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Software Architecture in Practice

Architectural Reflection

Literature

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Main

– [Menasce and Kephart, 2007]
  - Menasce, D. and Kephart, J. (2007). Guest Editors' Introduction: Autonomic Computing. *IEEE Internet Computing, 11(1), pp 18-21*

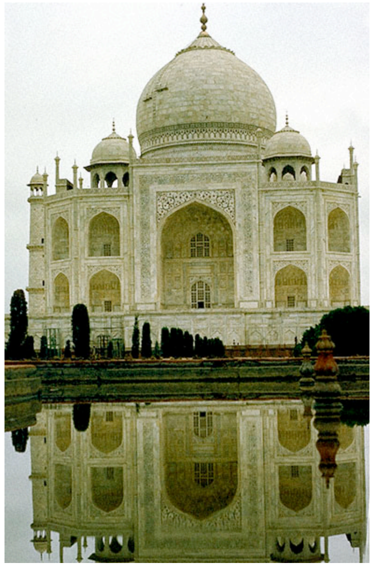
– [Kramer and Magee, 2007]
  - Kramer, J. and Magee, J. (2007). Self-Managed Systems: an Architectural Challenge. In Proceedings of Future of Software Engineering (FOSE '07), pp 259-268

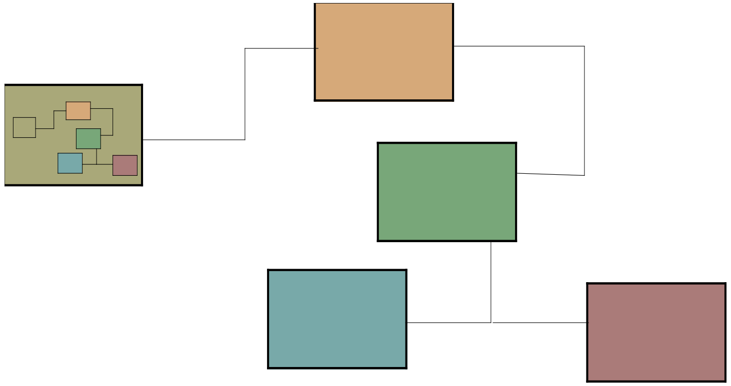
– [Schmerl et al., 2006]
  - Schmerl, B., Aldrich, J., Garlan, D., Kazman, R., and Yan, H. (2006). Discovering Architectures from Running Systems. In IEEE Transactions on Software Engineering, vol 32, no. 7, pages 454-466

Reflection

Architectural reflection

- The ability for a system to observe and possibly modify its (runtime) architecture
- Is concerned with reification of whole systems rather than e.g objects reachable within a given programmatic scope
- If reflection in e.g. Java or Lisp is reflection-in-the-small, then architectural reflection is reflection-in-the-large.





Styles of Reflection

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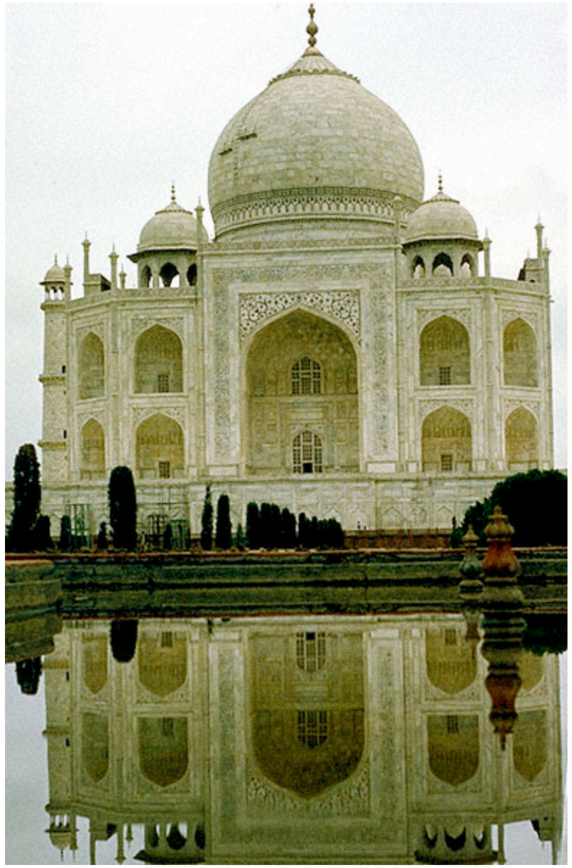
Structural vs behavioral

