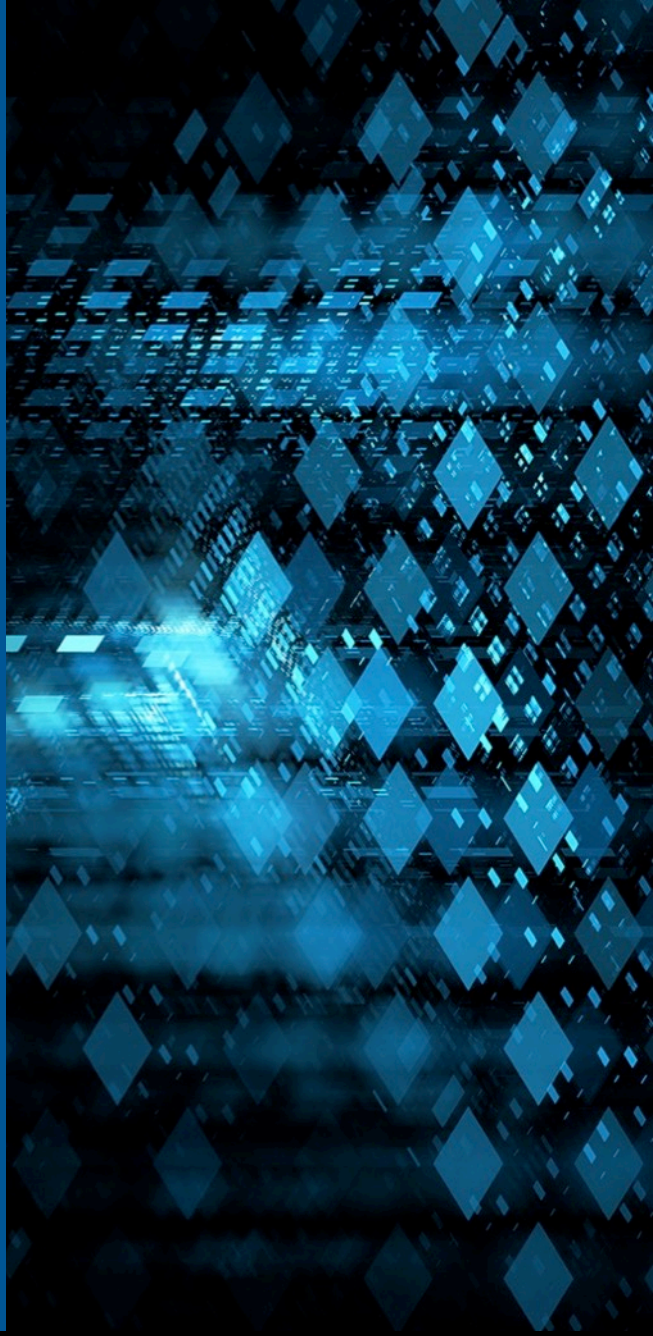
AADL: Bindings and Resources

Peter Feiler

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213



This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

DM17-0309

Bindings between System Hierarchies

AADL supports a (primary) containment hierarchy

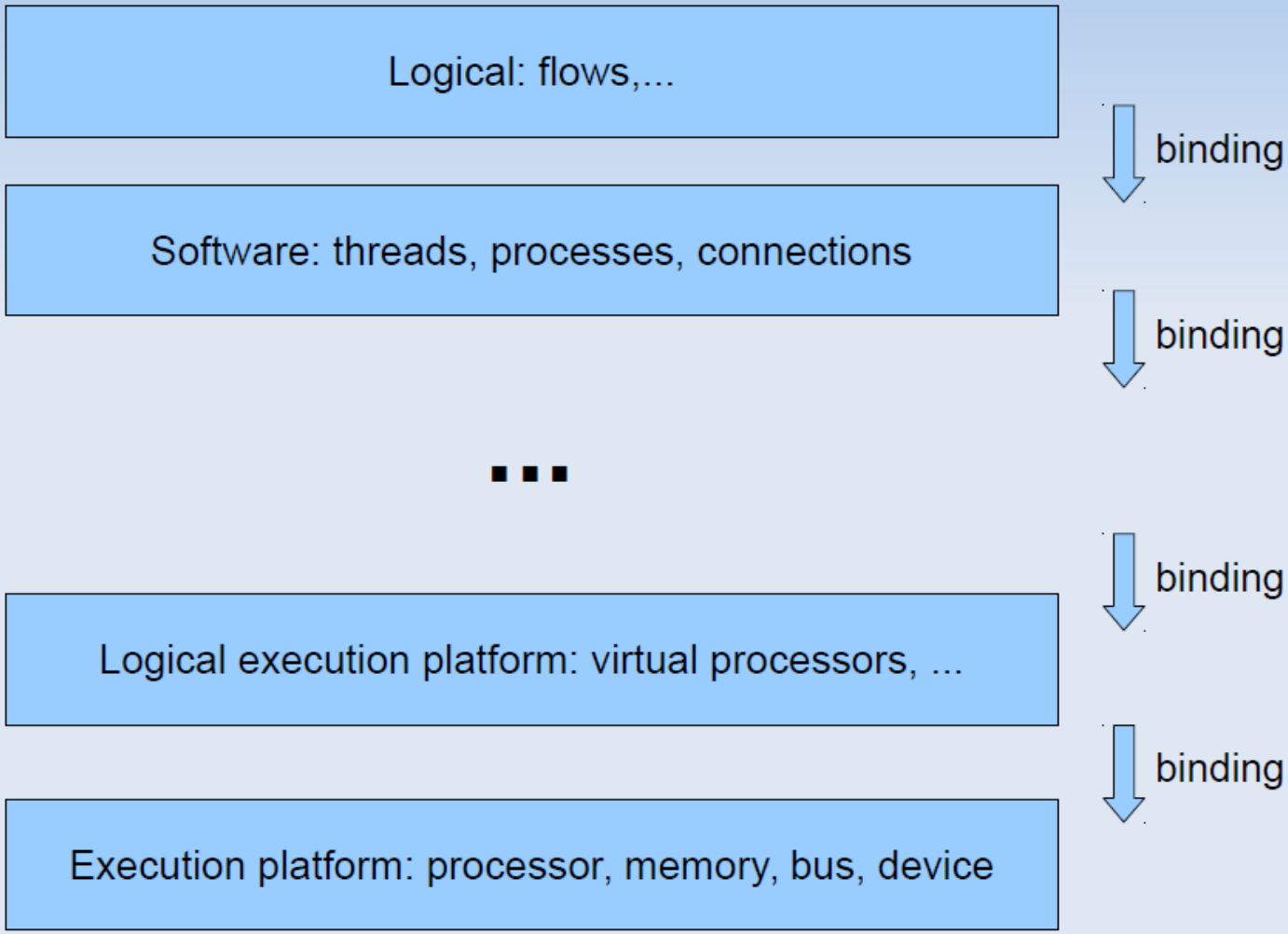
Semantic connections represent flow between and within subtrees

