

DEPARTMENT OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING  
CONCORDIA UNIVERSITY  
Montreal, Qc, Canada

# Towards an Autonomic Element Architecture for ASSL

(SEAMS 2007)  
ICSE 2007 Workshop on  
“Software Engineering for Adaptive and Self-managing Systems”  
Minneapolis, MN, USA  
May 26-27, 2007

by Emil Vassev & Joey Paquet

## Index

- Problem Statement
- Autonomic Computing Background
- Related Work
- ASSL Multi-Tier Specification Model
- AE Architecture for ASSL
- Conclusion & Future Work

## Problem Statement

### **Current Situation:**

Tremendous increase of application complexity:

- Service-Oriented architecture running on grids.
- Multi-core CPUs, integrated communication and management.

### **Solution:**

Self-adaptive and autonomic computing (AC) systems.

### **Problem:**

Crucial need of programming techniques and technologies:

- imply AC principles;
- provide us with programming concepts for implementing autonomic systems (AS).

## Autonomic Computing – State of the Art

### Four basic self-managing objectives:

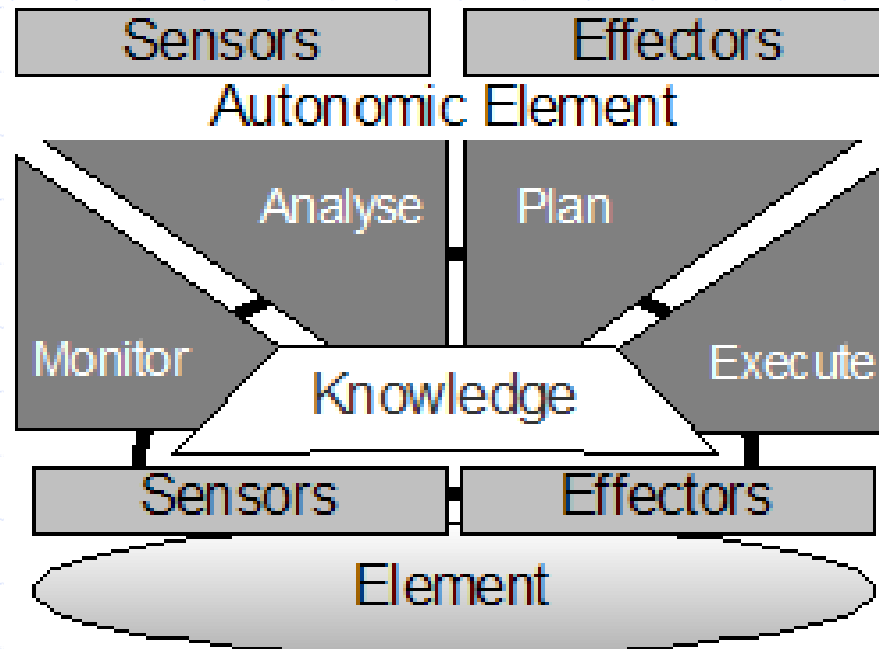
- self-configuration;
- self-optimization;
- self-healing;
- self-protection.

**Self-Protection.** The AS defends itself from accidental or malicious external attacks, which requires awareness of potential threats and the means to manage them.

## IBM Research AE Architecture Model

### Characteristics:

- Control loop - functionally related units - monitor, analyzer, planner, and executor; all of them sharing knowledge;
- Manageability Interface;
- Managed element.



AE Architecture for ASSL

## ASSL Multi-Tier Specification Model

### Autonomic System

- AS Service Level Objectives
- AS Self-Management Policies
- Metric Space
- Architecture

### Autonomic System Interaction Protocol (ASIP)

- Public AS Messages & Negotiation Protocol
- Public Communication Channels
- Public Communication Functions

### Autonomic Element

- AE Service Level Objectives
- AE Self-Management Policies
- Friends
- Autonomic Element Interaction Protocol (AEIP)
  - Private AE Messages & Negotiation Protocol
  - Private Communication Channels
  - Private Communication Functions
  - Managed Resource Interface
- Recovery Protocol
- Behavior
- Outcomes
- Actions
- Events
- Metrics Space

### Rationale

- scalable specification model;
- provides judicious selection and configuration of infrastructure elements and mechanisms of ASs;
- decomposes an AS in two directions – 1) into levels of functional abstraction; 2) into functionally related sub-tiers;
- presents the system from three different perspectives – 1) AS; 2) ASIP; 3) AE;
- matches the AS builder needs;
- flexible approach to specification.

