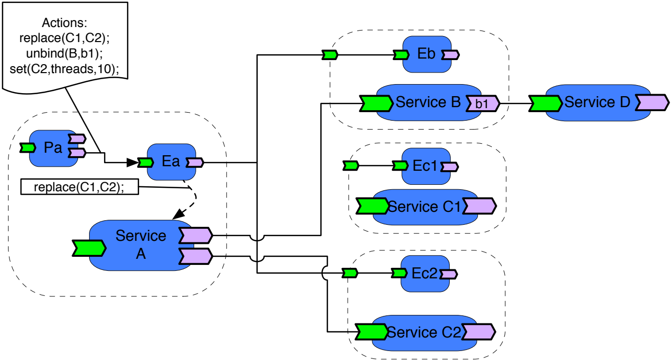

Actions:
replace(C1,C2);
unbind(B,b1);
set(C2,threads,10);

replace(C1,C2);

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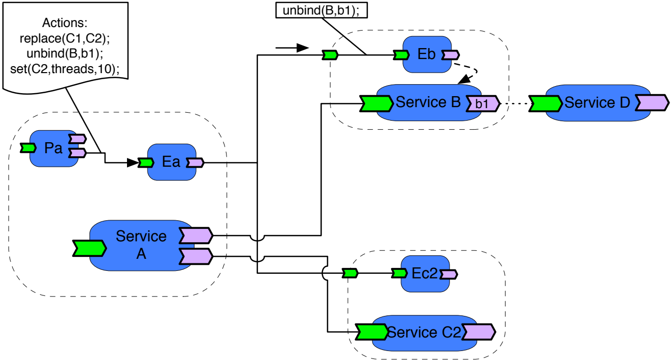

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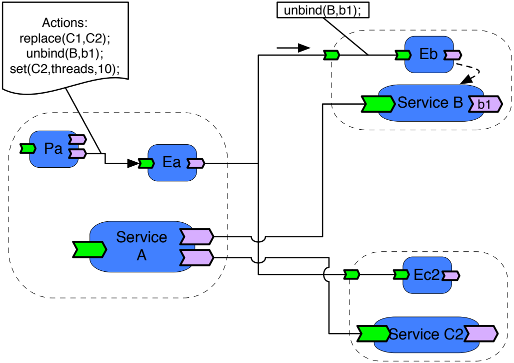
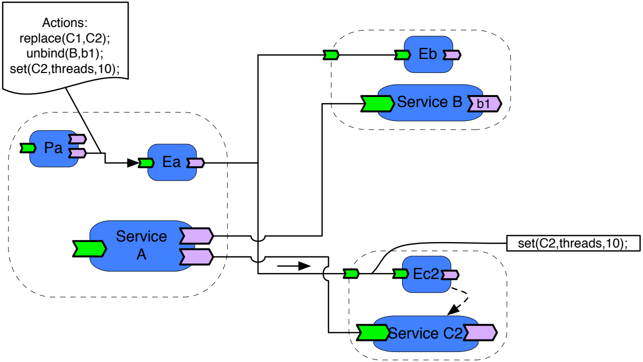


Execution: Example

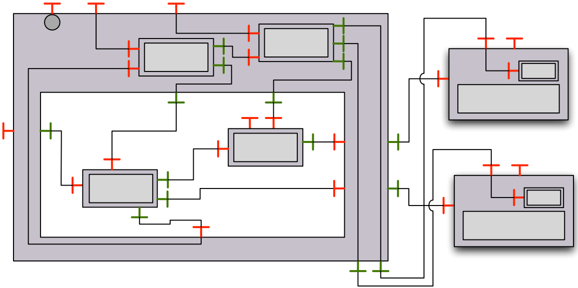
Actions may be propagated to the appropiate service

- Execute actions on the service according to the specific means allowed



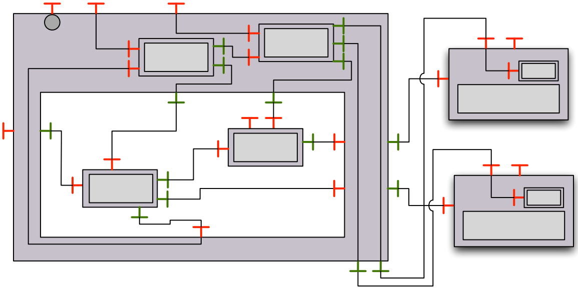
Implementation: background

- Grid Component Model (GCM)
  - Extension of the Fractal Component Model
  - Support for distributed deployment
  - Support for collective communications (*multicast*/*gathercast*)