- Managed interaction complexity by requiring connections up and down the hierarchy to restrict arbitrary connectivity
- Note: for subprogram calls we offer both a connection and a mapping specification

Deployment bindings (aka. allocations) are a mapping from elements of one subtree to elements of another subtree

- The subtrees represent different virtual machine layers with the lower layer typically representing resources to the higher layer
- Bindings represent resource allocation

Multi Layer Architecture



Issues in Current Binding Approach

Bindings are currently expressed by properties

Binding related properties are not distinguishable from others

- Properties that express bindings
- Properties that relate to bindings

EMV2 propagation paths are derived from bindings

- binding points currently are identified by special keyword

Binding properties reach down the instance containment hierarchy

- A primary driver for introducing contained property associations

Resource Flow and Resource Allocation

Resource flow within an architecture: follows interface rules

- Continuous: Electricity, fluid flow, … Discrete: data samples, messages
- Directional flow with continuous characteristics: producer –> consumer
- Can be modeled with abstract (physical) feature and connections
- Resource type represented as type (or abstract component type)
  - Annotations for discrete or continuous flow
- Fan out/in of flow “volume”
  - multiple features & multiple connections from one feature

Resource allocation/binding: Across different architecture layers

- Resource usage that needs to be allocated/scheduled
- SW to computer platform
- Logical to physical
- Resource capacity and demand as provides and requires features
  - Feature acts as binding point: resource type as classifier
  - Multiple

Binding Specification Proposal

Binding points

- Properties, constraints

Binding instances

- Source and target configurations
- Deployment bindings aka allocations

Binding Point Specification

Explicit in features section:

- Directional features to be used as source or target of binding
- Identify type of binding (type may represent resource or target type)
- Properties related to (resource) type: capacity/budget, other target characteristics

```
thread task1
features
RequiredCycles: Requires Resources::ProcessingCycles;

Processor IntelX86
features
ProvidedService: Provides Resources::ProcessingCycles;

Virtual bus myprotocol
features
RequiredService: Requires Resources::Bandwidth;
ProvidedService: Provides Resources::Bandwidth ;
```

Virtual bus acts a virtual channel resource and requires physical channel resource

Resource Types

Resource type

- May be separate from type of binding target
- Predefined set of resource types
- Use type system to represent resource types

```
ProcessorCycles: type real units CyclesPerSec;
MemorySpace: type int units Size_Units;
```

- Memory speed vs. Memory type as target type constraint

```
MemoryResource: record [
        Size: MemorySpace;
        AccessSpeed: Bandwidth;
];
```

- Memory allocation position

```
AllocatedMemorySpace: record [
        Location: MemoryAddress;
        Size: MemorySpace;
];
MemoryAddress: type int;
```

Generic Binding Types

Binding type

- Generic type as binding type

```
FunctionalBinding: type;
```

- Usage

```
Abstract WBSFunction
features
PhysicalComponent: Requires FunctionalBinding;
```

Target Type & Binding Constraint

Target Type of Binding:

- Target classifier as binding type

```
Virtual bus myprotocol
features
RequiredService: Requires ProtocolY;
End myprotocol ;
Virtual bus ProtocolY
End ProtocolY;
```

ProtocolY provides functionality but not resource

Binding Contraint:

- Optional classifier(s) to restrict the type of target

```
Virtual bus myprotocol
features
RequiredService: Requires Resources::Bandwidth of ProtocolX;
ProvidedService: Provides Resources::Bandwidth ;
End myprotocol;
```

Classifier as separate constraint specification. Classifier must provide specified resource type.