## Autonomic System Tier

### Autonomic System

- AS Service Level Objectives
- AS Self-Management Policies
- Metric Space
- Architecture

## AS Service-Level Objectives

- A higher-level form of behavioral specification that establishes objectives (ex. performance), eventually leading the system to determine the actions required to achieve those objectives.
- Our concept assumes that the AS service level objectives (AS SLO) are a global task whose realization is to be distributed among the AEs.
- Each AE has its own service level objectives (AE SLO), which are subordinates of the AS SLO.
- ASSL specifies the AS SLO as correlations between the AEs' SLO.



```
ASSELF_MANAGEMENT {  
  SELF_OPTIMIZING {  
    SWITCH: ON;  
    PRIORITY: 1;  
    EVENT lowPerformance: forall AE {  
      AE.METRIC_SPACE.performance <= 200;  
    }  
    EVENT normPerformance: forall AE {  
      AE.METRIC_SPACE.performance > 200;  
    }  
    FLUENT inLowPerformance {  
      INITIATES: lowPerformance;  
      TERMINATES: normPerformance;  
    }  
    MAPPING {  
      CONDITION: inLowPerformance;  
      ACTION {  
        foreach AE in AS { AE.ACTIONS.spawnWorker }  
      }  
    }  
  }  
  ...  
}
```