– Structural reflection is the representation of *(static) structure* of the system
– Behavioural reflection is the representation of *ongoing activity*

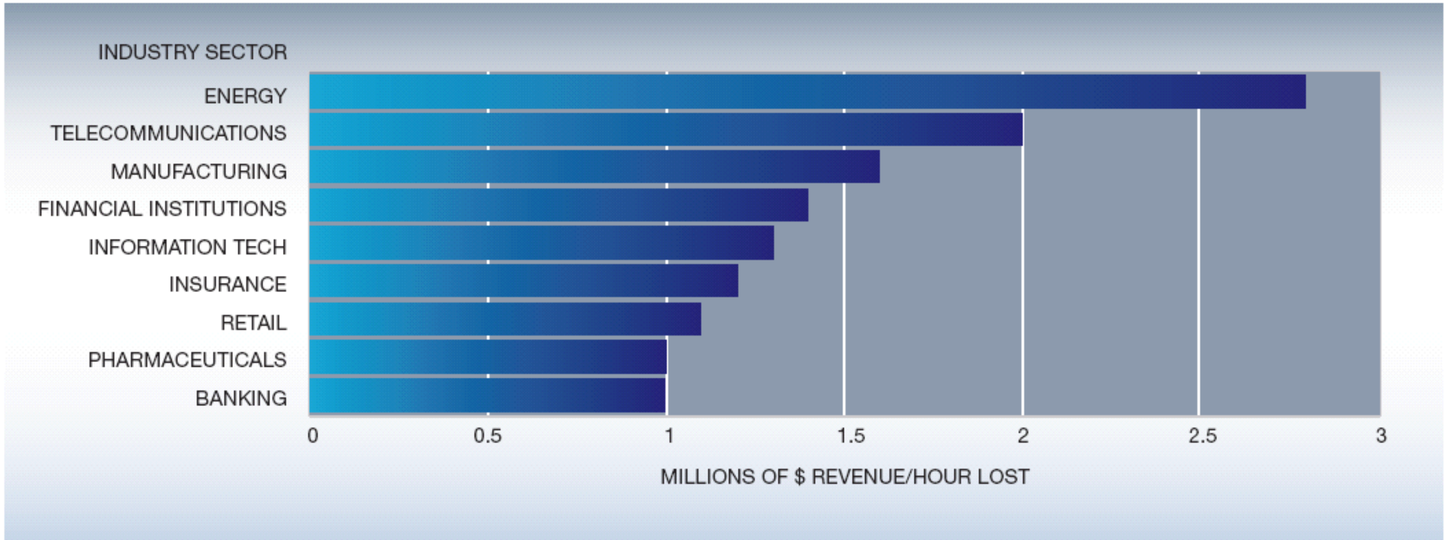
Procedural vs declarative

– Procedural reflection involves *direct manipulation* of the system
– In contrast, declarative reflection involves manipulation of a more *abstract representation*

[Gordon Blair]



The Complexity Problem



Data from *IT Performance Engineering and Measurement Strategies: Quantifying Performance Loss*, Meta Group, Stamford, CT (October 2000).

