Tutorial on
CORBA Component Model (CCM)

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Overview

- The purpose of this tutorial is to
  - present the motivation of CCM
  - introduce features most relevant to distributed, real-time, embedded applications
  - present common patterns for implementing important operations for CCM components
- but not to
  - enumerate through all the mapping rules
  - provide detailed references of all interfaces
  - make you capable of implementing a CCM framework

Motivation for and Overview of CORBA Component Model

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Where We Started From: Object-Oriented Programming

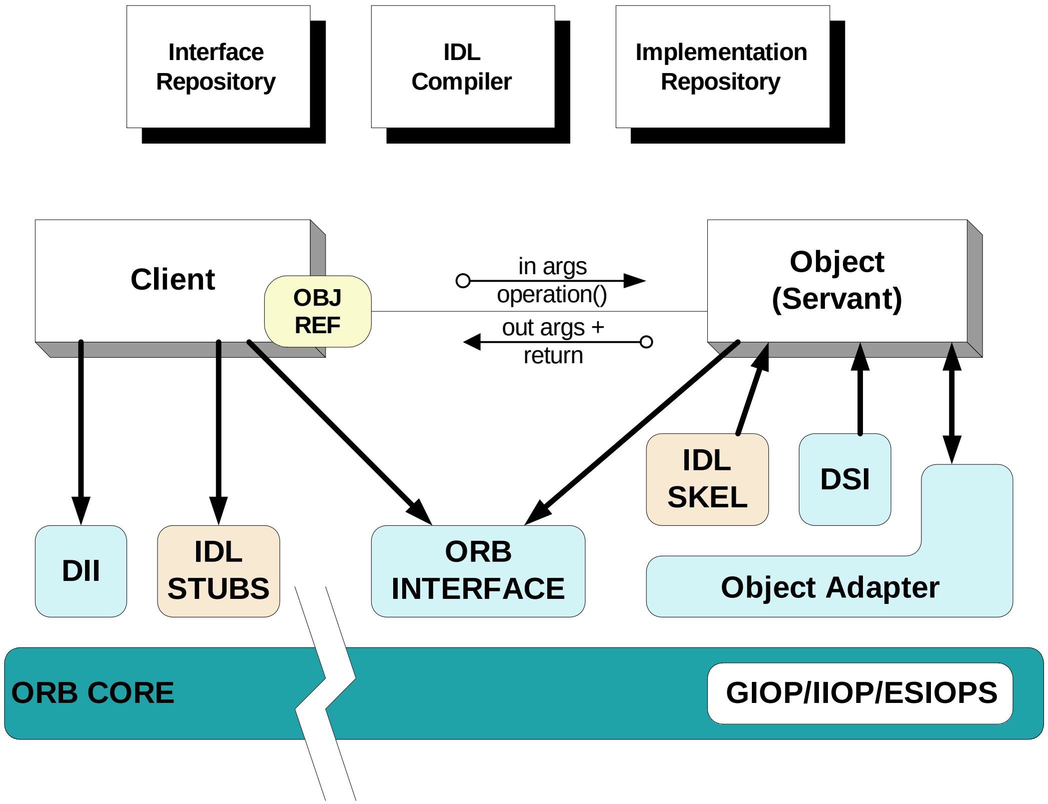
- Object-Oriented programming simplified software development through higher level abstractions (i.e. associating related data and operations)
- Applying OO to network programming (Distributed Object Computing, CORBA, RMI, etc.) simplified distributed systems development
- We now have more robust software and more powerful distributed systems

Motivations for Applying OO to Network Programming

- Abstract away lower-level OS and protocol specific details for network programming
- Create distributed systems which are easier to model and build
- Result: robust distributed systems built with OO middleware: CORBA, RMI, etc.

Overview of CORBA

- CORBA shields applications from heterogeneous platform *dependencies*
  - *e.g.,* languages, operating systems, networking protocols, hardware



- It simplifies development of distributed applications by automating/encapsulating
  - Object location
  - Connection & memory mgmt.
  - Parameter (de)marshaling
  - Event & request demultiplexing
  - Error handling & fault tolerance
  - Object/server activation
  - Concurrency
  - Security
- CORBA defines *interfaces*, not *implementations*

Example: Applying OO to Network Programming

- CORBA IDL specifies *interfaces* with operations
  - interfaces map to objects in programming languages (C++, Java)

```
interface Foo {
   void MyOp(in long arg);
};
```

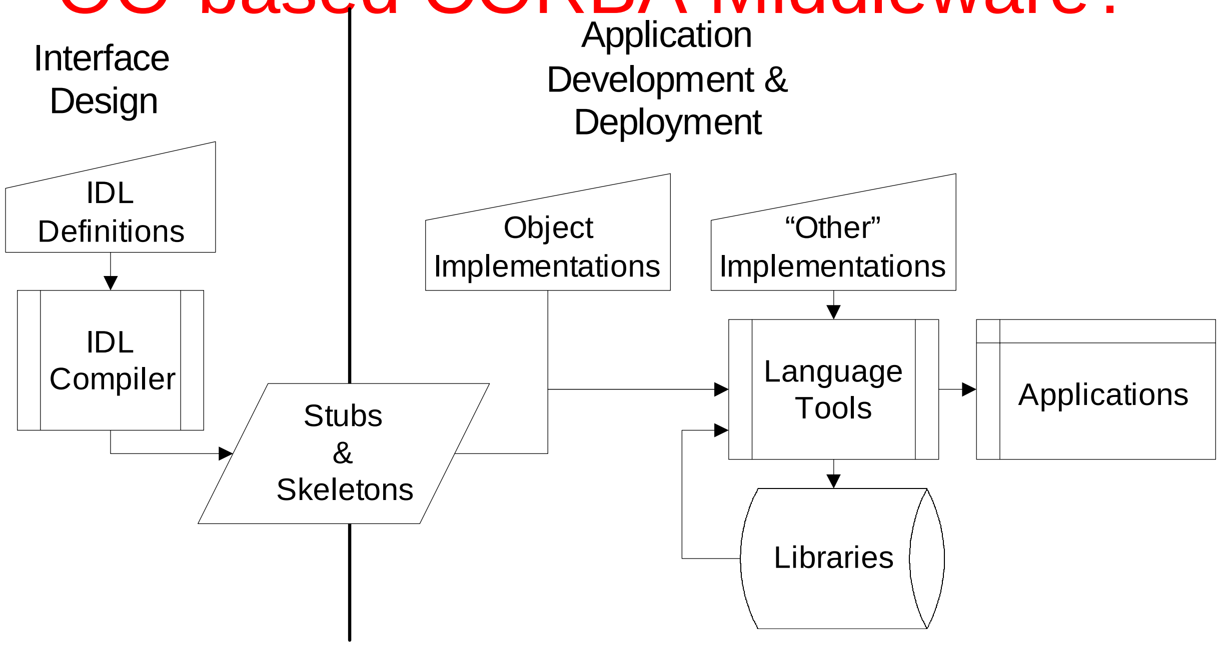
IDL

```
class Foo : public virtual CORBA::Object {
  virtual void MyOp( CORBA::Long arg);
};
```

C++

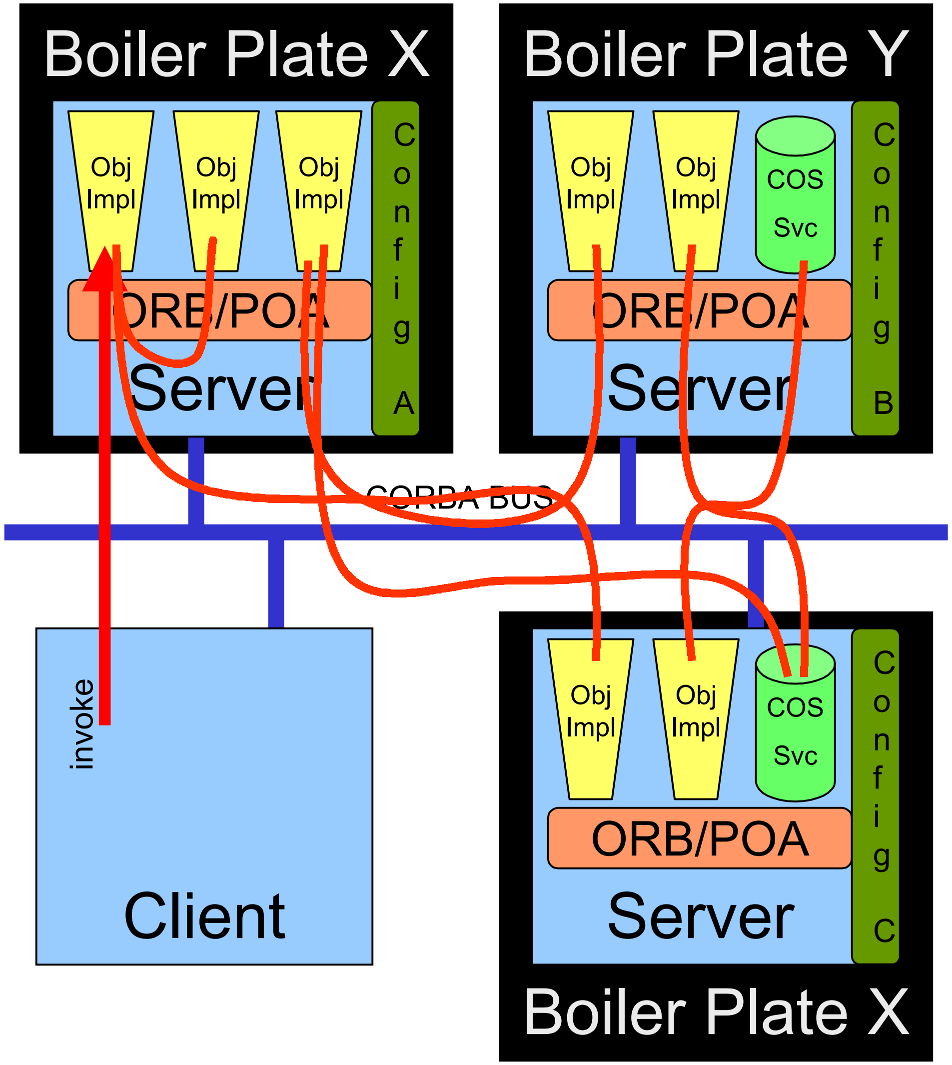
  - Operations in interfaces can be on local or remote objects

Shortcomings of Traditional OO-based CORBA Middleware?



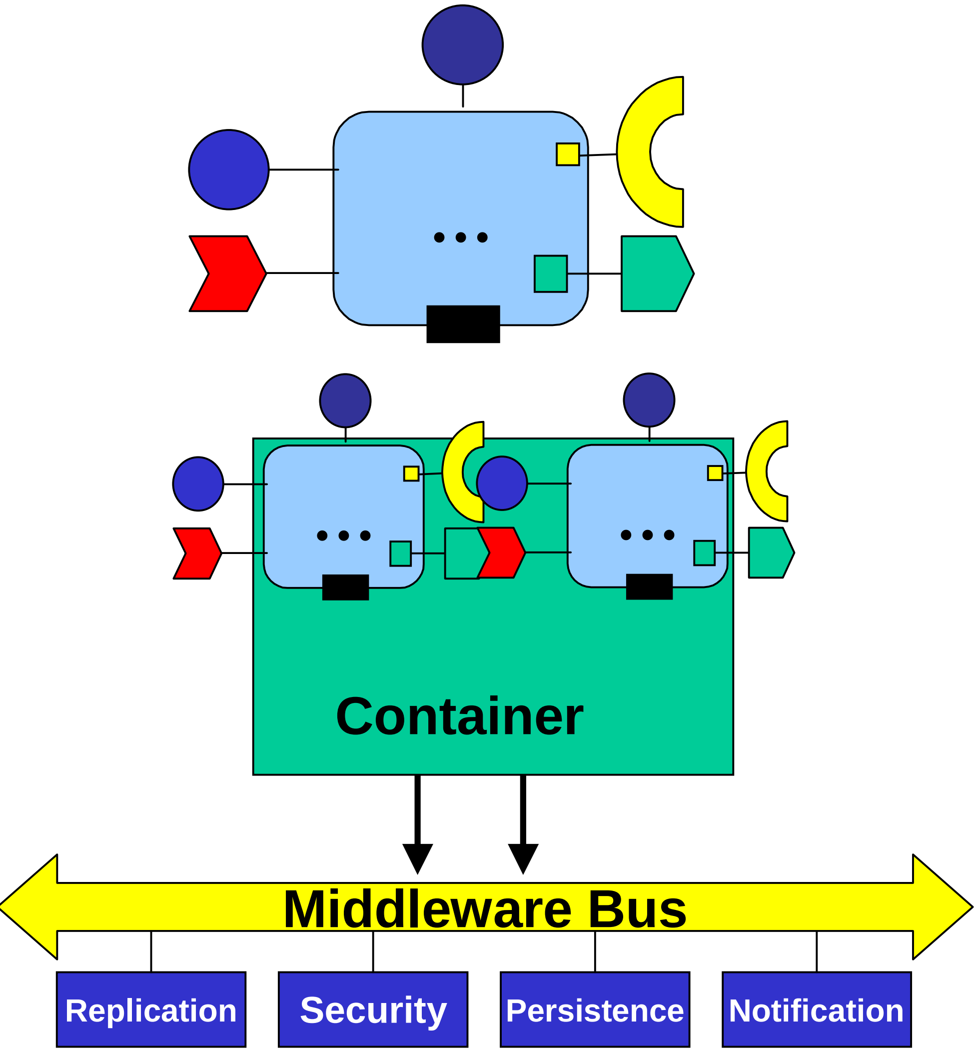
- CORBA does not specify how "assembly" and "deployment" of object implementations should be done to create larger applications
  - Proprietary infrastructure and scripts are usually written to facilitate this
- CORBA IDL does not provide a way to logically group together related interfaces to offer a specific service
  - CORBA IDL does not offer such a feature, so such "bundling" must be done by the developer