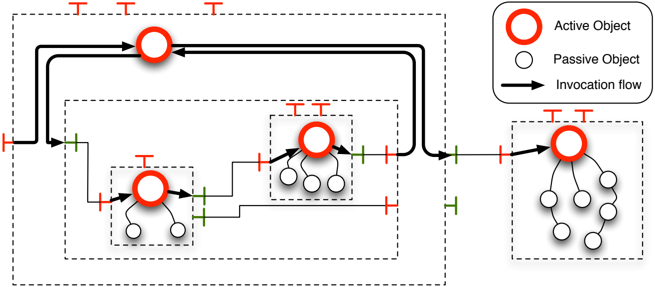
Implementation: background

- Grid Component Model (GCM)
    - Extension of the Fractal Component Model
    - Support for distributed deployment
    - Support for collective communications (*multicast*/*gathercast*)
    - Separation between F and NF concerns



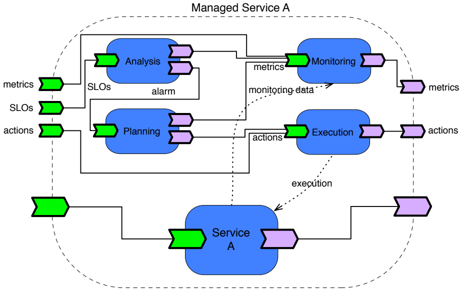
Implementation: background

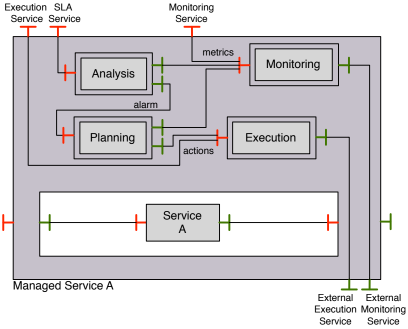
- Grid Component Model (GCM)
  - Extension of the Fractal Component Model
  - Support for distributed deployment
  - Support for collective communications (*multicast*/*gathercast*)
  - Separation between F and NF concerns
- Using the GCM/ProActive reference implementation
  - Based on asynchronous active objects, and *futures*
  - *JMX*-based instrumentation



Implementación: *SCA→ GCM*

- MAPE components in the membrane of GCM componentes
- NF (non-functional) interfaces
- Implementation of each MAPE component
- Definition of an API to manipular los componentes MAPE

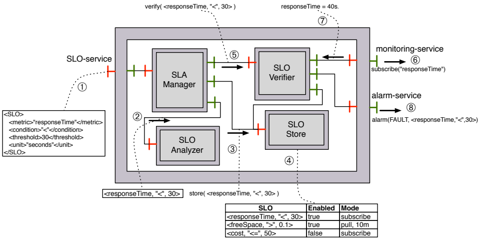




Monitoring and Analysis Components

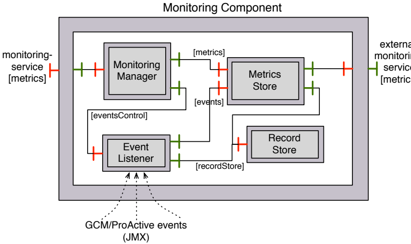
Collection, storage, computation of metrics

- *Listeners* JMX
- Insertion/removal of metrics. Push/pull access.
- Sending of *Alarm* objects
- *SLO* representation: $\langle \textit{metric}, \textit{condition}, \textit{threshold} \rangle$



```
<SLO>
  <metric>"responseTime"</metric>
  <condition>"<"</condition>
  <threshold>30</threshold>
  <unit>"seconds"</unit>
</SLO>
```

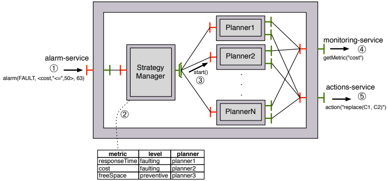
SLO	Enabled	Mode
<responseTime, "<", 30>	true	subscribe
<freeSpace, ">", 0.1>	true	pull, 10m
<cost, "<=", 50>	false	subscribe