Autonomic Computing

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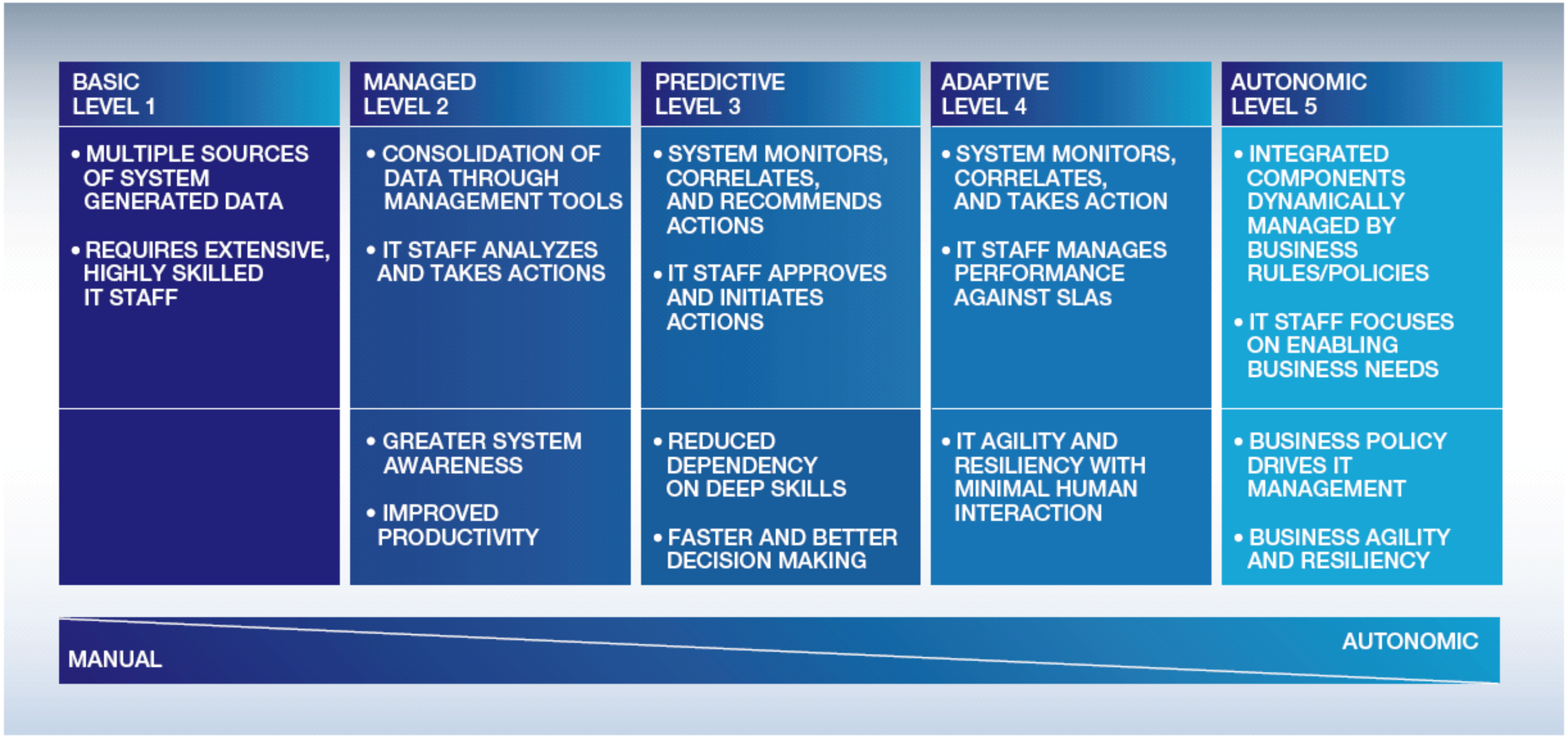
- Computer systems that manage themselves
  - Given high-level objectives from administrator
- Initiative spearheaded by IBM