Quantified Resource Binding Specification

Quantity specification

- Leverage directionality of binding point feature
- Separate property

```
thread task1
features
RequiredCycles: Requires Resources::ProcessingCycles => 200 MIPS;

Processor IntelX86
features
ProvidedService: Provides Resources::ProcessingCycles => 1200 MIPS;
```

Binding Point Specification

One component can have multiple binding points

- Binding points of different types
  - Need/provision of different resources, e.g., at system level
- Binding points of same type
  - Provider: subsets of total resource capacity
  - Other characteristics: address range for memory, encryption

Binding related properties

- Number of acceptable bindings
  - Provider: multiple binding points and one per binding point
  - Requestor: multiplicity of resource providers
- Resource related
  - Provider: capacity per binding point & provider component
  - Requestor: demand(budget)
- Other characteristics

Binding Instances

- System implementation contains subtrees to be mapped to each other
  - Elements of one subtree to be bound to element of another

```
System implementation AS.impl
Subcomponents
  Platform: system myplatform:Asplatform;
  Appsys: system myapp:ASApp;
End AS.impl;
configuration AS.deploymentconfig extends AS.impl (
Platform => myplatform:Asplatform.config,
Appsys => myapp:ASApp.config
);
```

Configurations of platform and Appsys

- Binding of unchangeable source and target hierarchies (Configurations)
- Multiple bindings for same configuration

```
configuration AS.boundconfig1 extends AS.deploymentconfig
(
  Appsys.sub.proc.thread1.RequiredCycles -> Platform.cpu1.ProvidedService,
  Appsys.sub.proc.thread2.cache -> Platform.cpu2.cache
);
configuration AS.boundconfig2 extends AS.deploymentconfig
(
  Appsys.sub.proc.thread1.RequiredCycles -> Platform.cpu2.ProvidedService,
  Appsys.sub.proc.thread2.cache -> Platform.cpu2.cache
);
```

Specification of bindings: need for a keyword indicating **bindings**?

Visibility of Binding Points

How far down can the allocation declaration reach

- Processor, memory, bus as boundary within design space
- Parameterized configuration as boundary for external use

Map binding point at configuration interface to component(s) in implementation that manage or represent resource

```
System ASplatform
features
  ComputeCycles: provides Resources::ProcessingCycles;
  Storage: provides Resources::cache;
End ASPlatform;
ASplatform.boundconfig configures ASPlatform.impl (
Cpu => MyHW::X86.i7,
Storage => MyHW::FasstMem.L1,
ComputeCycles -> cpu,
Storage -> Cachememory
);
```

Partial and Nested Bindings

Partial binding configurations

- Partially configured source and target system
  - Only for those elements that have been configured
- Subset of elements are bound
  - Bindings cannot be overridden

Configurations with binding points

- System may make part of its resources externally available, e.g., camera provides some of its processing capacity for a user plugin
- System may have some driver software that needs to run on an external resource

Connection Bindings

Currently: sequence of target elements

Connection acts as binding point

- Propagation identifies connection by name

```
connections
Conn1: port sub1.p1 -> sub2.p1 Requires XferBandwidth;
Conn2: abstract sub1.fe1 -> sub2.fe1 Requires WattsPerHour;
```

Platform End-to-end flow as binding target

- Expressed by end to end flow declaration
- Source and destination of ETE flow must match binding target of connection source and destination
- Each element of the flow has binding point of matching type

Virtual bus as binding target

- Virtual bus itself needs to be bound to a sequence of items => ETE flow

End-to-end flow as closed platform configuration binding point

- How to expose platform internal ETEF as external binding point? => access to virtual bus that is bound to ETE flow

Binding of Features to Platform

Processors provide ports and subprogram access

Processor features

Portx: **provides** **in data port** DT;

Applications declare processor port proxies in the processor features section of an implementation.

Move to features section of type

Portx: **requires** **in data port** DT;

Actual binding

- Once a binding of the application to the processor is specified a “connection” between the application level and the platform level is inferred by name matching of port
- Do we need to separately define the binding of the two or keep inferring?

Resource Scheduling & Binding Multiplicity

Scheduling over multiple resources

- Virtual processor (scheduler) responsible for scheduling multiple resources
  - VP binding to processors represents the set to be scheduled
- Scheduling protocol reflect in virtual processor type and Scheduling_Protocol property on VP/Processor

Memory allocation

- Starting location & size
- Relation to virtual memory?

Allocation across multiple targets

- Replicated allocation: multiple binding targets
- Partial allocation
  - multiple bindings each with percentage
  - Segmentation of data component – handling via virtual memory?