Specification-Carrying Code for Self-Managed Systems

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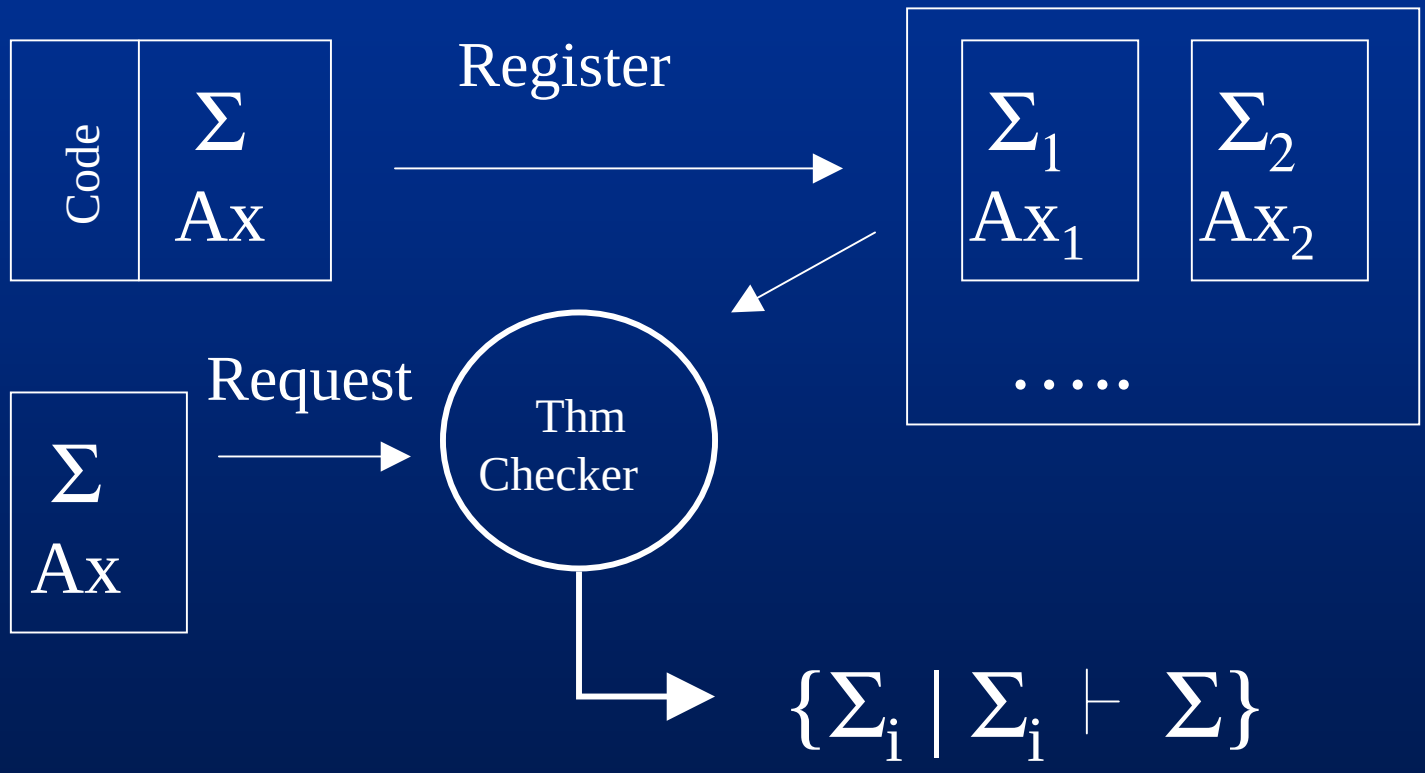
Outline

- Semantic Infrastructure
  - « Specification-Carrying Code » (SCC)
  - Service-oriented architecture
- SCC for Autonomic Computing