Autonomic Computing – Status

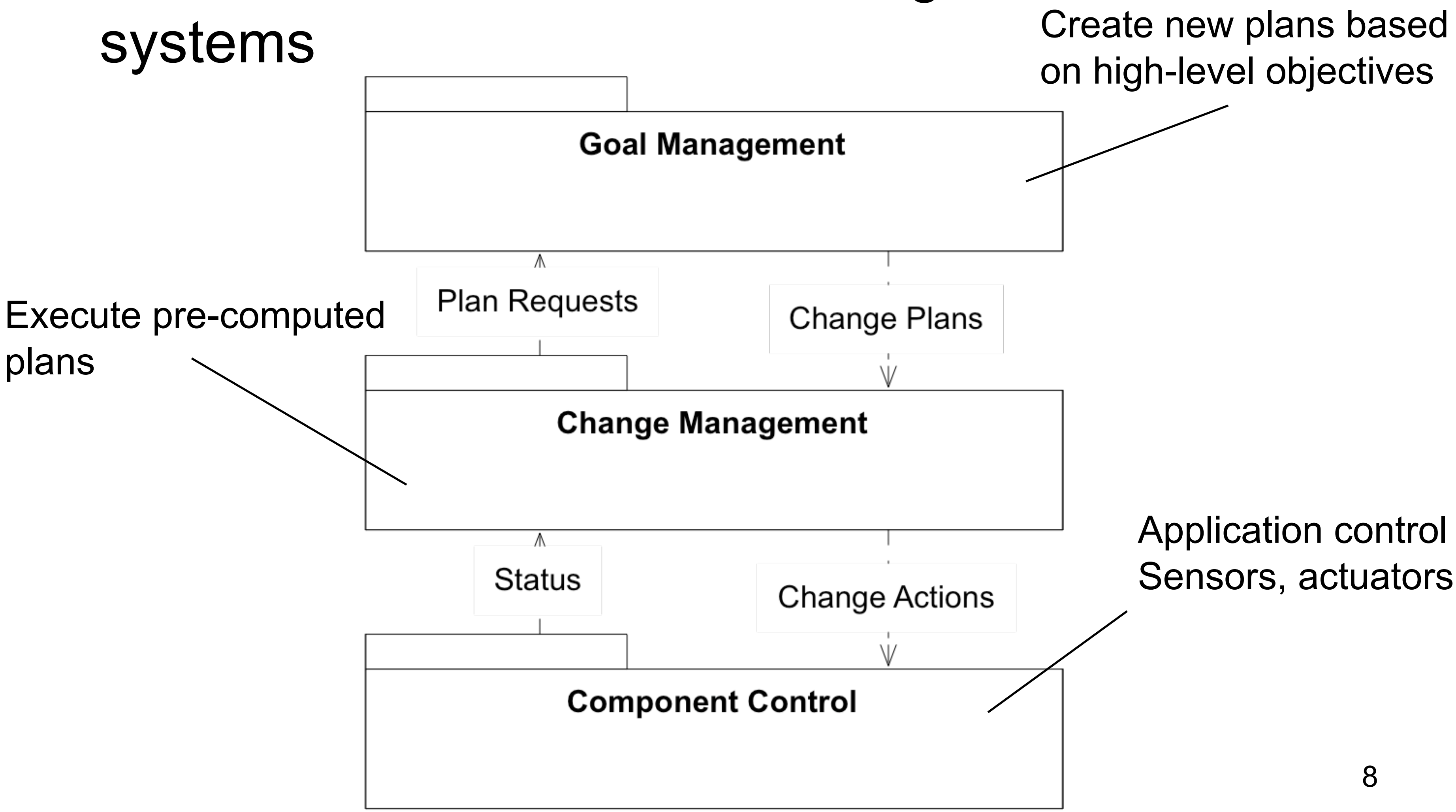
Products
- Parts of, e.g., IBM Tivoli and MS SQL are autonomic

Specifications
- Oasis's Web Services Distributed Management (WSDM)

