

Introduction

- Architecture is key to reducing development costs
 - development focus shifts to coarse-grained elements
 - Formal architectural models are needed
 - ADLs have been proposed as a possible answer
 - Several prototype ADLs have been developed
 - ACME
 - Aesop
 - ArTek
 - C2
 - Darwin
 - LILEANNA
 - MetaH
 - Rapide
 - SADL
 - UniCon
 - Weaves
 - Wright
- What an ADL is and its role are still open questions

ADL Roles

- Provide models, notations, and tools to describe components and their interactions
 - Support for large-scale, high-level designs
 - Support for principled selection and application of architectural paradigms
 - Support for abstractions
 - user-defined
 - application-specific
 - Support for implementing designs
 - systematic
 - possibly automated
- Close interplay between language and environment
- language enables precise specifications
 - environment makes them (re)usable

What Does and ADL Description Look Like? (1)

- A Rapide Component

```

type Application is interface
  extern action Request(p : params);
  public action Results(p : params);
behavior
  (?M in String) Receive(?M) => Results(?M);;
end Application;

```

- A Wright connector

```

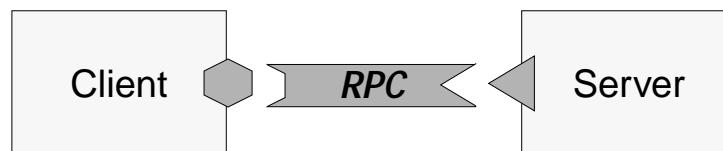
connector Pipe =
  role W = write → W ∩ close → √
  role R =
    let Exit = close → √
    in let DoR = (read → R
                 ∩ read-eof → Exit)
    in DoR ∩ Exit

  glue = let ROnly = R.read → ROnly
          ∩ R.read-eof → R.close → √
          ∩ R.close → √
          in let WOnly = W.write → WOnly
                ∩ W.close → √
          in W.write → glue
              ∩ R.read → glue
              ∩ W.close → ROnly
              ∩ Reader.close → WriteOnly

```

What Does and ADL Description Look Like? (2)

- An ACME architecture



```

System simple_cs = {
  Component client = {Port send-request}
  Component server = {Port receive-request}
  Connector rpc = {Roles {caller, callee}}
  Attachments : {
    client.send-request to rpc.caller;
    server.receive-request to rpc.callee
  }
}

```

Attempts at Understanding and Classifying ADLs

- Previous ADL surveys
 - Kogut and Clements
 - Vestal
- Insights from individual systems
 - Luckham and Vera
 - Shaw et al.
- Identifying underlying ADL characteristics
 - Tracz
 - Shaw and Garlan
 - Medvidovic, Taylor, and Whitehead
 - Medvidovic and Rosenblum
- Architecture interchange
 - ACME

Example Attempts at Understanding ADLs

- Shaw and Garlan
 - composition
 - abstraction
 - reusability
 - (re)configuration
 - heterogeneity
 - analysis
- Tracz
 - components
 - connectors
 - configurations
 - constraints

ADL Definition

- ADL Definition
 - An ADL is a language that provides features for modeling a software system's *conceptual* architecture.
- *Essential* features: *explicit* specification of
 - components
 - interfaces
 - connectors
 - configurations
- *Desirable* features
 - specific aspects of components, connectors, and configurations
 - tool support

Differentiating ADLs

- Approaches to modeling configurations
 - implicit configuration
 - in-line configuration
 - explicit configuration
- Approaches to associating architecture with implementation
 - implementation constraining
 - implementation independent

Related Notations

- High-level design notations
- Module interconnection languages (MIL)
- Object-oriented notations
- Programming languages
- Formal specification languages

ADL Components

- Definition
 - A **component** is a unit of computation or a data store. Components are loci of computation and state.
- All ADLs support component modeling
- Differing terminology
 - *component*
 - *interface*
 - *process*

Component Classification Categories

- **Interfaces**
 - model both required and provided services
- **Types**
 - enable reuse and multiple instances of the same functionality
- **Semantics**
 - facilitate analyses, constraint enforcement, and mapping of architectures across levels of refinement
- **Constraints**
 - ensure adherence to intended component uses, usage boundaries, and intra-component dependencies
- **Evolution**
 - components as design elements evolve
 - supported through subtyping and refinement
- **Non-Functional Properties**
 - enable simulation of runtime behavior, analysis, constraints, processor specification, and project management

Components	Interface	Types	Semantics	Constraints	Evolution	Non-Funct. Properties
ACME	■	■	□	□	□	□
Aesop	■	■	□	□	□	□
C2	■	■	■	□	■	□
Darwin	■	■	■	□	□	□
MetaH	■	□	■	■	□	■
Rapide	■	■	■	■	□	□
SADL	■	■	□	□	□	□
UniCon	■	□	□	■	□	■
Weaves	■	■	□	□	□	□
Wright	■	■	□	■	□	□

