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;
```

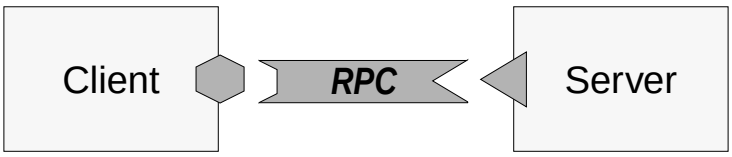
- A Wright connector

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

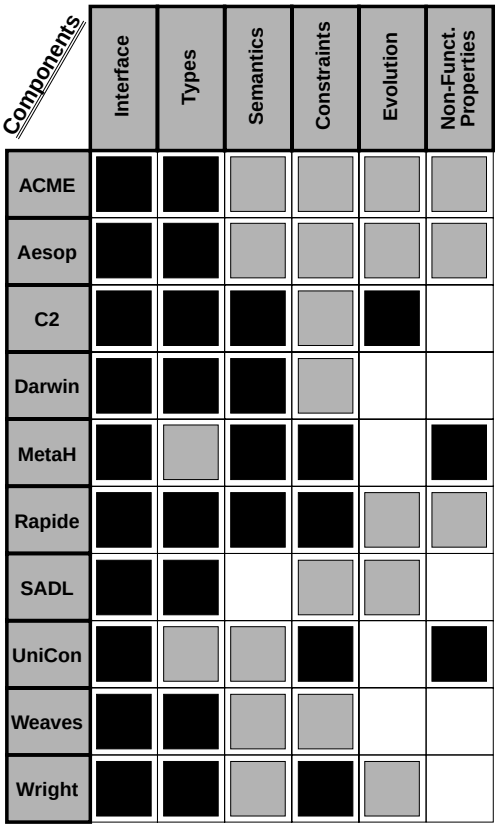
- High-level design notations
- Module interconnection languages (MIL)
- Object-oriented notations
- Programming languages
- Formal specification languages

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

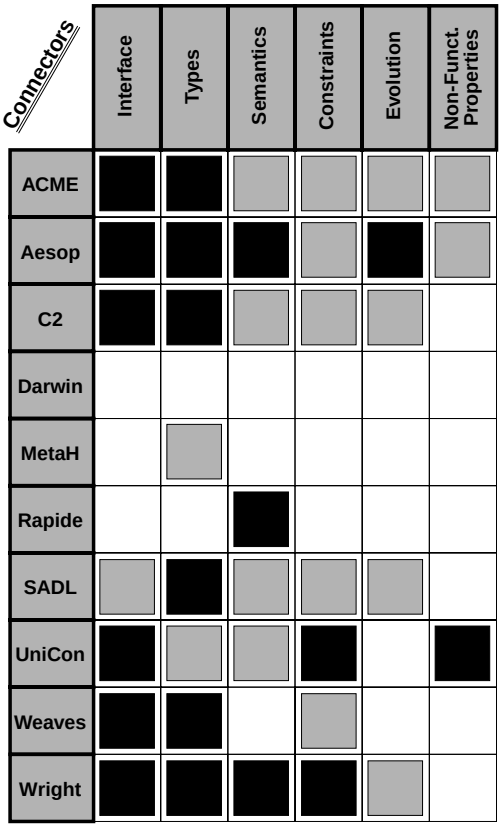


ADL Connectors

- 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



ADL Configurations

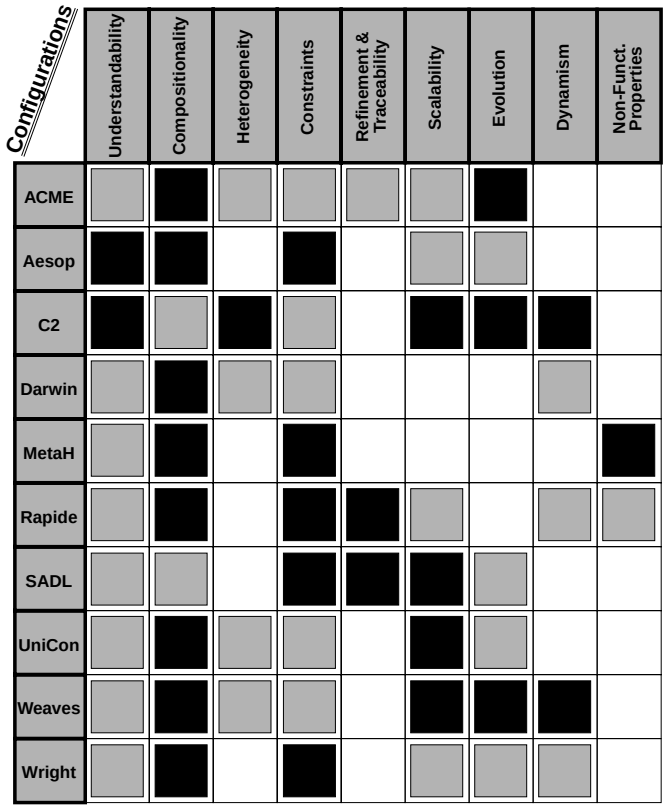
- Definition
  - An ***architectural configuration*** or ***topology*** is a connected graph of components and connectors which describes architectural structure.
- ADLs must model configurations explicitly by definition
- Configurations help ensure architectural properties
  - proper connectivity
 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

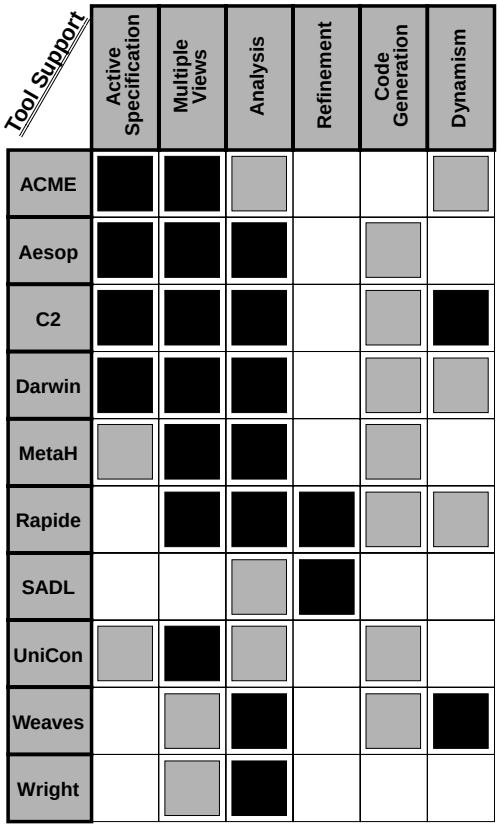


ADL Tool Support

- 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



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