Caveat: Limitations of CORBA 2.x Specification



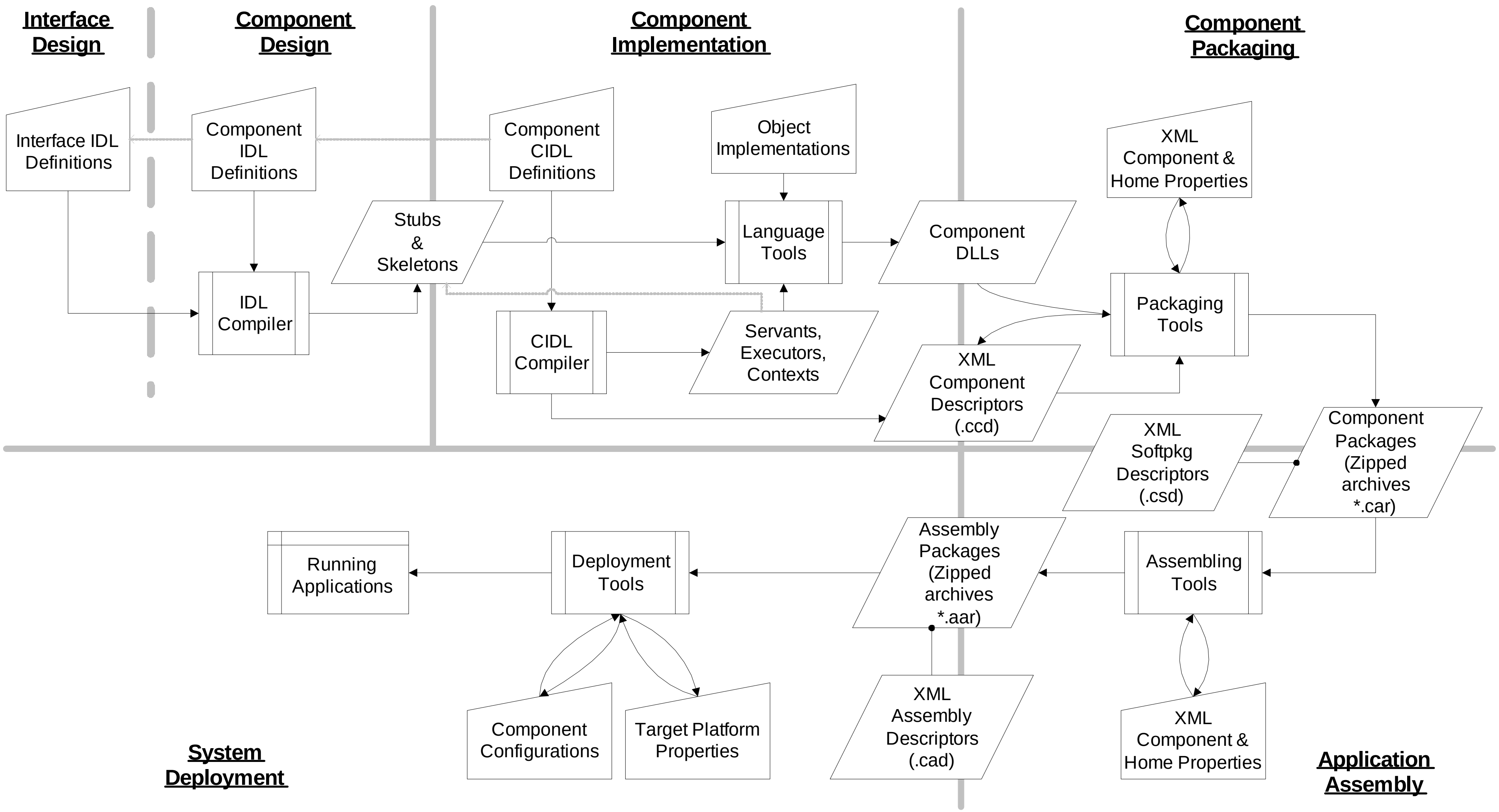
- Requirements of non-trivial applications:
  - Collaboration of multiple objects and services
  - Wide-spread deployment on diverse platforms
- Limitations – Lack of standards
  - Server configuration
  - Object/service configuration
  - Application configuration
  - Object/service deployment
- Consequences – tight couplings at various layers
  - Brittle, non-scalable implementation
  - Hard to adapt and maintain
  - Increase time-to-market

The Emergence of Component Middleware

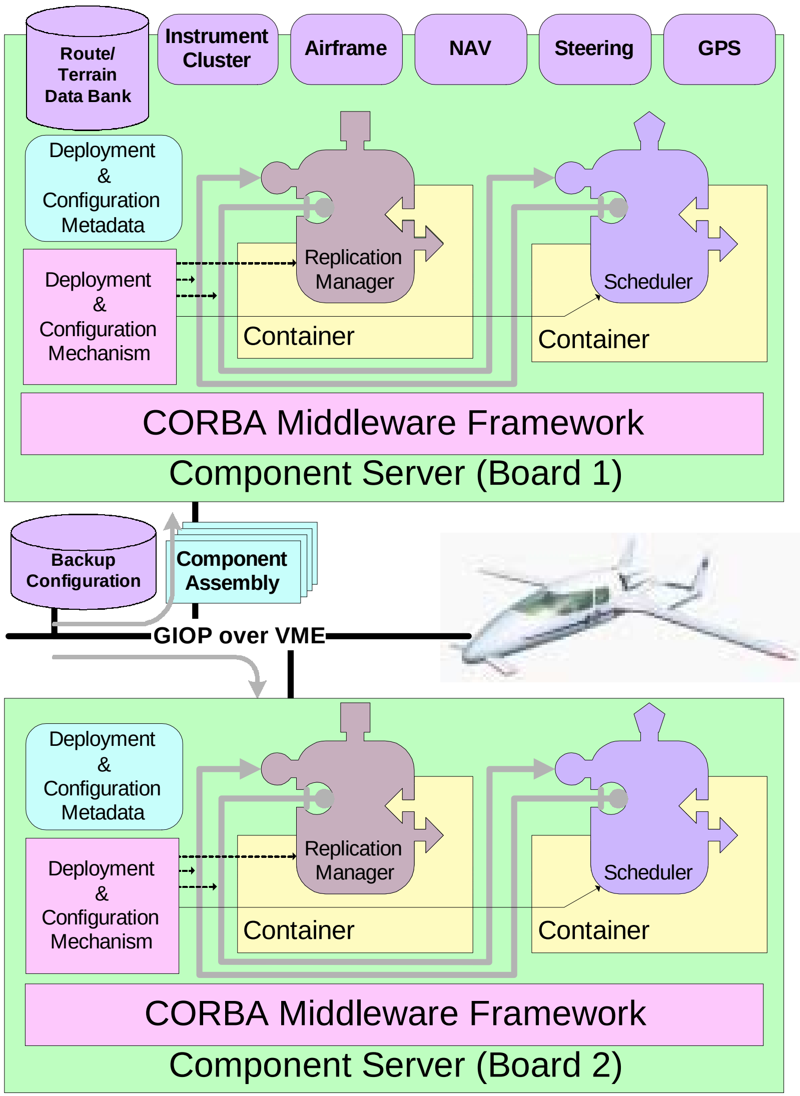


- Components give standard mechanisms for “assembly” and “deployment” of applications
- Components aggregate together related interfaces into logical units which are reusable
- Containers provide execution environment for components
- Containers communicate via a middleware bus

Stages of Component Development Lifecycle



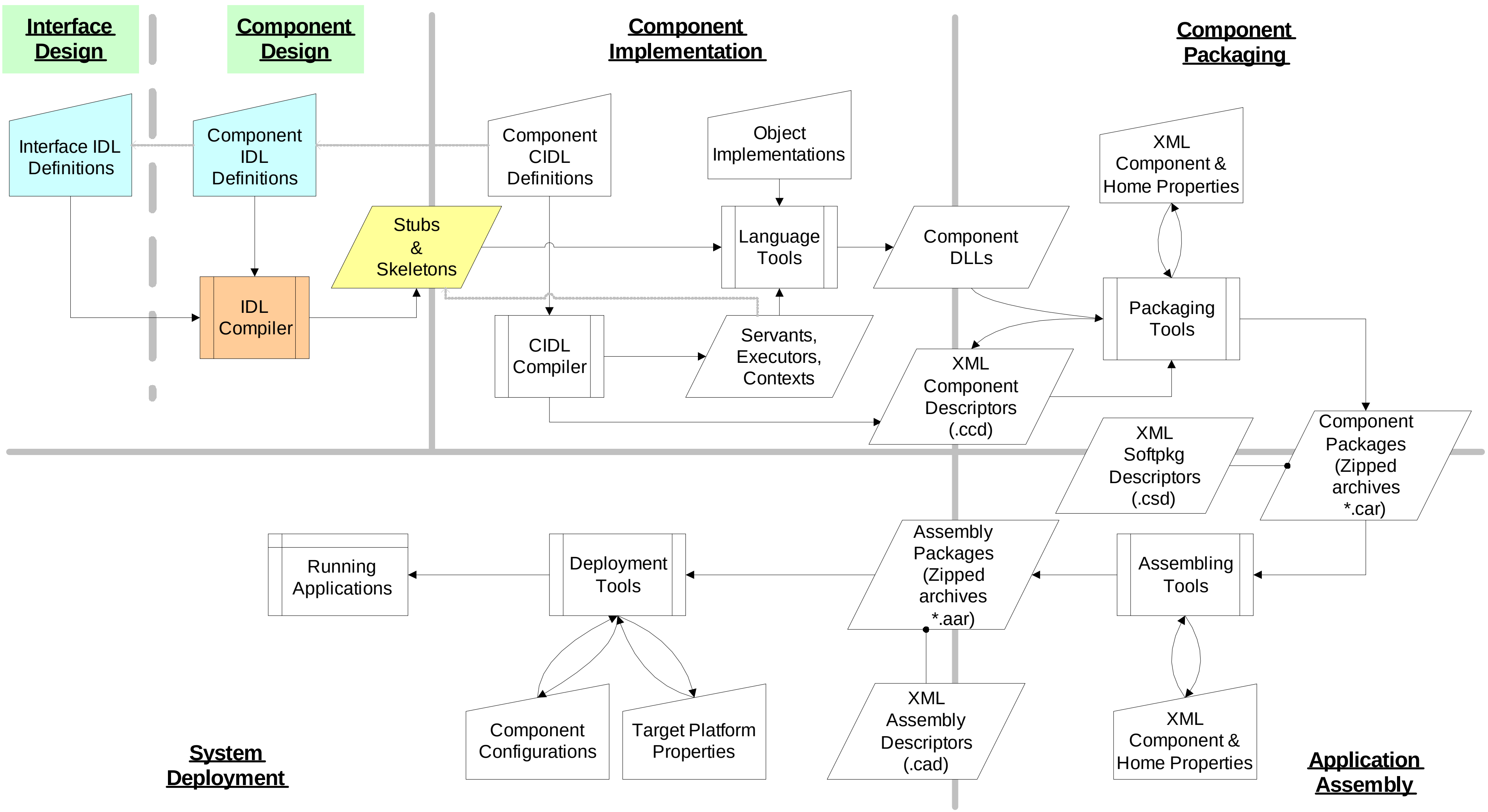
The CORBA Component Model (CCM)



- Supporting mechanisms
  - **Component Server**: a generic server process for hosting containers and components/homes
  - **Component Implemenation Framework**: automate the implementation of many component features
  - **Packaging and Assembling tools:** for collecting implementations and configurations information into deployable assemblies
  - **Deployment mechanism:** automate the deployment of component assemblies to component servers
- Goals: Separating configuration concerns into aspects:
  - Server configuration
  - Object/service configuration
  - Application configuration
  - Object/service deployment

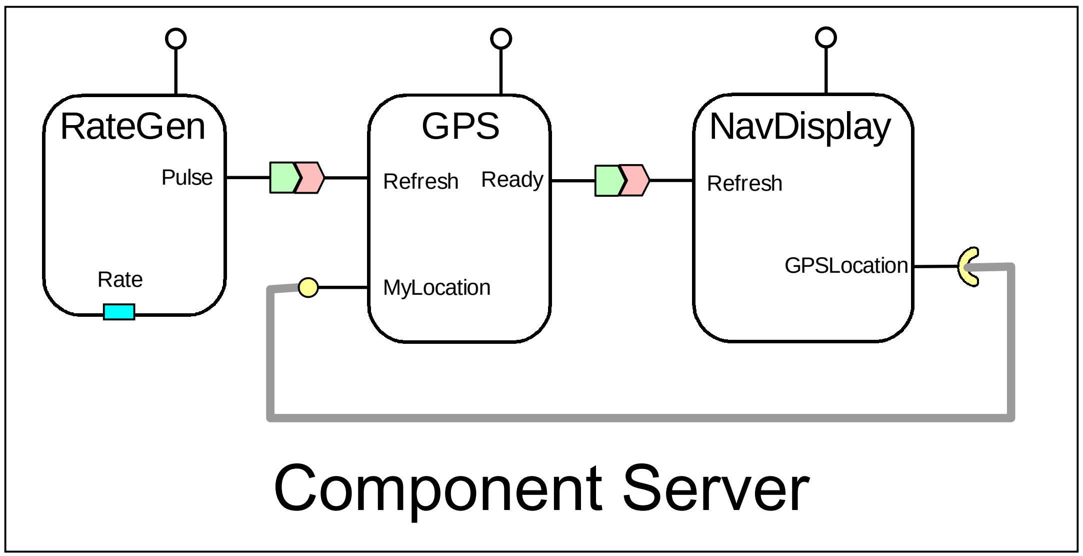
Component Features

Interface and Component Designing Stage



Application Development via Composition

Rate Generator | Positioning Sensor | Displaying Device

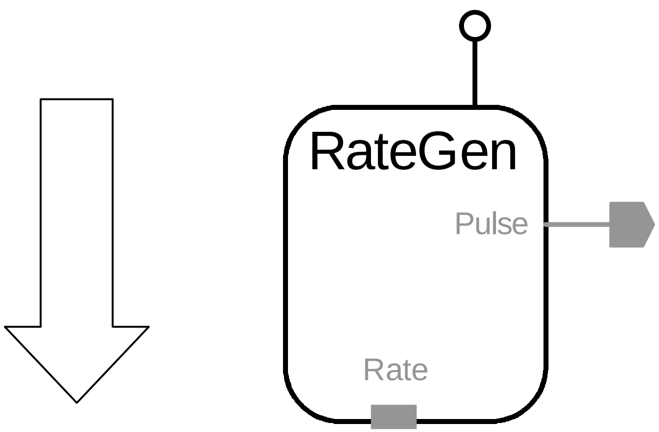


A typical use case for industrial/automotive/avionics control

- ***Rate Generator***
  - Sends periodic “Pulse” events to subscribers
- ***Positioning Sensor***
  - Refreshes cached coordinates available thru **`MyLocation`** facet
  - Notifies subscribers via “Ready” events
- ***Displaying Device***
  - Reads current coordinates via its **`GPSLocation`** receptacle
  - Updates display