ADL Connectors

- **Definition**
 - A **connector** is an architectural building block used to model interactions among components and rules that govern those interactions.
- All ADLs support connector modeling
 - several ADLs do not model connectors as first-class entities
 - all ADLs support at least syntactic interconnection
- Differing terminology
 - *connector*
 - *connection*
 - *binding*

Connector Classification Categories

- **Interfaces**
 - ensure proper connectivity and communication of components
- **Types**
 - abstract away and reuse complex interaction protocols
- **Semantics**
 - analyze component interactions, enforce constraints, and ensure consistent refinements
- **Constraints**
 - ensure adherence to intended interaction protocols, usage boundaries, and intra-connector dependencies
- **Evolution**
 - maximize reuse by modifying or refining existing connectors
- **Non-Functional Properties**
 - enable simulation of runtime behavior, analysis, constraint enforcement, and selection of OTS connectors

Connectors	Interface	Types	Semantics	Constraints	Evolution	Non-Funct. Properties
ACME	■	■	□	□	□	□
Aesop	■	■	■	□	■	□
C2	■	■	□	□	□	□
Darwin	□	□	□	□	□	□
MetaH	□	□	□	□	□	□
Rapide	□	□	■	□	□	□
SADL	□	■	□	□	□	□
UniCon	■	□	□	■	□	■
Weaves	■	■	□	□	□	□
Wright	■	■	■	■	□	□

ADL Configurations

- Definition
 - An **architectural configuration** or **topology** is a connected graph of components and connectors which describes architectural structure.
- ADLs must model configurations explicitly by definition
- Configurations help ensure architectural properties
 - proper connectivity
 - concurrent and distributed properties
 - adherence to design heuristics and style rules

Configuration Classification Categories (1)

- ***Understandability***
 - enables communication among stakeholders
 - system structure should be clear from configuration alone
- ***Compositionality***
 - system modeling and representation at different levels of detail
- ***Heterogeneity***
 - development of large systems with pre-existing elements of varying characteristics
- ***Constraints***
 - depict dependencies among components and connectors

Configuration Classification Categories (2)

- ***Refinement and Traceability***
 - bridge the gap between high-level models and code
- ***Scalability***
 - supports modeling of systems that may grow in size
- ***Evolution***
 - evolution of a single system or a system family
- ***Dynamism***
 - enables runtime modification of long-running systems
- ***Non-Functional Properties***
 - enable simulation, analysis, constraints, processor specification, and project management

<i>Configurations</i>	Understandability	Compositionality	Heterogeneity	Constraints	Refinement & Traceability	Scalability	Evolution	Dynamism	Non-Funct. Properties
ACME	□	■	□	□	□	□	■	□	□
Aesop	■	■	□	■	□	□	□	□	□
C2	■	□	■	□	□	■	■	■	□
Darwin	□	■	□	□	□	□	□	□	□
MetaH	□	■	□	■	□	□	□	□	■
Rapide	□	■	□	■	■	□	□	□	□
SADL	□	□	□	■	■	■	□	□	□
UniCon	□	■	□	□	□	■	□	□	□
Weaves	□	■	□	□	□	■	■	■	□
Wright	□	■	□	■	□	□	□	□	□

ADL Tool Support

- Formality of ADLs enables their manipulation by tools
 - toolset is not part of an ADL
 - usefulness of an ADL depends on its support for architecture-based development
- Every ADL provides some tool support
- Focus typically on a particular area and/or technique
- Limited overall support motivated the need for architectural interchange
 - ACME

Tool Support Classification Categories

- **Active Specification**
 - support architect by reducing cognitive load
 - proactive vs. reactive
- **Multiple Views**
 - support for different stakeholders
- **Analysis**
 - upstream evaluation of large, distributed, concurrent systems
- **Refinement**
 - increase confidence in correctness and consistency of refinement
- **Code Generation**
 - ultimate goal of architecture modeling activity
 - manual approaches result in inconsistencies and lack of traceability
- **Dynamism**
 - enable changes to architectures during execution

<i>Tool Support</i>	Active Specification	Multiple Views	Analysis	Refinement	Code Generation	Dynamism
ACME	■	■	■			■
Aesop	■	■	■		■	
C2	■	■	■		■	■
Darwin	■	■	■		■	■
MetaH	■	■	■		■	
Rapide		■	■	■	■	■
SADL			■	■		
UniCon	■	■	■		■	
Weaves		■	■		■	■
Wright		■	■			

Discussion

- Goal: distinguish different kinds of ADLs
- ADL definition is a simple litmus test
- Several ADLs straddle the boundary
 - implementation constraining languages
 - in-line configuration languages
- Support extensive in certain areas, lacking in others
 - implementation of complex connectors
 - non-functional properties
 - refinement
 - dynamism
- Determine relative “value” of an ADL
- Aid development of ADLs
- Aid architecture interchange
 - identifying complementary ADLs