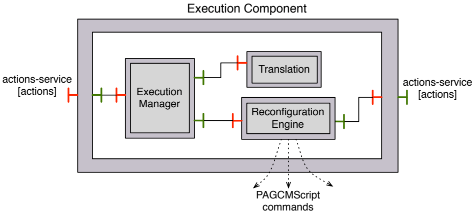
Planning and Execution Components

Execution of planning algorithms (strategies)

- *Alarm*s associated to one or more strategies
- Support for multiple strategies using multicast interfaces
    - Selection, parallel execution of strategies
- Delegation of actions to other components
    - *GCMScript* for executing reconfigurations

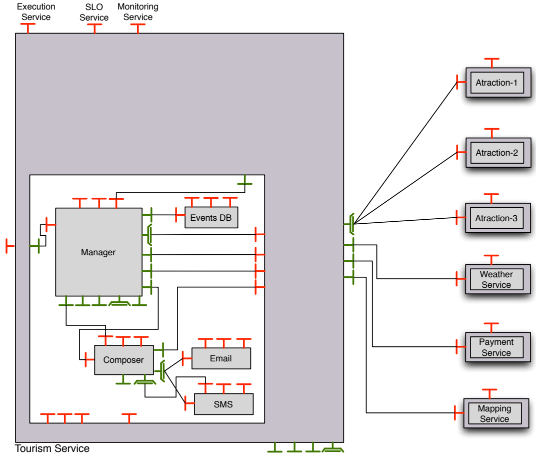


metric	level	planner
responseTime	faulting	planner1
cost	faulting	planner2
freeSpace	preventive	planner3



Use Case: Setting up

- Insertion of MAPE components via API
    - Automatic creation of *bindings* following the functional architecture of the system.



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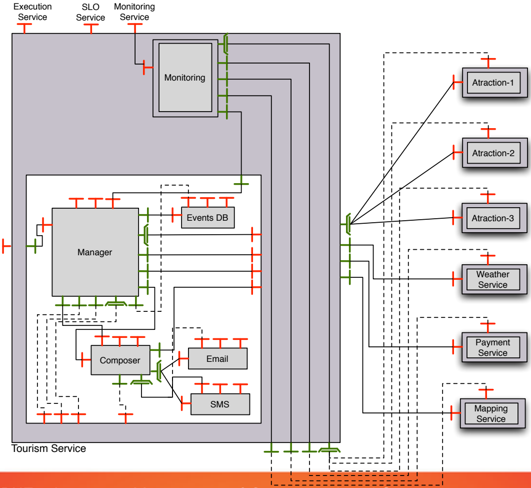

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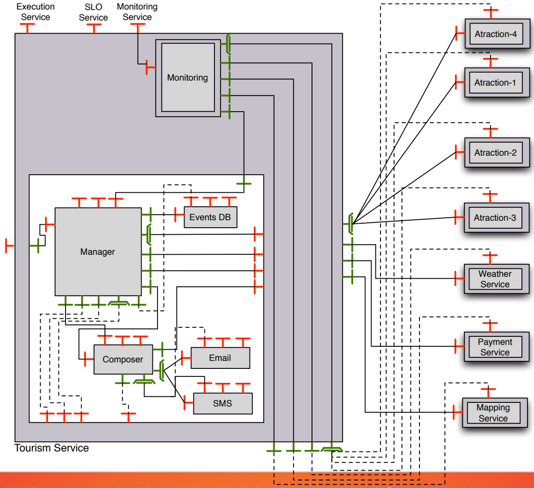
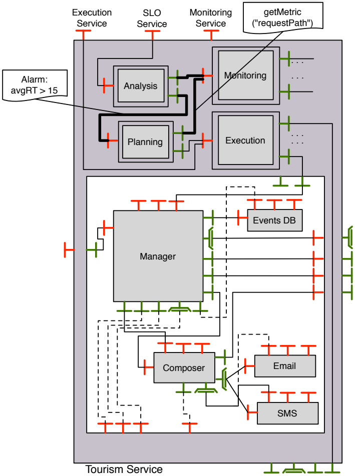