A CORBA Component

```
interface rate_control
{
  void start ();
  void stop ();
};

component RateGen
  supports rate_control
{
};
```




```
interface RateGen :
  Components::CCMObject,
  rate_control
{
};
```

- Context: To support development via composition
- Limitations of CORBA objects
  - Merely identify interfaces
  - No direct relation with reusable/deployable implementations
- Goals
  - Define a unit of reuse and implementation
  - Encapsulate an interaction and configuration model
- A component is a new CORBA meta-type
  - Extension of Object
  - Has an interface, and an object reference
- Could inherit from a single component type
- Could *supports* multiple interfaces

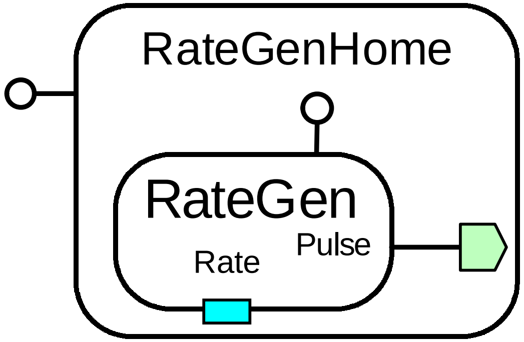
Managing Component Lifecycle

- Context:
  - Components need to be created by the CCM run-time
- Problems:
  - No standard way to manage component's lifecycle
  - Need standard mechanisms to strategize lifecycle management
- CCM Solution:
  - Integrating Lifecycle service into component definitions
  - Using different component home's to provide different lifecycle managing strategies

A CORBA Component Home

```
home RateGenHome
  manages RateGen
{
  factory create_pulser
    (in rateHz r);
};
```

```
interface RateGenHomeExplicit :
  Components::CCMHome
{
 RateGen create_pulser
  (in rateHz r);
};

interface RateGenHomeImplicit :
  Components::KeylessCCMHome
{
  RateGen create ();
};

interface RateGenHome :
 RateGenHomeExplicit,
 RateGenHomeImplicit
{};
```



- “home” is a new CORBA meta-type
  - Has an interface, thus is identified by object reference
- Manages a unique component type
  - More than one home type can manage the same component type
  - A component instance is managed by one home instance
- Standard `factory` & `finder` operations
- Can have arbitrary user-defined operations

A Quick Example

Component and Home for HelloWorld

```
interface Hello
{
  void sayHello
    (in string username);
};


component HelloWorld supports Hello
{
};


home HelloHome manages HelloWorld
{
};
```

- IDL Definitions for
  - Component: **`HelloWorld`**
  - Managing home: **`HelloHome`**

Client for HelloWorld Component

```
int
main (int argc, char *argv[])
{
  CORBA::ORB_var orb = CORBA::ORB_init (argc, argv);
  CORBA::Object_var obj =
    orb->resolve_initial_references ("NameService");
  CosNaming::NamingContextExt_var nc =
  CosNaming::NamingContextExt::_narrow (obj);
  obj = nc->resolve_str ("HelloHome");
  HelloHome_var hh = HelloHome::_narrow (obj);
  HelloWorld_var hw = hh->create ();
  hw->sayHello (“Simon”);
  hw->remove ();
  return 0;
}
```

```
$>./hello-client
Hello World!  -- from Simon.
```

1. Obtain object reference to home
2. Create component
3. Invoke remote method
4. Remove component instance
5. Clients don’t always manage component lifecycle directly

More on Component Features

Components Can Have Different Views

- Context:
  - Components need to collaborate with several different kinds of components/systems
  - These collaborating components/systems may understand different interface types

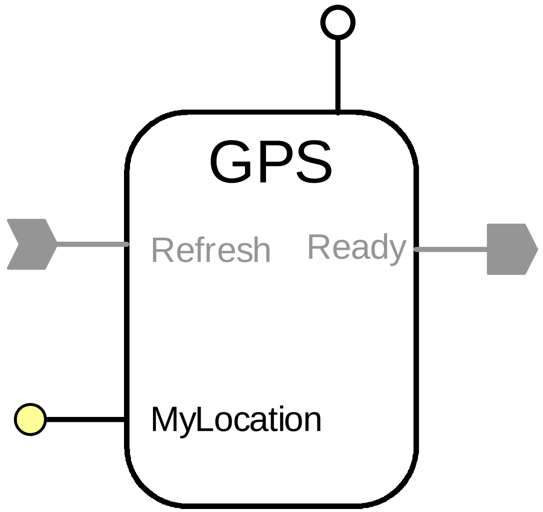
- Problems:
  - Difficult to extend an interface
  - No standard way to acquire new interfaces

- CCM Solution:
  - Define facets, aka., provided interfaces

Component Facets

```
interface position
{
  long get_pos ();
};

component GPS
{
  provides position
           MyLocation;
  …
};
```

```
interface GPS :
  Components::CCMObject
{
  position
    provide_MyLocation ();

  …
};
```



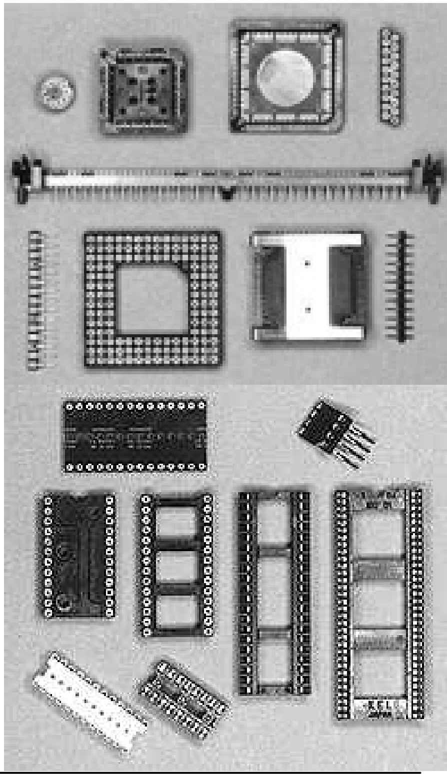
- Component facets:
  - Facets give offered operation interfaces
  - Specified with “provides” keyword

Using Other Components

- Context:
  - Components need to collaborate with several different kinds of components/systems
  - These collaborating components/systems may provide different types of interface

- Problems:
  - No standard way to specify capability to handle, or dependency to use other interfaces
  - No standard way connect an interface to a component

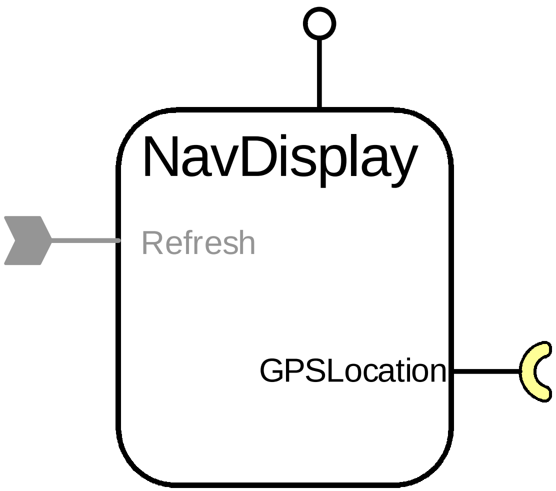
- CCM Solution:
  - Define receptacles



Component Receptacles

```
component NavDisplay
{
 …
 uses position GPSLocation;
 …
};
```

```
interface NavDisplay :
  Components::CCMObject
{
 …
 void connect_GPSLocation (in position c);
 position disconnect_GPSLocation();
 position get_connection_GPSLocation ();
 …
};
```



- Specifies a way to connect an interface to this component
- Specified with “uses” keyword

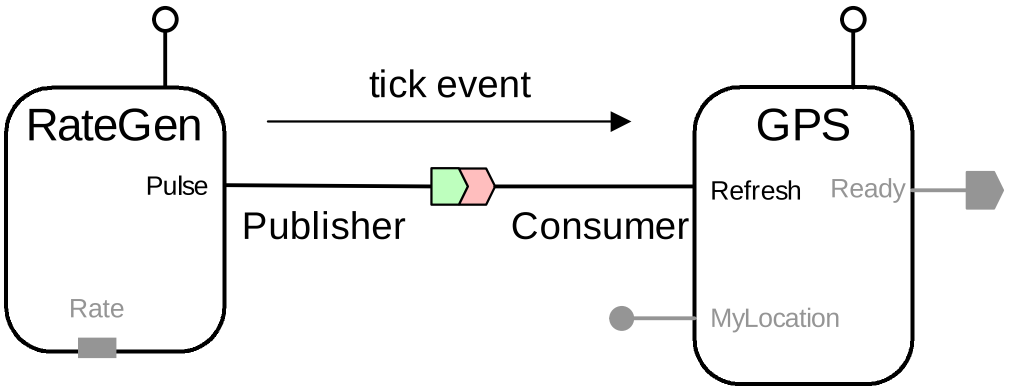
Event Passing

- Context:
  - Components may also communicate using anonymous publishing/subscribing message passing syntax
- Problems:
  - Non-trivial to extend existing interface to support event passing
  - Standard CORBA Event Service is non-typed → no type-checking connecting publishers-consumers
  - No standard way to specify component's capability to generate and process events
- CCM Solution:
  - Standard eventtype/eventtype consumer interface
  - Event sources
  - Event sinks

Component Events

```
eventtype tick
{
  public rateHz rate;
};
```

```
valuetype tick :
  Components::EventBase
{
  public rateHz rate;
};

interface tickConsumer :
  Components::EventConsumerBase
{
  void push_tick
    (in tick the_tick);
};
```

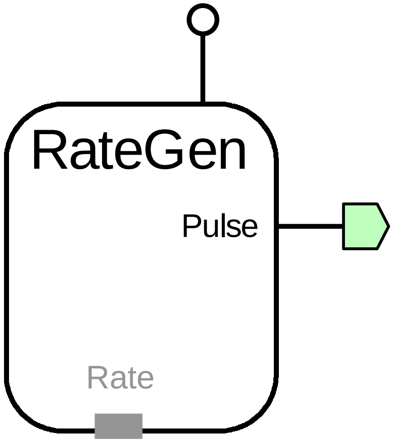


- Events are IDL valuetypes
- Defined with the new **`eventtype`** keyword

Component Event Sources

```
component RateGen
{
  publishes tick Pulse;
  emits tick trigger;
  …
};
```

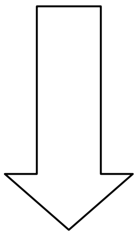
```
interface RateGen :
  Components::CCMObject
{
  Components::Cookie
    subscribe_Pulse
    (in tickConsumer c);
  tickConsumer
    unsubscribe_Pulse
    (in Components::Cookie ck);
  …
};
```



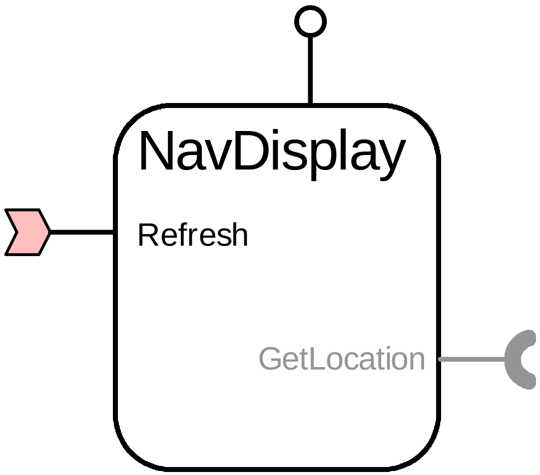
- Event sources:
  - Named connection points for event production
  - Two kinds: *Publisher* & *Emitter*
    - `publishes` = multiple consumers
    - `emits` = only one consumer
- Event delivery
  - Consumer subscribes/connects directly
  - Container mediates access to CosNotification channels or other event delivery mechanism

Component Event Sinks

```
component NavDisplay
{
 …
 consumes tick Refresh;
};
```



```
interface NavDisplay :
  Components::CCMObject
{
 …
 tickConsumer get_consumer_Refresh ();
 …
};
```



- Event sinks
  - Named interface specifies which events may be pushed
  - Event sink can subscribe to multiple event sources
  - No distinction between emitter and publisher