Research and Development
- Large companies
  - IBM: Autonomic Computing project
  - HP: Adaptive Enterprise project
  - MS: Data Management, Exploration and Mining (DMX) group
- Google Scholar
  - "Autonomic Computing" -> 6.530 results…

Robotics-Inspired Three-Layer Model

Reference model for self-managed/autonomic systems



[Schmerl et al., 2005]: Dynamically Discovering Architectures with DiscoTect

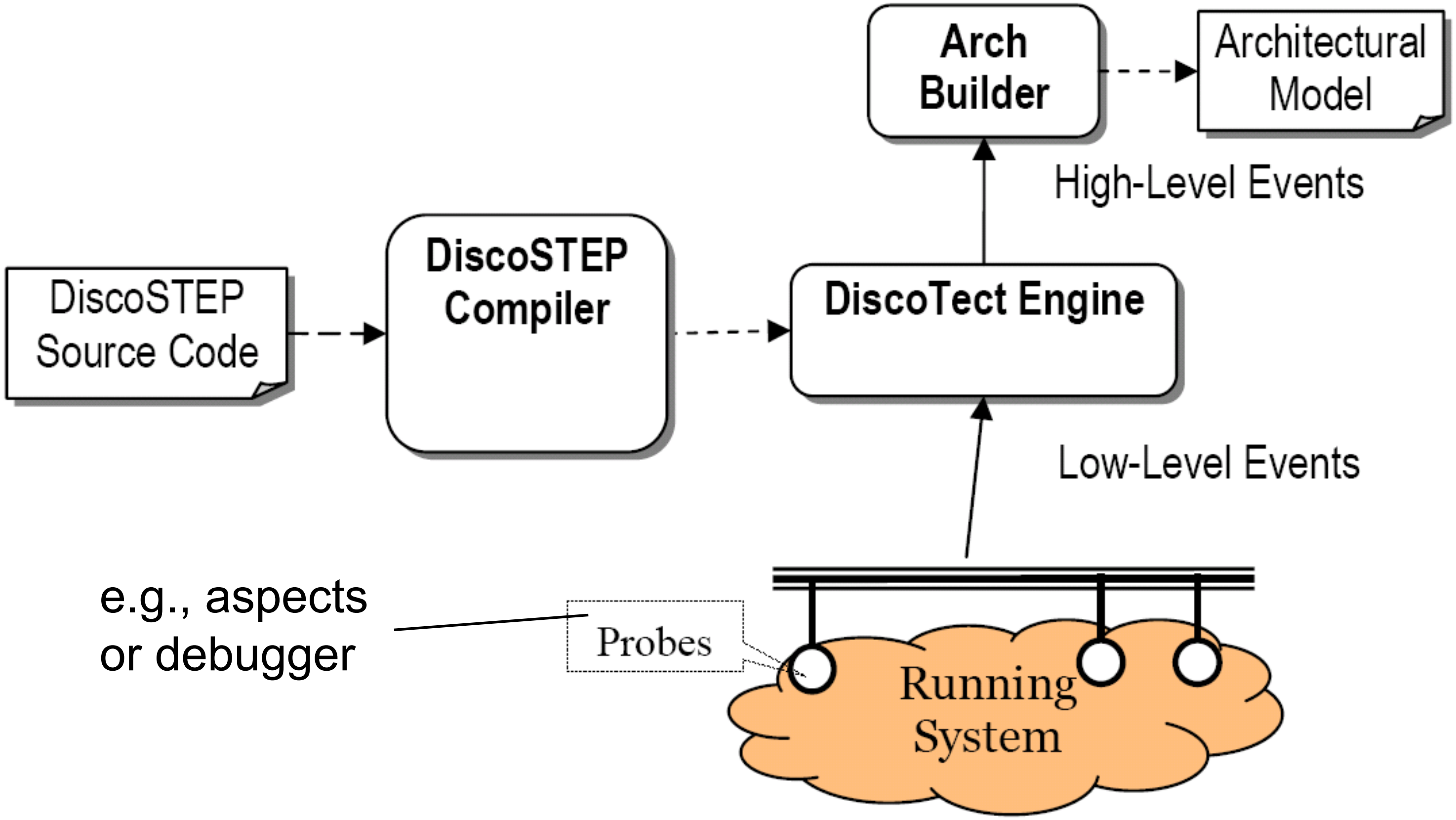
*Disco*vering Archi*tect*ure

- Mapping of runtime system events to architectural events constructing C&C views
- Online analysis while monitored system is running
- Hooks into AcmeStudio

Challenges

- Runtime system events may have a many-to-many relationship with architectural events
- Architecturally relevant events are interleaved in systems
- Architectural elements may be implemented in differing ways

DiscoTect Overview



(Cf. reference [21])

DiscoSTEP

Specification language for mapping between runtime system events and architectural events

Input event consumed by rule

Output events produced by rule

Condition, determining whether the rule will fire

Actions that produce output events

```
rule CreateServer {
  input { init $e; }
  output { string $server_id;
              create_component $create_server; }
  trigger {?
    contains($e/@type, "ServerSocket")
  ?}
  action = {?
    let $server_id := $e/@instance_id;
    let $create_server :=
      <create_component name="{$server_id}"
                        type="ServerT" />;
  }
}
```

- Triggers and actions use XQuery
- Rules may be composed with other rules via output/input events

DiscoSTEP – Events

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Input

```
<init
   type= "java.net.ServerSocket"
   instance_id="0x0f67d9"
/>
```

Output

```
<string value="0x0f67d9"/>
<create_component
   name="0x0f67d9" type="ServerT"/>
```

Code

```
ServerSocket ss = new ServerSocket(1111)
```

Event schema, input

```
<element name="init">
    <complexType>
        <attribute name="type" type="string" />
        <attribute name="instance_id" type="string" />
    </complexType>
</element>
```