Use Case: Propagation of autonomic adaptations

The actions is propagated through the internal components



Use Case: Propagation of autonomic adaptations

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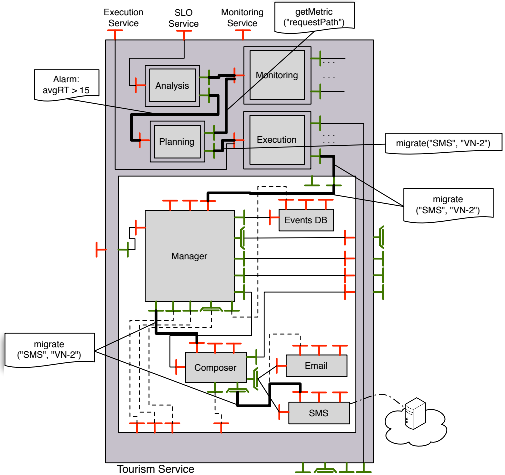
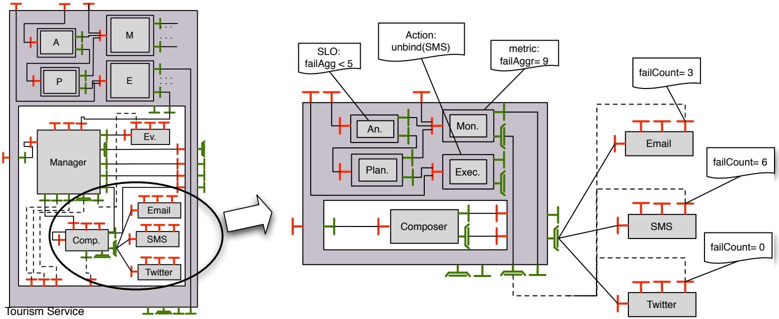


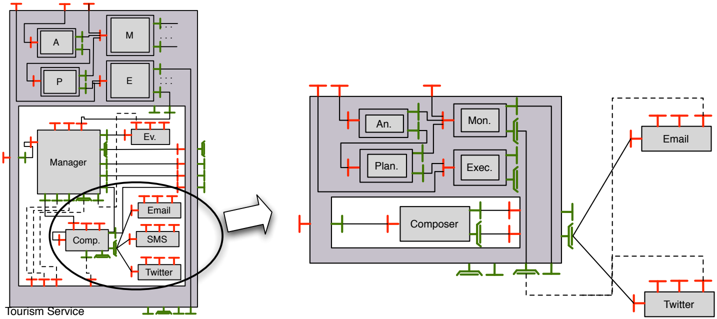
Use Case: Propagation to external components

Internal control loop

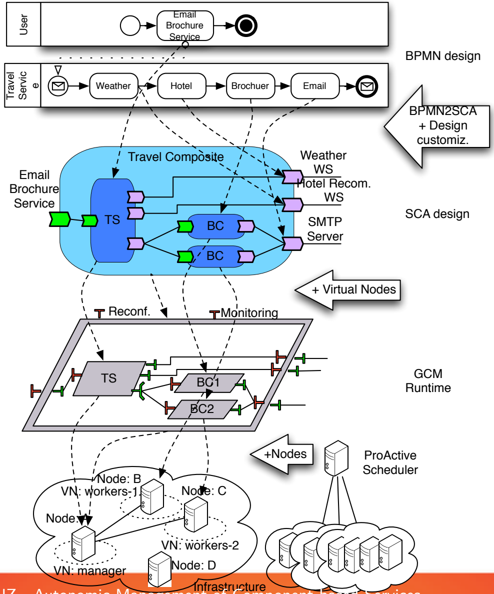


Use Case: Propagation to external components

Internal control loop



Use Case: Mapping the lifecycle of services



4
PERSPECTIVAS

Additional work

- Non-Functional ADL
- Distributed reconfiguration of compoments
- Autonomic *deployment* on *cloud* environments
- Integration of the autonomic framework with *skeletons*
- Dynamic adaptation of *workflows*

Perspectives

Challenges on autonomic computing

- Implementation and experimentation of collaborative strategies
    - Division of goals in sub-tasks
    - Hierarchical planning
- Verification of (*safety*) of reconfiguration actions
    - Avoid *livelock* of adaptations
    - Avoid inconsistencies of the applications

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