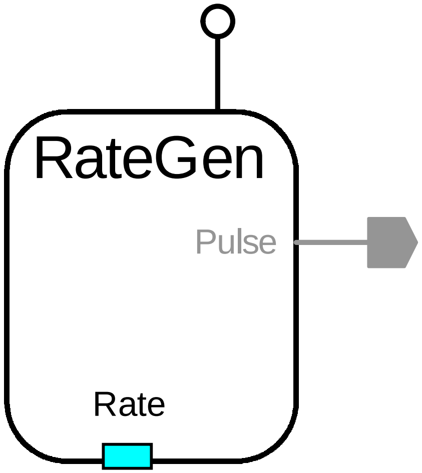
The Need to Configure Components

- Context:
  - To make component implementations more adaptable, components should be reconfigurable
- Problems:
  - Should not commit to a configuration too early
  - No standard way to specify component's configurable knobs
  - Need standard mechanisms to configure components
- CCM Solution:
  - Use component attributes for component configurations
  - Configuration mechanisms

Component Attributes

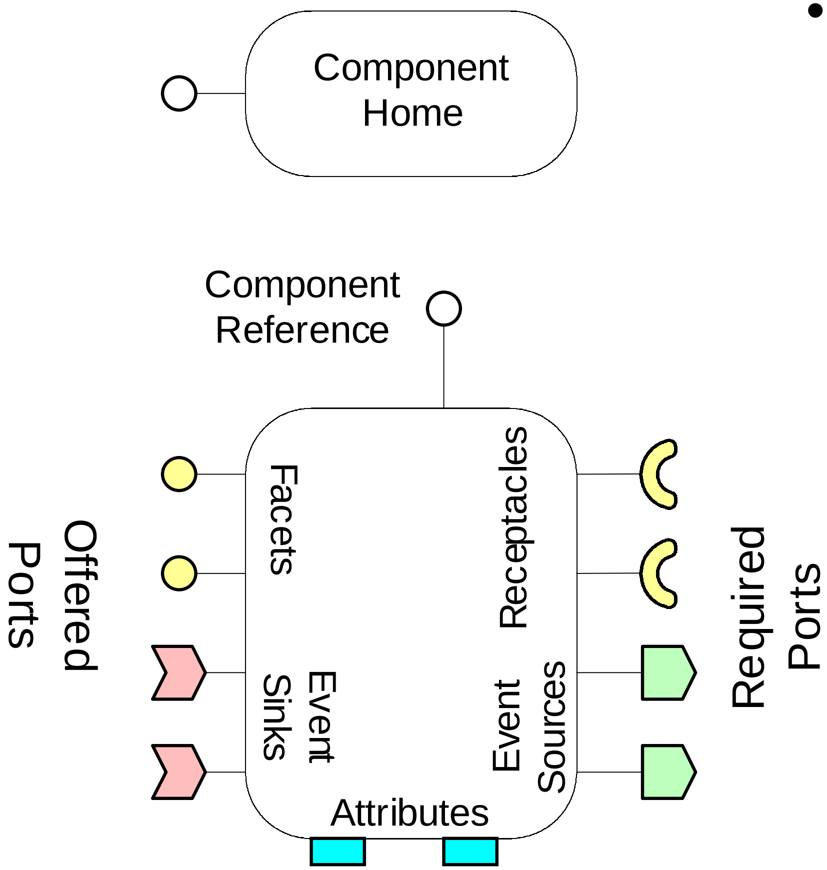
```
typedef unsigned long
        rateHz;

component RateGen
  supports rate_control
{
  attribute rateHz Rate;
};
```

```
interface RateGen :
  Components::CCMObject,
  rate_control
{
  attribute rateHz Rate;
};
```



- Named configurable properties
  - Intended for component configuration
    - e.g., optional behaviors, modality, resource hints, etc.
  - Could raise exceptions
  - Exposed through accessors and mutators

Recap – Component Features



- IDL3 definition of a component from a "client-view"
  - What the component life cycle operations are (*i.e.*, **home**)
  - What a component **offers** to other components
  - What a component **requires** from other components
  - What collaboration modes are used between components
    - Synchronous via operation invocation
    - Asynchronous via event notification
  - Which component **properties** are configurable
- Maps to "Equivalent IDL2 Interfaces"

Configuring and Connecting Components

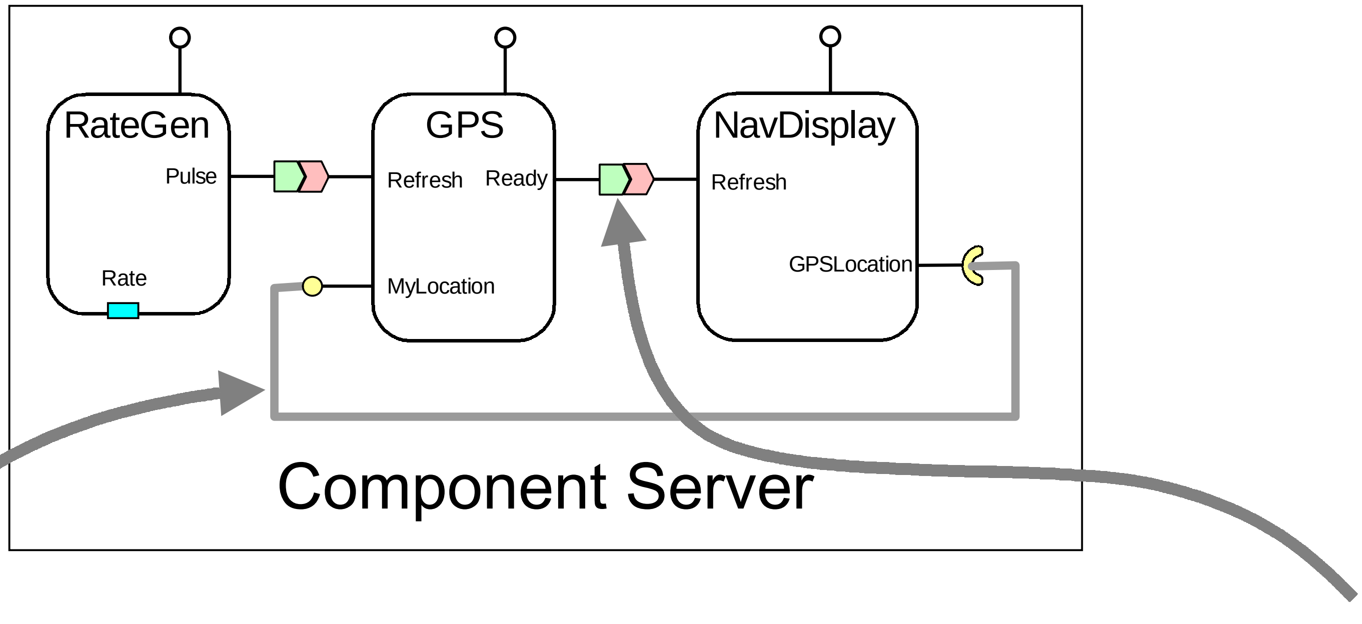
- Context:
  - Components need to be configured and connected together to form application
- Problems:
  - Components have different ports of different types and names
  - Non-scalable to generate code to connect a specific set of components
- CCM Solution:
  - Provide introspection interface to discover component capability
  - Provide generic port operations to compose/configure components

Generic Port Operations

Port	Equivalent IDL2 Operations	Generic Port Operations (`CCMObject`)
Facets	`provide_`**`name`**` ();`	`provide (“`**`name`**`”);`
Receptacles	`connect_`**`name`**` (con);` `disconnect_`**`name`**` ();`	`connect (“`**`name`**`”, con);` `disconnect (“`**`name`**`”);`
Event sources (publishes only)	`subscribe_`**`name`**` (c);` `unsubscribe_`**`name`**` ();`	`subscribe (“`**`name`**`”, c);` `unsubscribe (“`**`name`**`”);`
Event sinks	`get_consumer_`**`name`**`();`	`get_consumer (“`**`name`**`”);`

- Generic ports operations for `provides`, `uses`, `subscribes`, `emits`, and `consumes`.
  - Apply the “Extension Interface Pattern”
  - Used by deployment tools
  - Light Weight CCM spec won’t include equivalent IDL2 operations

Example of Connecting Components



- Interface → Receptacle

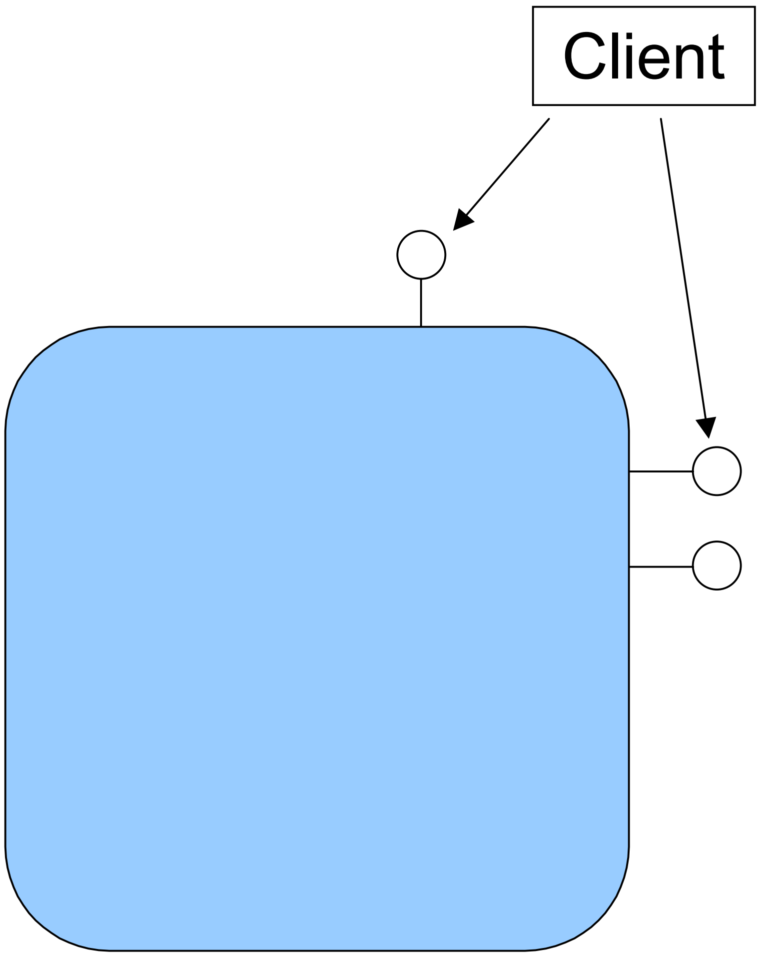
```
objref = GPS->provide
   (“MyLocation”);

NavDisplay->connect
   (“GPSLocation”,
    objref);
```

- Event Source → Event Sink

```
consumer = NavDisplay->
 get_consumer (“Refresh”);

 GPS->subscribe
   (“Ready”,
    consumer);
```

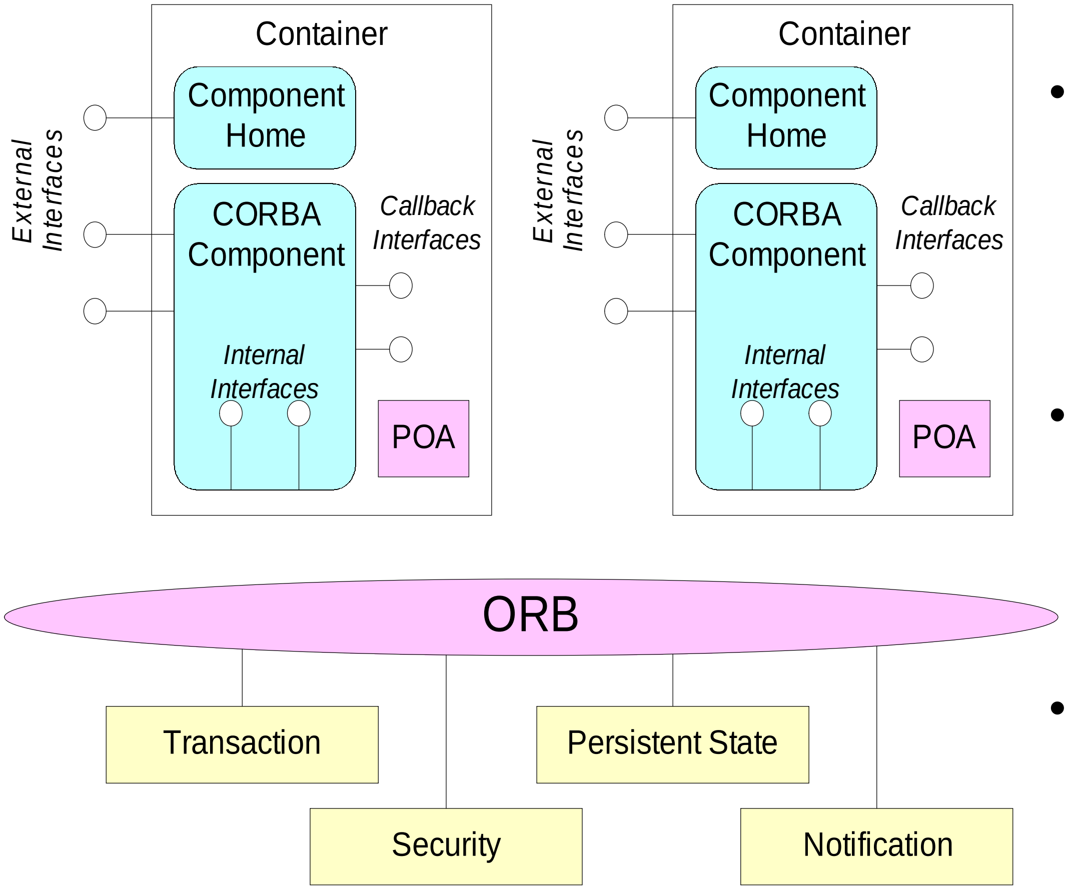
Component Runtime Environment

CCM Server-side Features



- CCM is all about component – server - application configuration
- CORBA 2.x specifications lack higher level abstractions of servant usage models
- Require programmatic configuration (more often with boiler plate-like code)
- Apply meta-programming techniques
  - Reusable run-time environment
  - Drop in and run
  - Transparent to clients

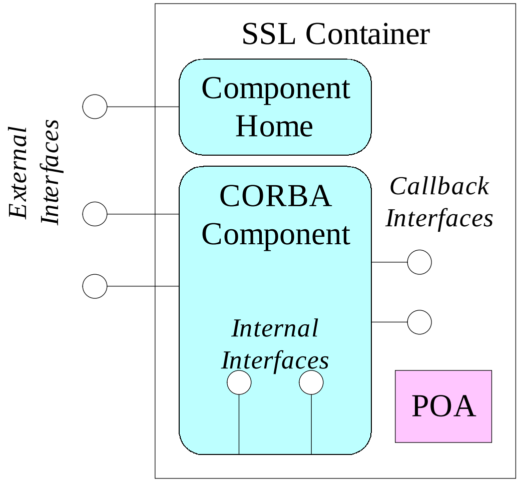
The Container Model

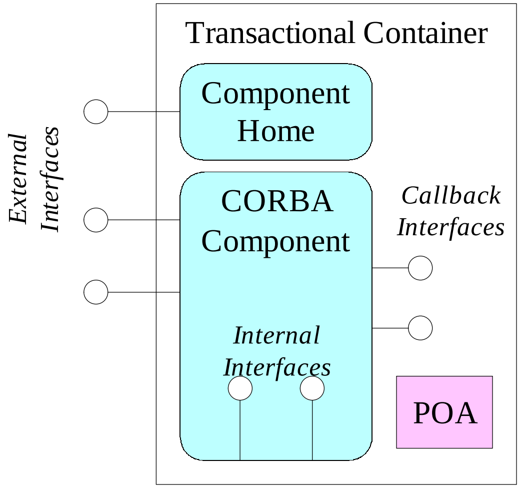


- A framework in component servers
- Built on the Portable Object Adaptor
  - Automatic activation / deactivation
  - Resource usage optimization
- Provides simplified interfaces for CORBA Services
  - Security, transactions, persistence, and events
- Uses callbacks for instance management
  - session states, activation, deactivation, etc.