and  
take  
d as  
system  
ment  
or the

## AS Metric Space

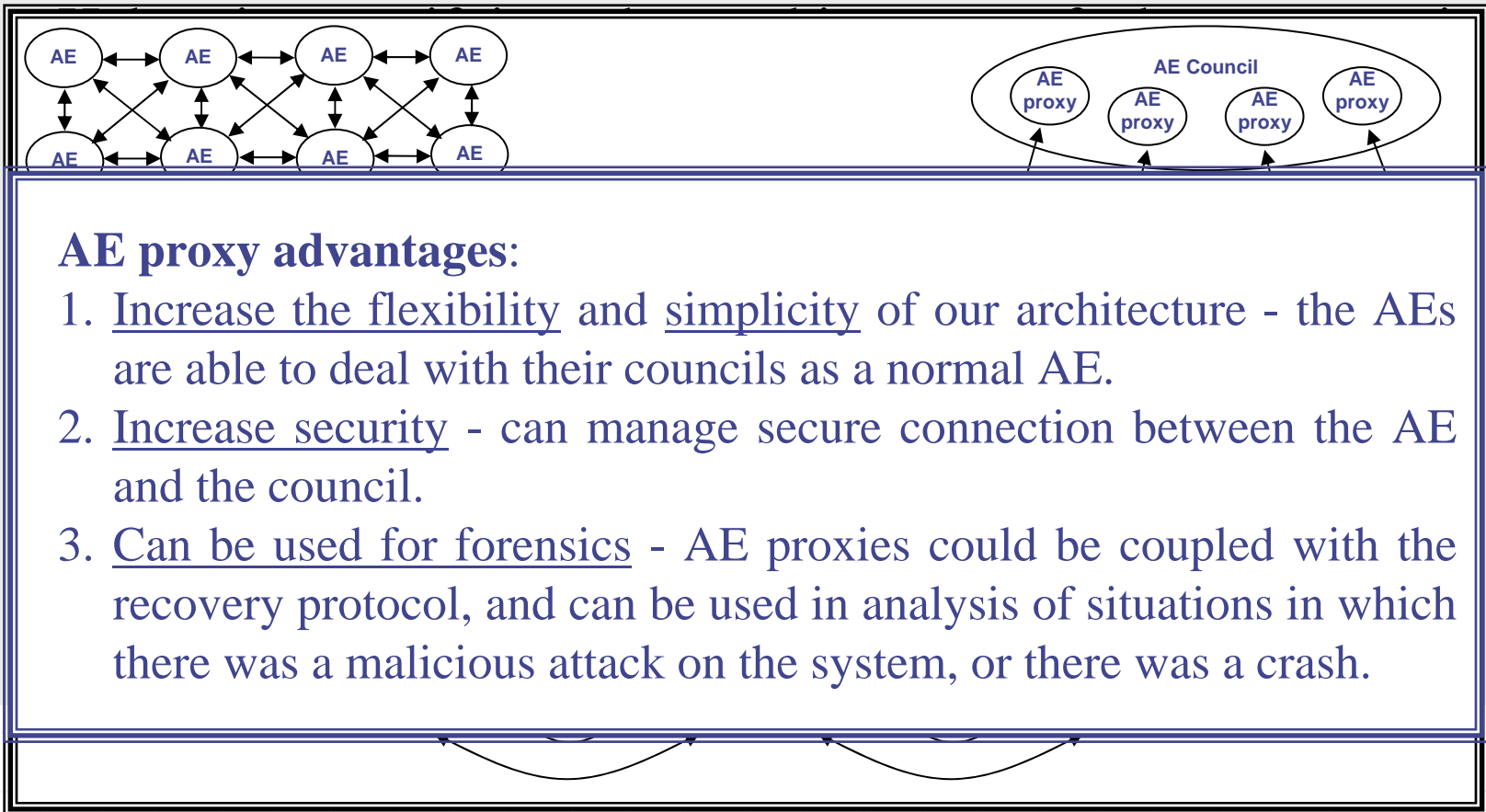
### **The AS-level metrics can be:**

- resource metrics – measure resources;
- quality metrics – measure qualities like performance, response time etc;
- scalar metrics – measure predefined dynamic AS variables.

### **We express metrics by specifying:**

- a type of the metric - it could be resource, quality, scalar, or composite;
- a description of the metric;
- a measure unit of the metric – seconds for time, MB for size etc.;
- threshold classes specifying the range of valid values;
- logical expressions over the threshold classes if needed.

## AS Architecture



### AE proxy advantages:

1. Increase the flexibility and simplicity of our architecture - the AEs are able to deal with their councils as a normal AE.
2. Increase security - can manage secure connection between the AE and the council.
3. Can be used for forensics - AE proxies could be coupled with the recovery protocol, and can be used in analysis of situations in which there was a malicious attack on the system, or there was a crash.

## Autonomic System Interaction Protocol (ASIP) Tier

### **Autonomic System Interaction Protocol (ASIP)**

- Public AS Messages & Negotiation Protocol
- Public Communication Channels
- Public Communication Functions

## Public AS Messages & Negotiation Protocol

- AEs can exchange information in the form of messages.
- Public AS messages - recognizable by all the AEs.
- AEs communicate them over public channels.
- AEs use empty ASSL structures for queries and their complete homolog for responses.
- Negotiation Protocol – a set of messages needed to start and close a message-exchanging session.

## Public Communication Channels

- abstract means of communication, connecting AEs:

```
ASIP {  
  MESSAGES {...}  
  CHANNELS {  
    FINAL CHANNEL poster {  
      ACCEPT: ID/ANY;  
      ACCESS: SEQUENTIAL/ DIRECT;  
      DIRECTION: IN/OUT/BYDIRECTIONAL;  
    }  
    CHANNEL urgency {...}  
  }  
  FUNCTIONS {...}  
}
```

## Public Communication Functions

- routines using the communication channels to propagate messages among the AEs;
- a communication function could use a single or multiple channels, or operate in unicast or broadcast mode;

### Example:

A routine can propagate a message to all the input and bidirectional public channels, or choose to rely on a bus to send very large messages.

- public communication functions – common to all the AEs.