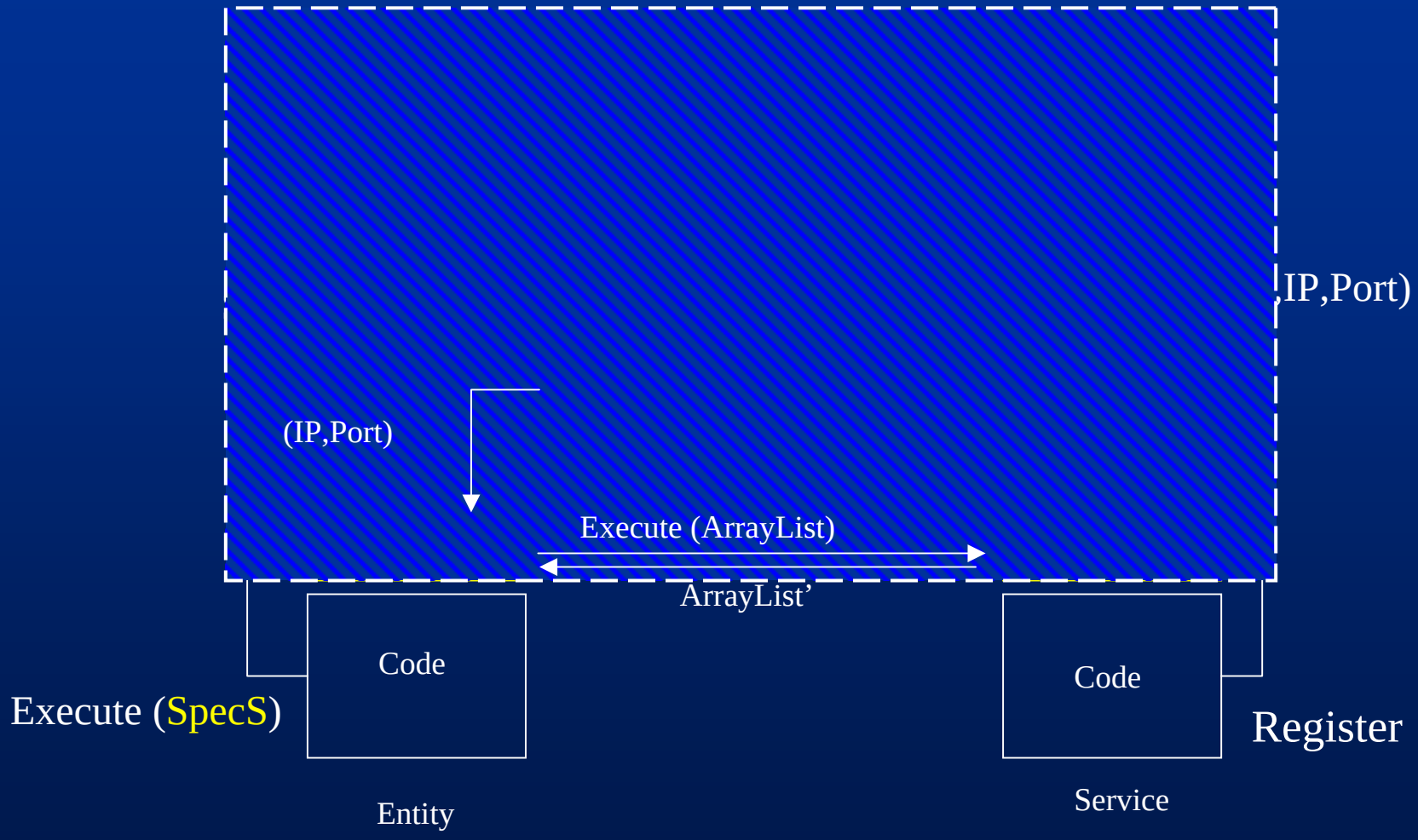
Specification-Carrying Code

- Idea: *communication is based on a formal specification of the behaviour of a peer entity*
  - Software « carries » a formal description of its own functional behaviour
  - Communication occurs without API
  - Formal specification defines the semantics of the behaviour

SCC - Principle



SCC - Architecture



SCC – Prolog

- Registration

```
<specs>
  <description active="true">
    <content> Reverse List Service
    </content>
  </description>
  <prolog active="true">
   <content>
      append([],L,L).
       append([H|T],L2,[H|L3]):-
            append(T,L2,L3).

      rev([],[]).
      rev([H|T],R) :-  rev(T,RevT),
           append(RevT,[H],R).
    </content>
  </prolog>
</specs>
```

- Request

```
<specs>
  <description active="true">
      <content> ReverseList Request
    </content>
  </description>
  <prolog active="true">
    <content>
      rev([],[]), rev([A|B],R), rev(B,RevB),
      append(RevB,[A],R), rev(R,[A|B]).
   </content>
  </prolog>
</specs>
```

SCC – Java (no API!)

- Registration

```
public class ReverseList extends Service {

public class static void main(String[] args)
      //register reverse list specification
      new ReverseList().register(« localhost »,
       « specService.xml » );
     }

public ArrayList execute(ArrayList list) {
      Collections.reverseList(list);
      return list;
     }
}
```

- Request

```
public class UseReverseList extends Entity {

private void askForReverseList() {
     // request a reverse list service
      result = Entity.execute(SM_ADDRESS,
       « specRequest.xml », parameters);
     }
}
```

SCC - Advantages

- Interest
  - Minimum basis for communication
    - Specification language (for expressing concepts)
  - Interaction/Interoperability with new/unknown software
    - No common design / No common API
  - Self-assembly
  - Seamless Integration of new entities
  - Robustness

SCC for Autonomic Computing

- SCC expresses
  - Functional Behaviour
  - Non-Functional Aspects
    - Policies
    - Trust
    - Quality of Service
  - Execution Flow

SCC for Autonomic Computing

- Self-Configuration (installation, configuration, integration)

  "Automated configuration of components and systems follow high-level policies. Rest of System adjusts automatically and seamlessly [Kephart03]"

  - SCC expresses high-level configuration policies
    - High-level requests (goals) from human admin (installation needs)
    - High-level requests for configuration policies (Grid distribution)
    - Local-level: components express individual installation needs (CPU, memory, etc.)

  - Unanticipated dynamic run-time evolution of code
    - Seamless integration of new components
    - Distribution of application on-the-fly

SCC for Autonomic Computing

- Self-Optimisation (parameters)

  "*Components and systems continually seek opportunities to improve their own performance and efficiency [Kephart03*]"

  - SCC expresses optimisation policies
    - Parameters description
    - Permanent optimisation of parameters depending on the context

  - At each request
    - SCC Middleware seeks optimised service (most recent, most efficient, etc.)

SCC for Autonomic Computing

- Self-Healing (error detection, diagnostic, repair)

  "System automatically detects, diagnoses, and repairs localized software and hardware problems [Kephart05]"

  - Generation of correct code from SCC
  - Replace error code with code having matching specification
  - Checking of code against specification

SCC for Autonomic Computing

- Self-protection (detection and response to attacks)

  "System automatically defends against malicious attacks or cascading failures. It uses early warning to anticipate and prevent systemwide failures [Kephart05]"

  – SCC expresses high-level security policies
    - Conditions regulating services delivery
    - Signatures of attacks / Response schema

  – Self-regulating schema
    - Trust and reputation information

Conclusion

- SCC
  - Specifications of behaviour
  - Implementation through a middleware infrastructure
  - Interoperability solution
  - No need for compatible interfaces
- SCC for Self-Managed Systems
  - Functional properties
  - Non-functional properties
  - Run-time (re)configuration policies/schemas
  - Run-time description of interaction protocols