Container Managed CORBA Policies

- Goal: decouple runtime configuration from the component implementation & configuration
- Specified by the component implementors using XML-based metadata
- Implemented by the container, not the component
- CORBA Policy declarations defined for:
  - Servant Lifetime
  - Transaction
  - Security
  - Events
  - Persistence





Implementing CORBA Components

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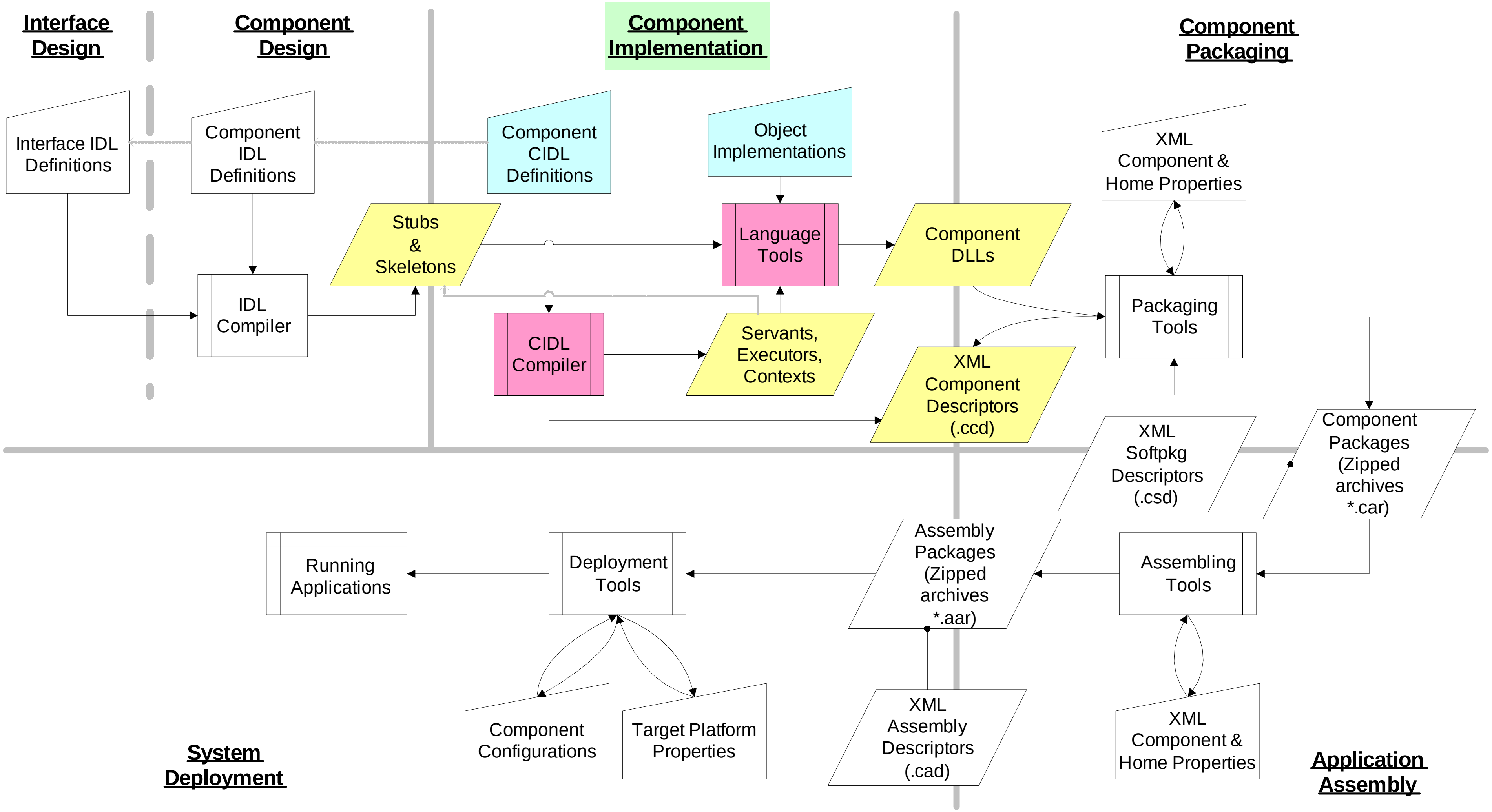
Component Implementation Stage



Requirements for Implementing Components

Component and home Definitions

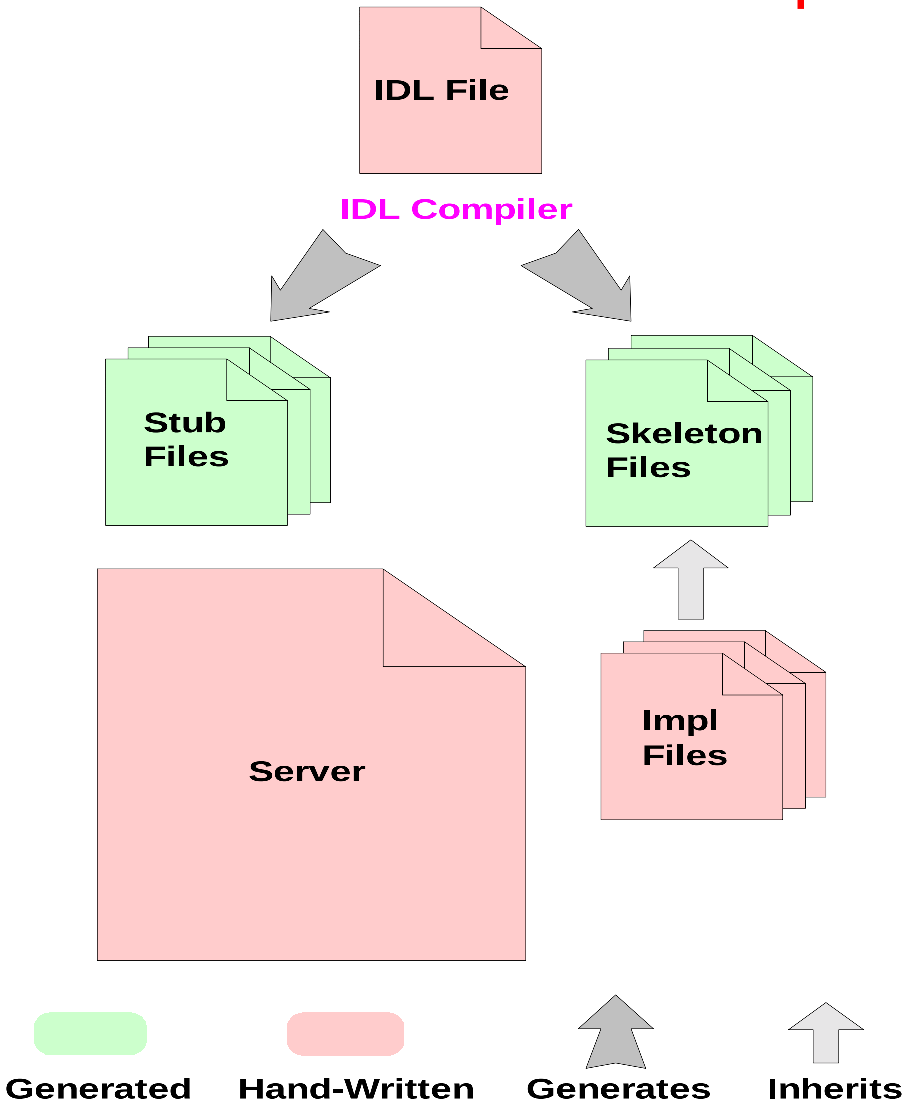
↓

Component and home servants:

- Navigation interface operations
  Receptacles interface operations
  Events interface operations
- CCMObject interface operations
  CCMHome interface operations
- Implied equivalent IDL2 port operations
- Application-related operations
  (in facets, supported interfaces,
  event consumers)

- Component implementations need to support introspection, navigation and manage connections.
- Different implementation may assume different run-time requirements
- Different run-time requirements use different container interfaces

Difficulties with Implementing Components



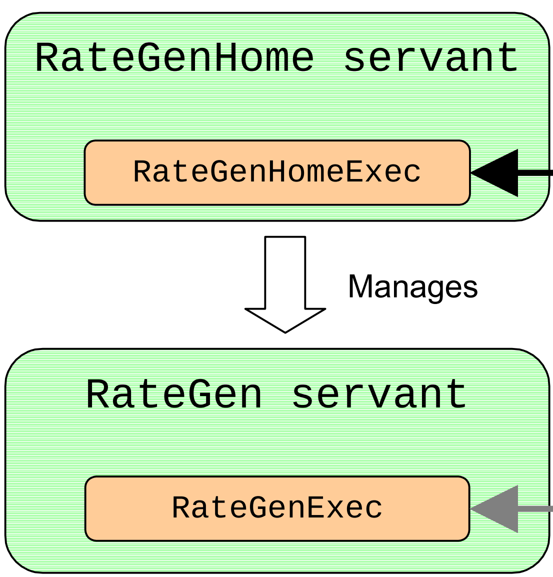
Problem:

Generic lifecycle and initialization server code must be handwritten.

- *Ad hoc* design
- Code bloat
- No reuse

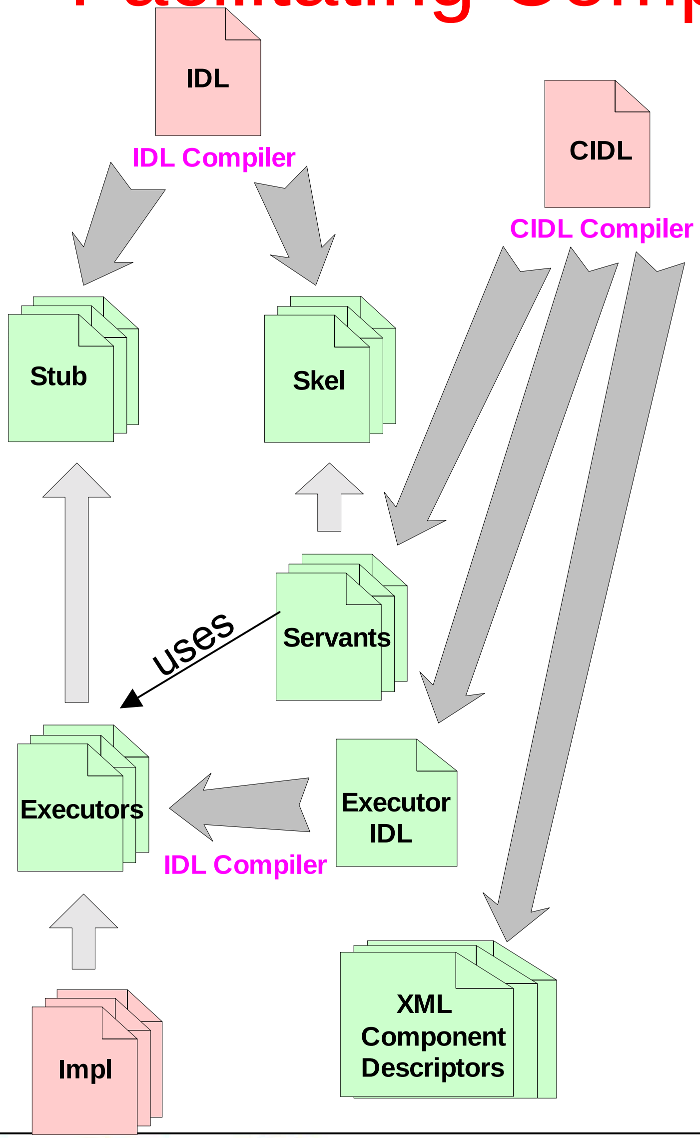
Component Implementation Framework (CIF)

```
// RateGen.cidl
#include "RateGen.idl"
composition session RateGenImpl
{
  home executor
    RateGenHomeExec
  {
    implement RateGenHome;
       manages RateGenExec;
  };
};
```



- CIF defines rules and tools for developing component implementations
  - Local executors
- Extends CCM-related declarations in IDL files.
- Describes component implementations.
- Automate most component implementation

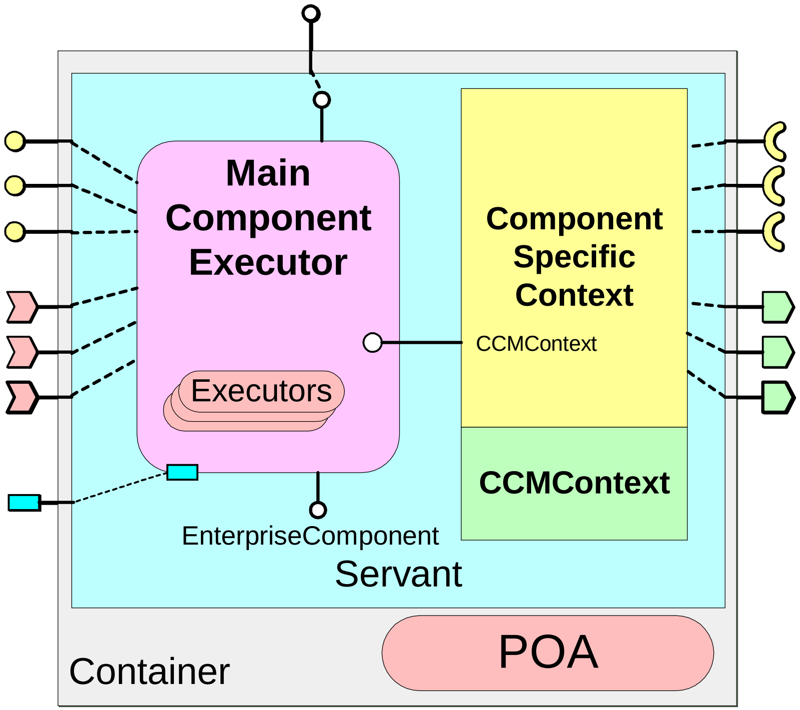
Facilitating Component Implementation



Solution: CIDL is part of CCM strategy for managing complex applications.