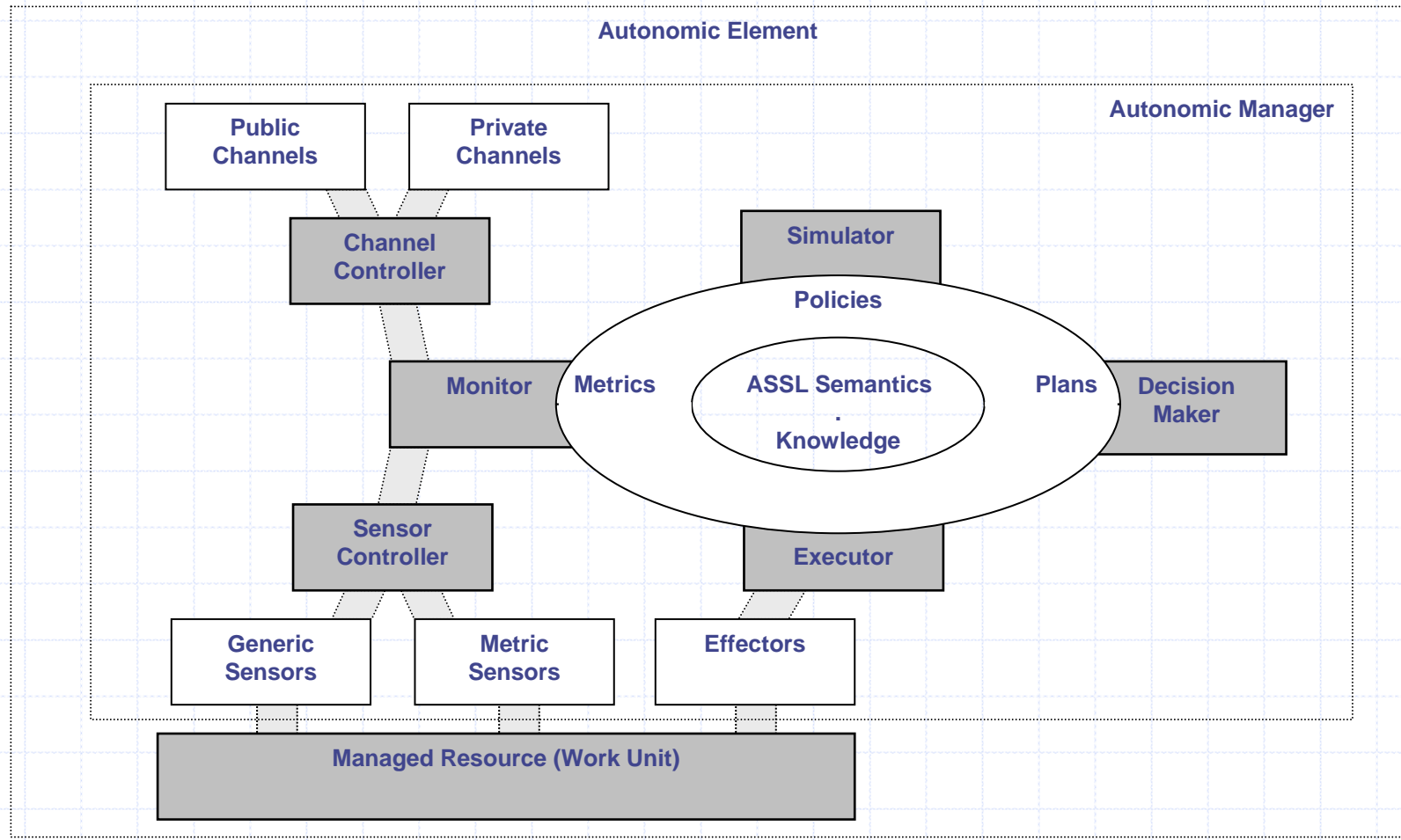
## Autonomic Element Tier

### Autonomic Element

- AE Service Level Objectives
- AE Self-Management Policies
- Friends
- Autonomic Element Interaction Protocol (AEIP)
  - Private AE Messages & Negotiation Protocol
  - Private Communication Channels
  - Private Communication Functions
  - Managed Resource Interface
- Recovery Protocol
- Behavior
- Outcomes
- Actions
- Events
- Metrics Space



## ASSL AE Architecture Model



## Public & Private Channels

- The AE uses a set of channels to communicate with other AEs or environmental entities.
- Specified by ASIP and AEIP.