DiscoSTEP – Formal Semantics

Using Coloured Petri Nets (CP-Nets)

```
rule CreateServer {
  input { init $e; }
  output { string $server_id;
              create_component $create_server; }
  trigger {?
    contains($e/@type, "ServerSocket")
  ?}
  action = {?
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}
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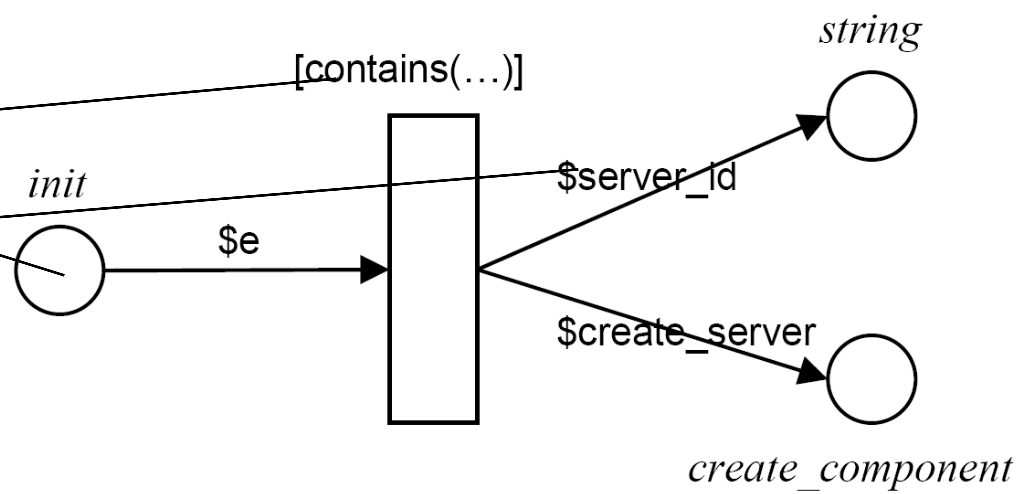

DiscoTect Example (1)