- Helps separation of concerns.
- Helps coordination of tools.
- Increases the ratio of generated to hand-written code.
- Server code is now generated, startup automated by other CCM tools.

Connecting Components and Containers with CIDL



- CIDL compiler generates infrastructure code which connects together component implementations and container which hosts them
- Infrastructure code in container intercepts invocations on executors
  for managing activation, security, transactions, persistency, and so on
- CIF defines "executor mappings"

Examples on Component Implementations

Simple HelloWorld & HelloHome Executors

```
interface Hello
{
  void sayHello
    (in string username);
};
component HelloWorld supports Hello
{};
home HelloHome manages HelloWorld
{};
```

```
class HelloWorld_Impl
  : public virtual CCM_HelloWorld,
    public virtual CORBA::LocalObject
{
public:
  HelloWorld_Impl () {}
  ~HelloWorld_Impl () {}

  void sayHello (const char *username)
    {
      cout << "Hello World for "
           << username
           << endl;
    }
};
```

```
class HelloHome_Impl
  : public virtual CCM_HelloHome,
    public virtual CORBA::LocalObject
{
public:
  HelloHome_Impl () {}
  ~HelloHome_Impl () {}

  Components::EnterpriseComponent_ptr
  create ()
  {
    return new HelloWorld_Impl ();
  }
};
```

- Implements behaviors of HelloWorld component
- Implement a lifecycle management strategy of HelloWorld component

Component Entry Point Example

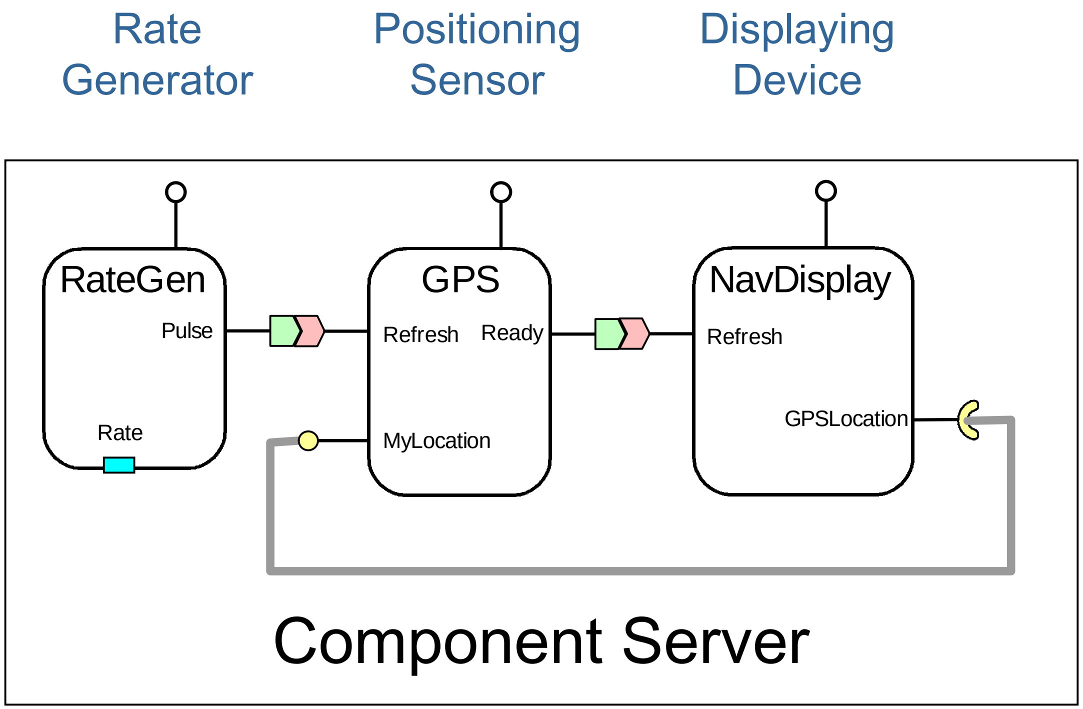
```
extern "C" {

Components::HomeExecutorBase_ptr
create_HelloHome ()
{
  return new HelloHome_impl;
}

}
```

- Container calls this method to create a home executor
- extern “C” required to prevent C++ name mangling, so function name can be resolved in DLL

Implementing Ports Mechanisms



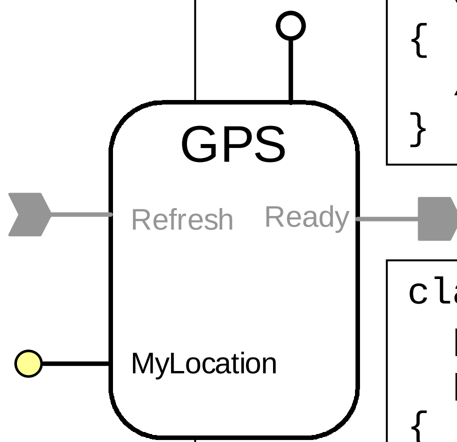
- Stuff that get invoked upon
  - Facets
  - Event sinks
- Stuff that the component invokes
  - Receptacles
  - Event sources

Implementing Facets

```
interface position
{
  long get_pos ();
};

component GPS
{
  provides position
           MyLocation;
  …
};
```

```
interface GPS :
  Components::CCMObject
{
  position
    provide_MyLocation ();
  …
};
```



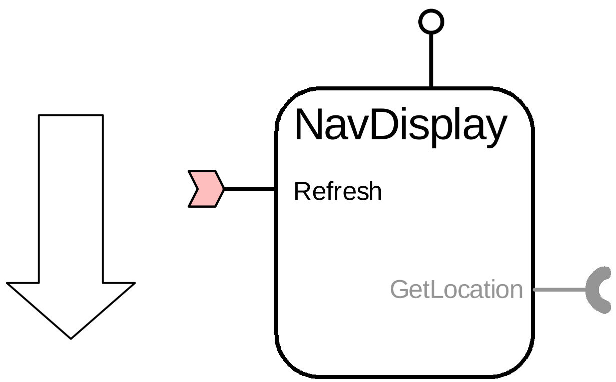

```
local interface GPS_Executor:
  CCM_GPS,
  CCM_position,
  Components::SessionComponent
{
  // Monolithic Executor Mapping
}
```

```
class GPS_Executor_Impl :
  public virtual GPS_Executor,
  public virtual CORBA::LocalObject
{
public:
  …
  virtual CCM_position_ptr
  get_MyLocation ()
  { return this; }

  virtual CORBA::Long
  get_pos ()
  { return cached_current_location; }
  …
};
```

Component Event Sinks

```
component NavDisplay
{
 …
 consumes tick Refresh;
};
```



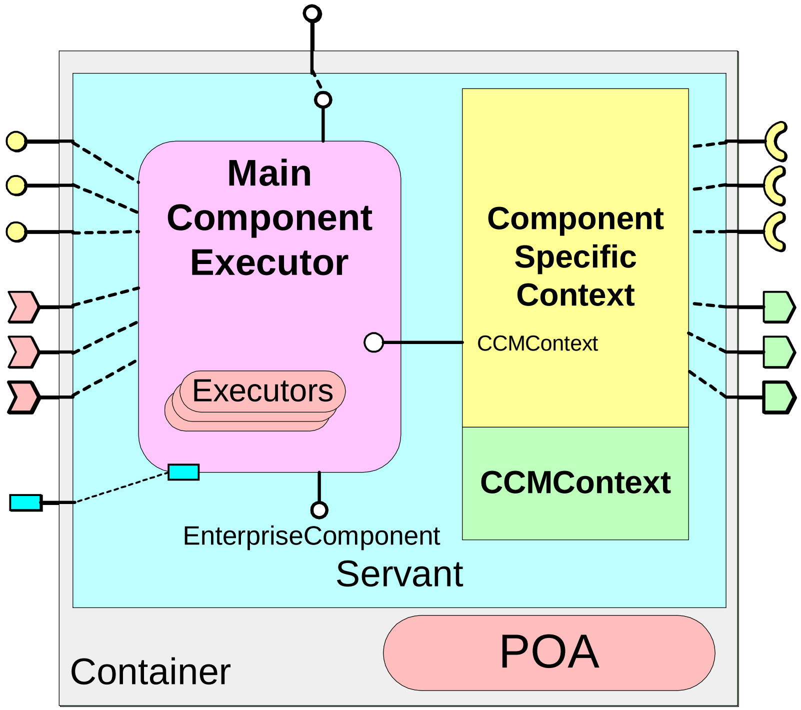

```
interface NavDisplay :
  Components::CCMObject
{

 …
 tickConsumer
  get_consumer_Refresh ();
 …
};
```

- Event sinks
  - Clients can acquire consumer interfaces, similar to facets
  - CIDL generates event consumer servants
  - Executor mapping defines push operations directly

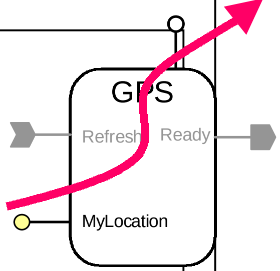
```
class NavDisplay_Executor_Impl :
  public virtual CCM_NavDisplay,
  public virtual CORBA::LocalObject
{
public:
  …
  virtual void push_Refresh (tick *ev)
  {
    this->refresh_reading ();
  }
  …
};
```

Initialize Component Specific Context



- Component-specific context manages connections and subscriptions
- Container passes component its context via either
  - `set_session_context`
  - `set_entity_context`

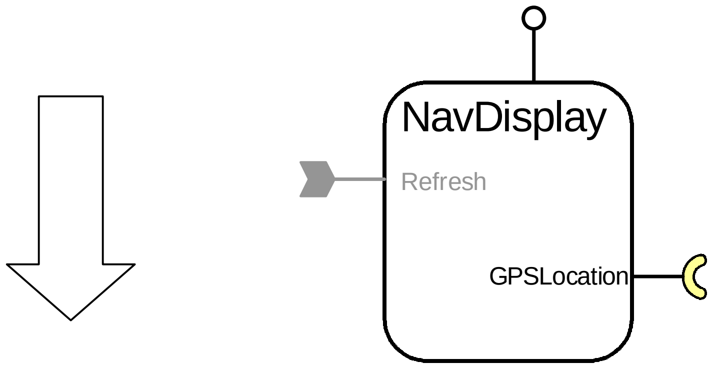
```
local interface GPS_Executor:
  CCM_GPS,
  CCM_position,
  Components::SessionComponent
{
}
```




```
class GPS_Executor_Impl :
  public virtual GPS_Executor,
  public virtual CORBA::LocalObject
{
private:
  CCM_GPS_Context_var context_;
public:
  …
  void set_session_context
    (Components::SessionContext_ptr c)
  {
    this->context_ =
      CCM_GPS_Context::narrow (c);
  }
  …
};
```

Using Receptacle Connections

```
component NavDisplay
{
 …
 uses position GPSLocation;
 …
};
```



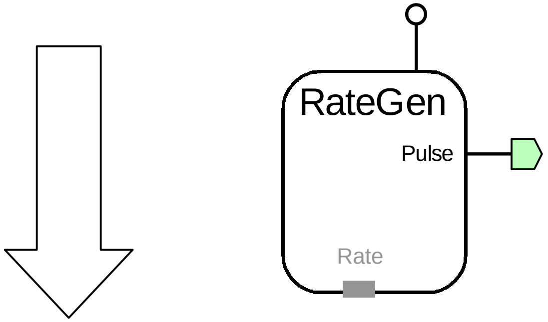

```
interface NavDisplay :
  Components::CCMObject
{
 …
 void connect_GPSLocation (in position c);
 position disconnect_GPSLocation();
 position get_connection_GPSLocation ();
 …
};
```

- Component-specific context manages receptacle connections
- Executor acquires the connected reference from the context

```
class NavDisplay_Executor_Impl :
  public virtual CCM_NavDisplay,
  public virtual CORBA::LocalObject
{
public:
  …
  virtual void refresh_reading
   (void) {
    position_var cur =
    this->context_->
      get_connection_GPSLocation ();
    long coord = cur->get_pos ();
    …
  }
  …
};
```