**Why communication channels are a better means of communication than the IBM's set of sensors and effectors?**

- 1. We explicitly specify the messages they can accept - prevents malicious attacks via unspecified messages.**
- 2. Private channels enhance the security level - only AE's friends can use the private channels.**
- 3. Channels can be used for forensics, i.e. for gathering evidence - can be used in analysis of situations in which there was a malicious attack on the system.**

## Channel Controller

- Operates the channels - can modify channels' settings, close, open, create channels or arrange channels into busses.
- Responsible for sending and receiving messages over the communication channels - implements the communication functions specified by the ASIP and AEIP.

### Advantages?

- 1. Brings great flexibility to channel management - takes care about the runtime changes in the channels.**
- 2. Achieves the separation of the abstract concepts of pure messaging and the message operation implementation - sending, receiving, breaking large-sized messages into chunks for transmitting them over busses and so on.**

## Metric and Generic Sensors

- Metric sensors measure specific metrics.
- Both kinds operate over the managed element.
- Generic Sensors explore the metric space and discover new metrics .
- The notion of generic sensors is still under discussion.

### **Advantage of having both Metric and Generic sensors?**

Flexibility - our model uses predefined metric sensors built for measuring metrics known at design time, but also uses generic sensors for measuring metrics unknown from the initial specification.

## Sensor Controller

- Controls the metric and generic sensors, by tuning and operating them.
- AEs could implement algorithms for optimizing the metric space.

### **Advantage?**

Flexibility - we separate the concept of measuring metrics from the concept of operating measurement tools.

## Effectors

- Manageability interface used by the executor to control the managed element.

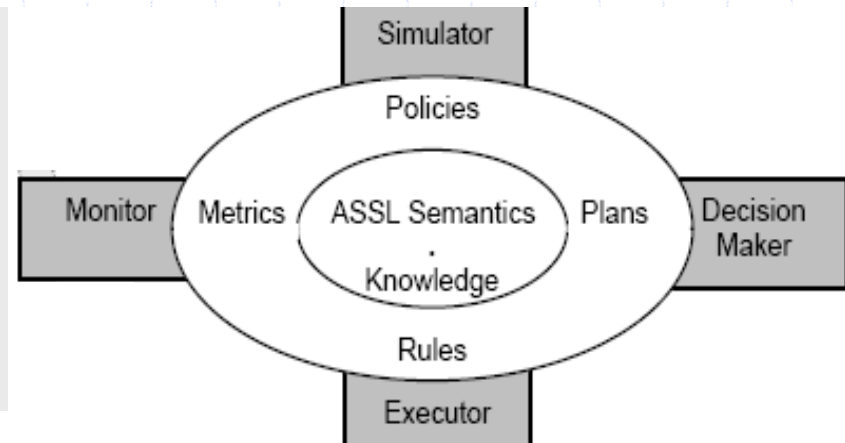
### **Advantage?**

Effectors could also be used for forensics. Any function call can be registered together with the returned result or raised exception, thus helping in further analysis.

## AE Control Loop

- Monitor, Simulator, Executor, and Decision Maker.
- ASSL Core & ASSL Bus.

**Advantage?**



In our architecture model, we separate simulation from analysis and planning, thus increasing the overall performance and manageability.

## Conclusion & Future Work

- ASSL - a framework that provides a multi-tier specification model for AS.
- ASSL allows expressing ASs, as a set of interacting AEs, at three main levels - AS level, ASIP level, and AE level.
- The new architecture model for AE emphasizes on the ASSL specification - forms the shared knowledge.
- The arch. model can be validated before building the system.
  
- Currently working on specifying two systems – DMS (distributed) and ASTRM (reactive).
- Next: 1) developing the ASSL framework; 3) validating the ASSL framework – generating AS DMS.
- Possible collaboration with NASA – ANTS project.



THANK YOU!

Questions?