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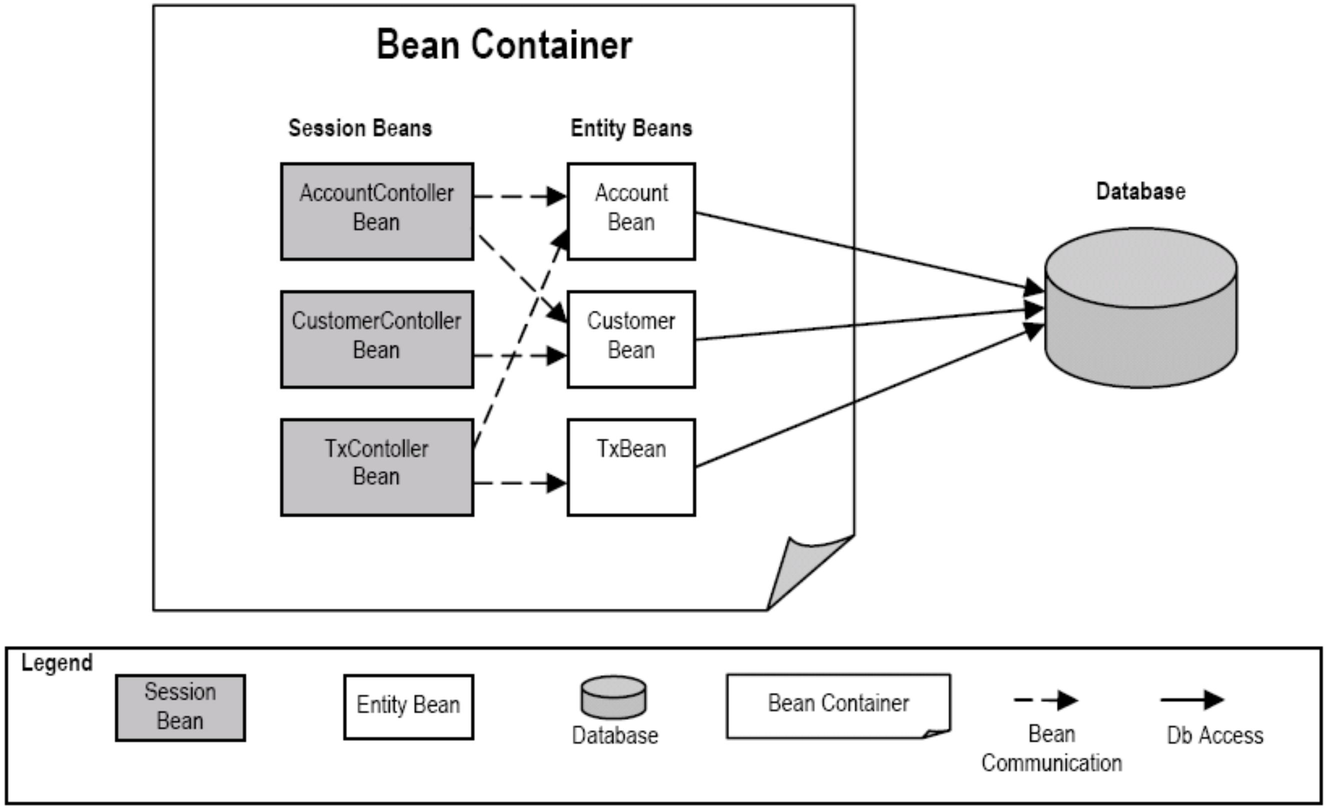

Figure 13. Documented architectural view of Duke's Bank Application

DiscoTect Example (2)

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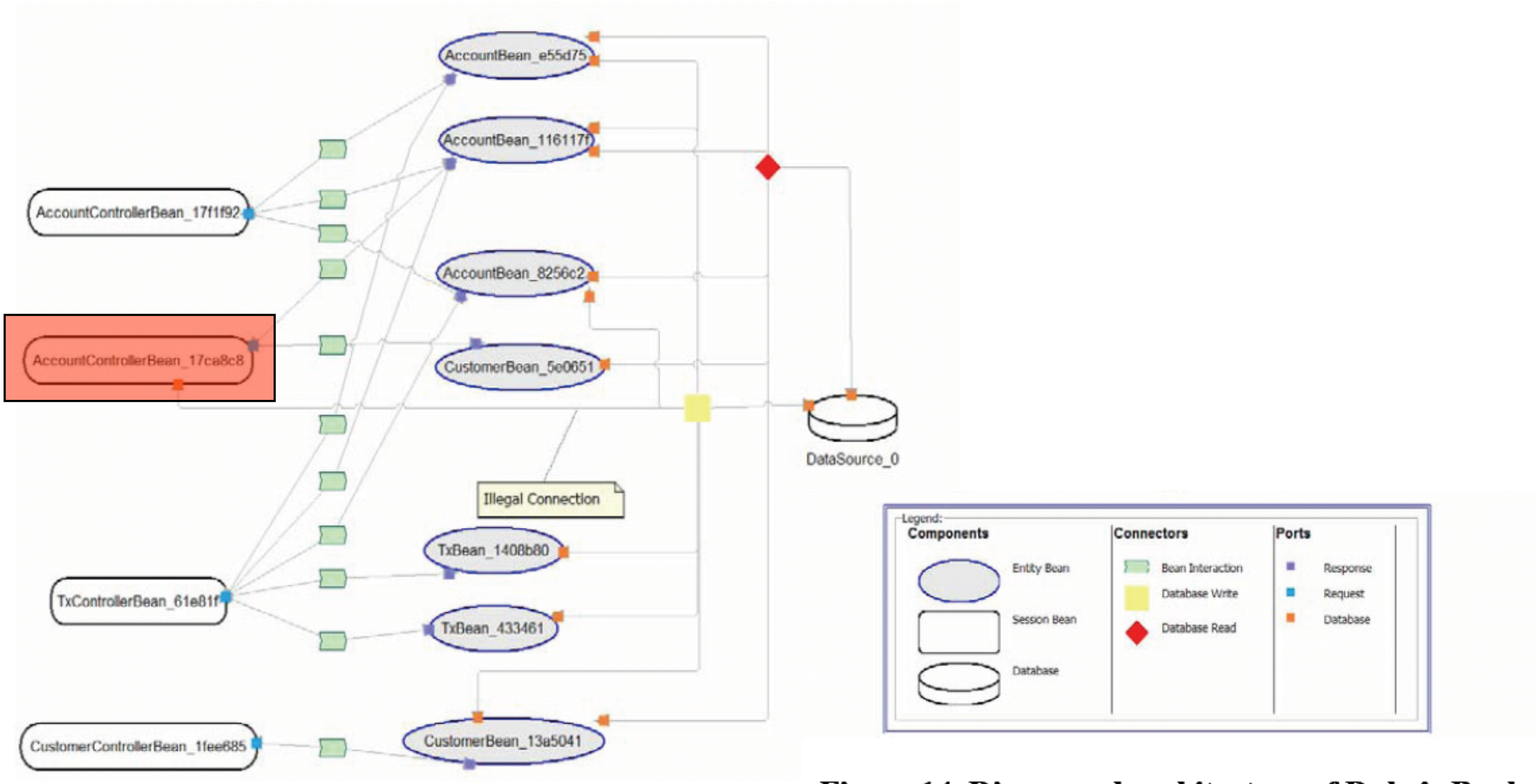

Figure 14. Discovered architecture of Duke's Bank

Summary

Three parts of architecture reflection

- Monitor, model, control
- Three-layer model

Modeling and controlling is hard

Examples

- Autonomic computing
- DiscoTect