Pushing Events from a Component

```
component RateGen
{
  publishes tick Pulse;
  emits tick trigger;
  …
};
```




```
interface RateGen :
  Components::CCMObject
{
  Components::Cookie
    subscribe_Pulse
    (in tickConsumer c);
  tickConsumer
    unsubscribe_Pulse
    (in Components::Cookie ck);

  …
};
```

- Component-specific context manages consumer subscriptions (for publishers) and connections (for emitters)
- Component-specific context also provides the event pushing operations and relays events to consumers

```
class RateGen_Executor_Impl :
  public virtual CCM_RateGen,
  public virtual CORBA::LocalObject
{
public:
  …
  virtual void send_pulse (void){
    tick_var ev = new tick ();
    this->context_->push_Pulse ();
  }
  …
};
```

Component Packaging, Assembly, and Deployment

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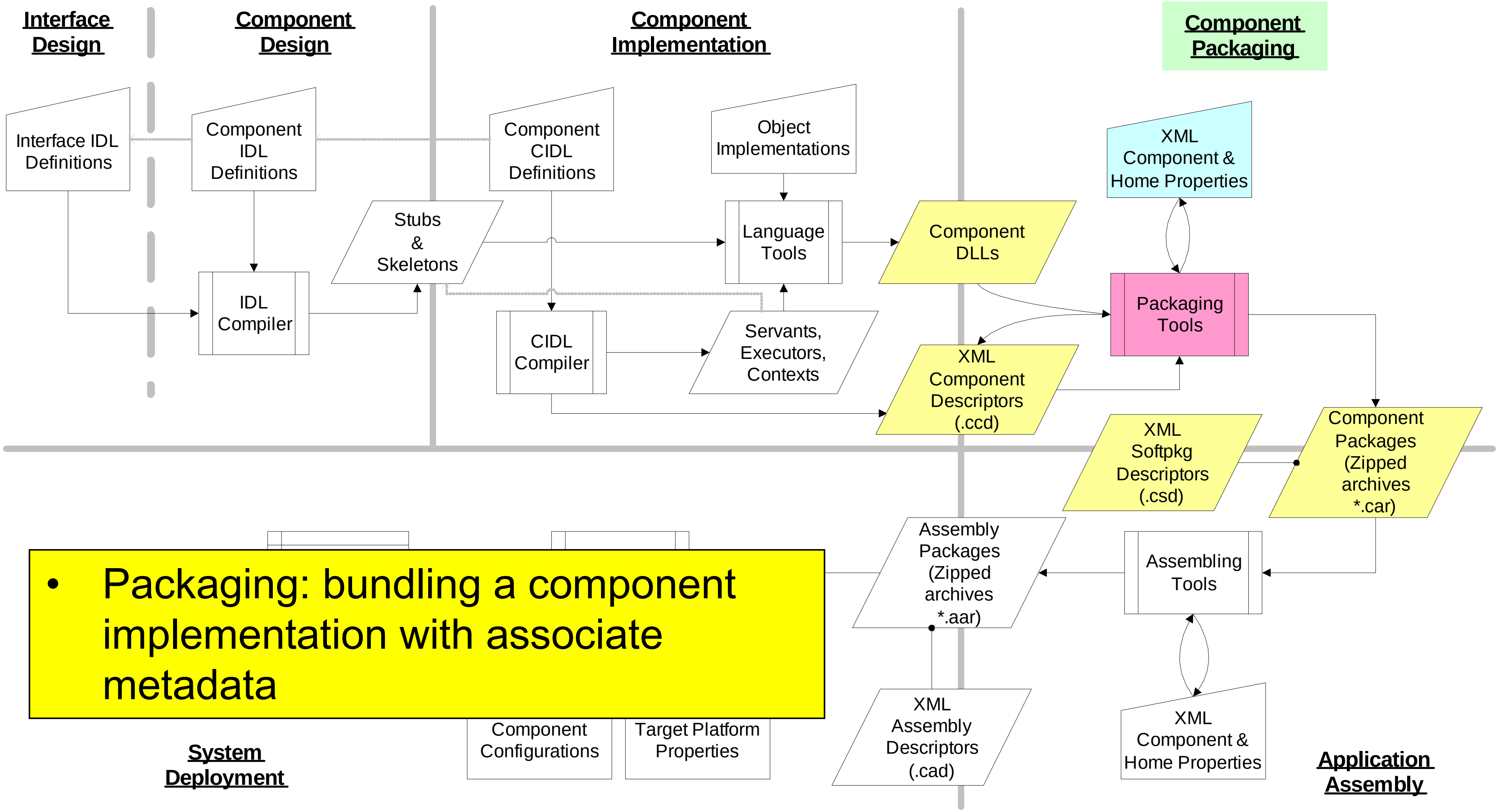
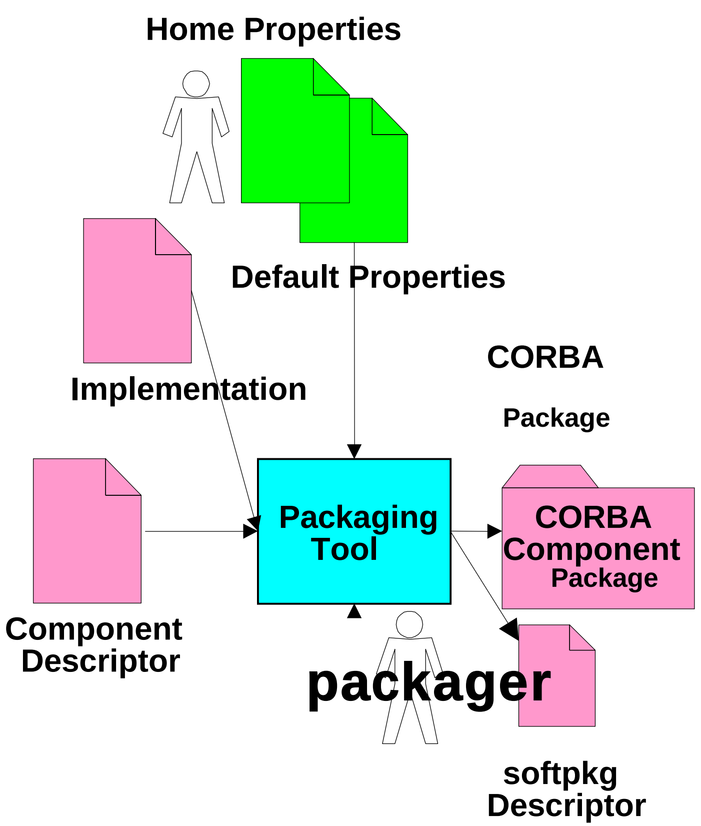
Component Packaging Stage



- Packaging: bundling a component implementation with associate metadata

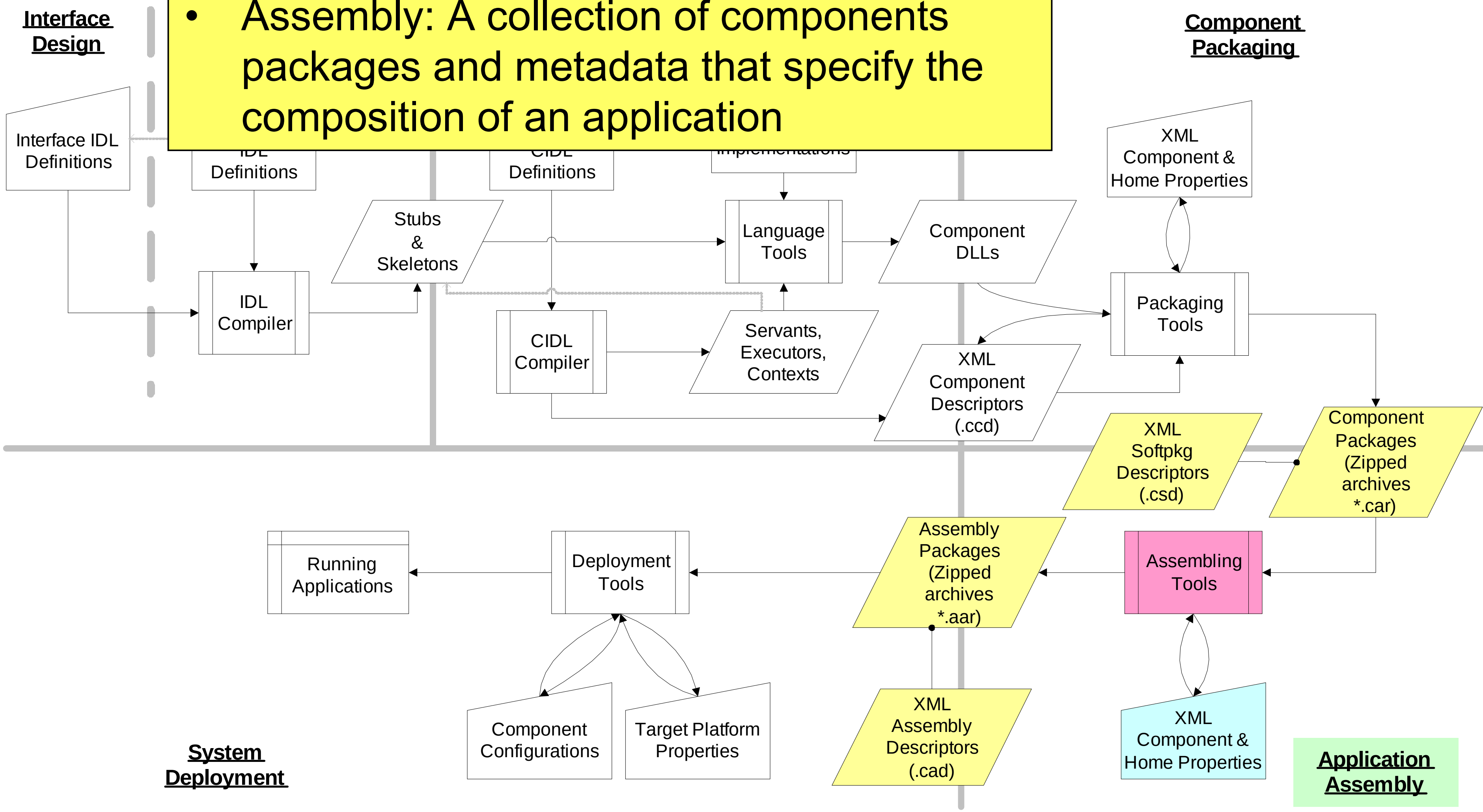
Component Packages



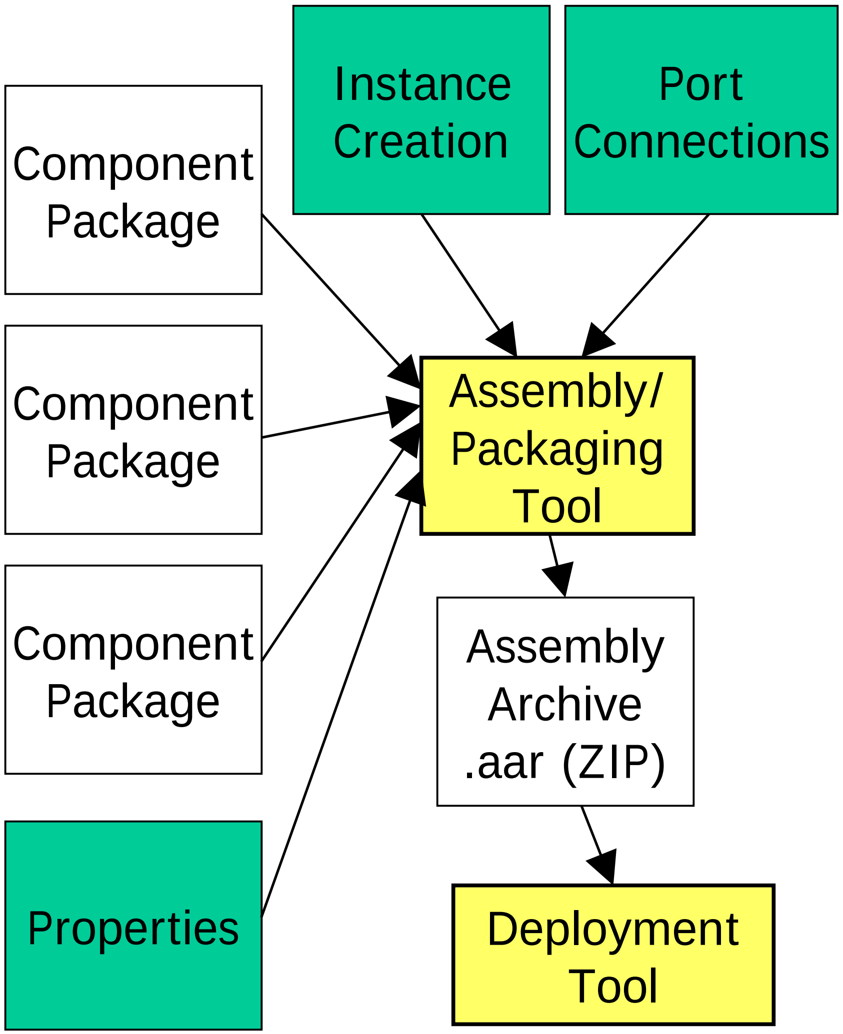
- Goals
  - Configure components, containers, servers
  - Extract these aspects into metadata
- That's a lot of stuff to be bundled together and moved around
- "Classic" CORBA: No standard means of
  - Configuration
  - Distribution
  - Deployment
- Packaging of components
  - Components are packaged into a self-descriptive package as a compressed archive
- XML descriptors provide metadata that describe
  - The content of a package
  - The capability of components
  - The dependencies to other software artifacts
    - Other components
    - 3rd party DLLs
    - Valuefactories

Application Assembling Stage

- Assembly: A collection of components packages and metadata that specify the composition of an application

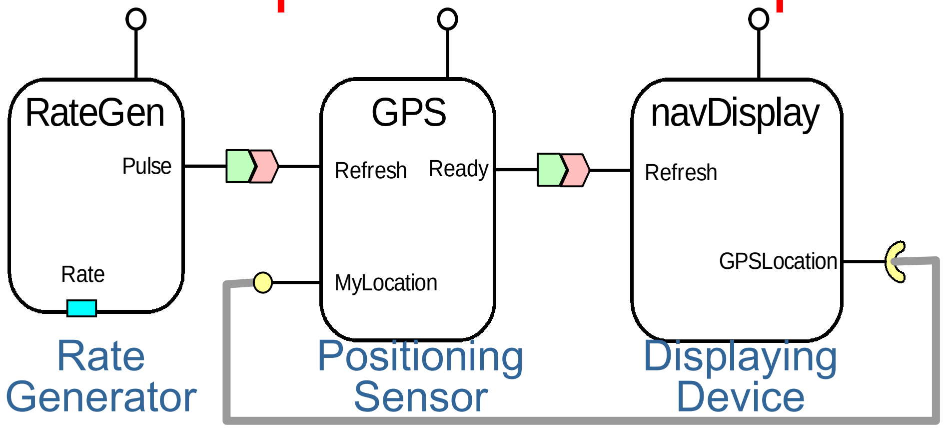


Component Assembling



- Goals
  - Configure components, containers, servers, and applications
  - Extract these aspects into metadata
  - Provide higher level of modeling
- "Classic" CORBA: No standard means of
  - Configuration
  - Distribution
  - Deployment
- An assembly descriptor specifies:
  - Component implementations
  - Component/home instantiations
  - Interconnections

Component Implementation Specifications




```
<!– Assembly descriptors associate components with implementations -->
<!- in software packages defined by softpkg descriptors (*.csd) files -->
<componentfiles>
    <componentfile id=“com-RateGen">
      <fileinarchive name=“RateGen.csd"/>
    </componentfile>

    <componentfile id=“com-GPS">
      <fileinarchive name=“GPS.csd"/>
    </componentfile>

    <componentfile id=“com-Display">
      <fileinarchive name=“NavDisplay.csd"/>
    </componentfile>

 </componentfiles>
```

Component Home/Instances Installation Specifications

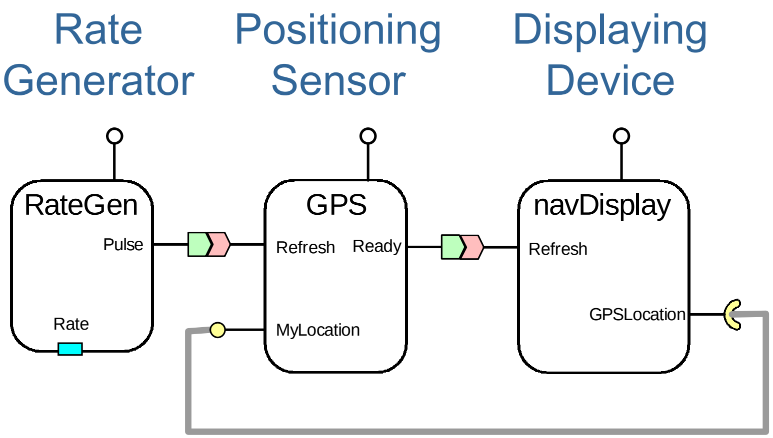
```
<!– Instantiating component homes/instances -->

<partitioning>
  <hostcollocation>
    ...

    <homeplacement id=“a_RateGenHome">
      <componentfileref idref=“com-RateGen"/>
      <componentinstantiation id=“a_RateGen">
        <componentproperties>
          <fileinarchive name=“NavRateGen.cpf"/>
        </componentproperties>
      </componentinstantiation>
    </homeplacement>
    ...
    <destination>A_Remote_Host</destination>
  </hostcollocation>
</partitioning>
```

- An assembly descriptor specifies how & where homes & components should be instantiated
- A component property file (.cpf) can be associated with a home or a component instantiation to override default component properties

Interconnection Specification

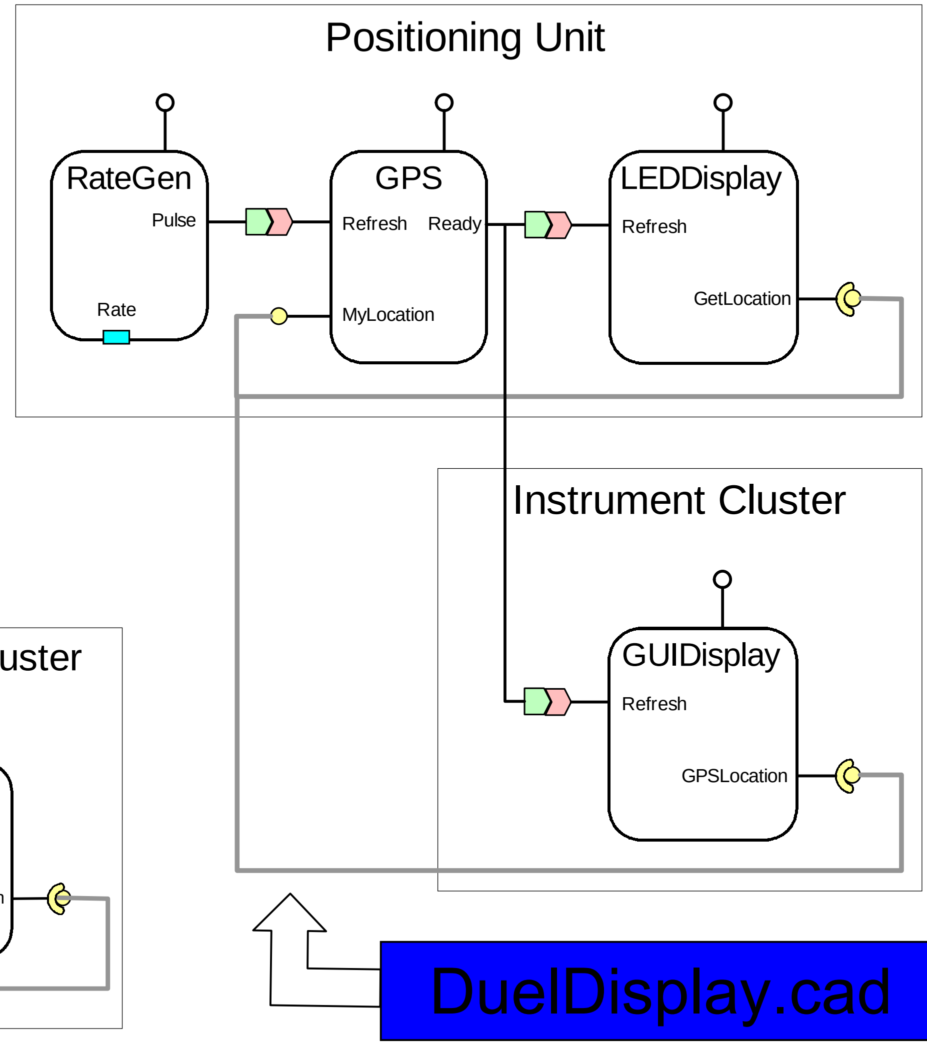


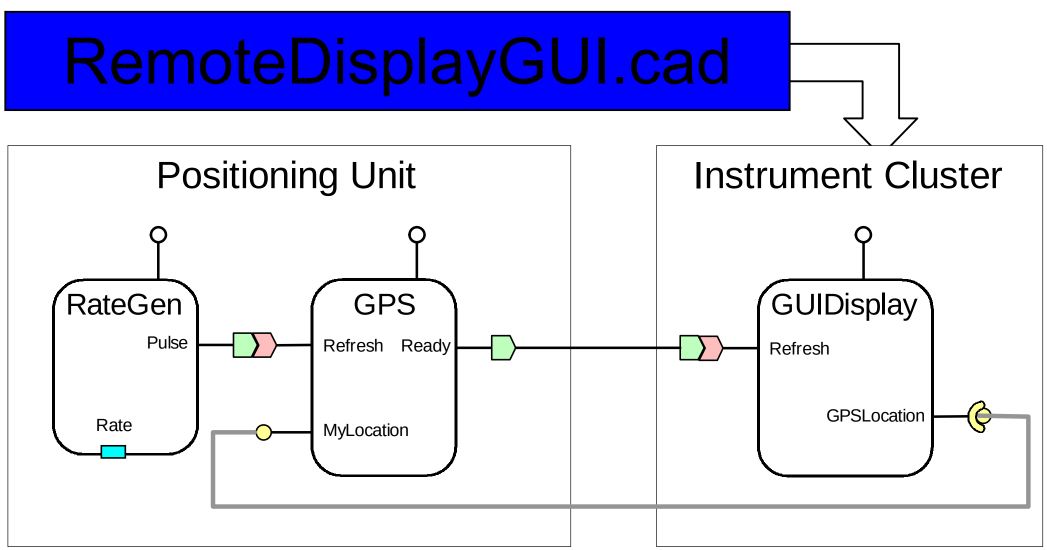

```
<connections>
  ...
  <connectinterface>
    <usesport>
      <usesidentifier>GPSPosition</usesidentifier>
      <componentinstantiationref idref=“a_NavDisplay"/>
    </usesport>
    <providesport>
      <providesidentifier>
         MyLocation
      </providesidentifier>
      <componentinstantiationref idref=“a_GPS"/>
    </providesport>
  </connectinterface>
  <connectevent>
    <consumesport>
      <consumesidentifier>Refresh</consumesidentifier>
      <componentinstantiationref idref=“a_GPS"/>
    </consumesport>
    <publishesport>
      <publishesidentifier>
         Pulse
      </publishesidentifier>
      <componentinstantiationref
             idref=“a_RateGen"/>
    </publishesport>
  </connectevent>
  ...
</connections>
```

- Assembly descriptors also specify how component instances are connected together

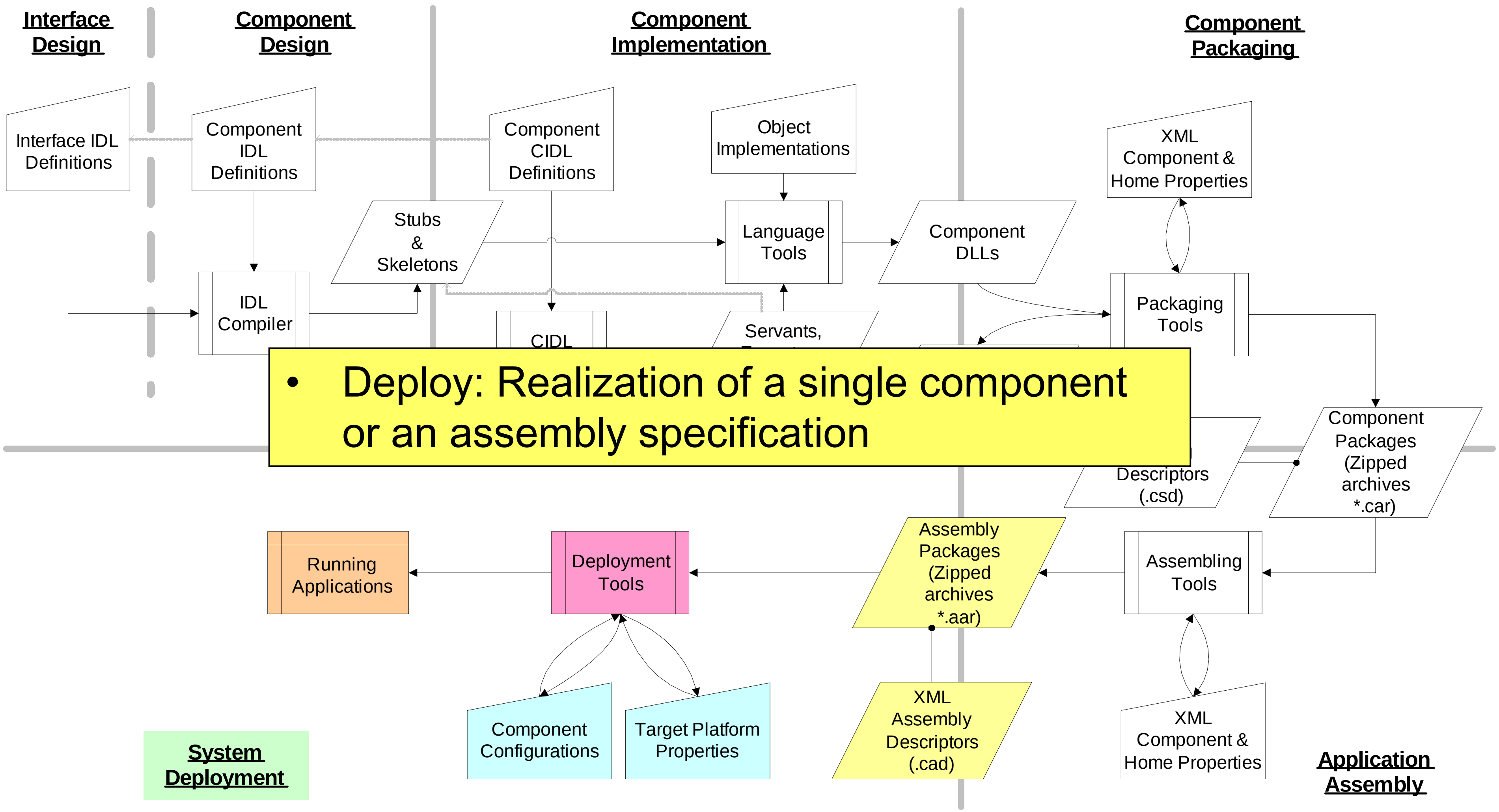
Two Deployment Examples

- Making configuring, assembling, & deploying of applications easy
  - Component configurations
  - Component implemenations
  - Inter-connections
  - Logical location constraints





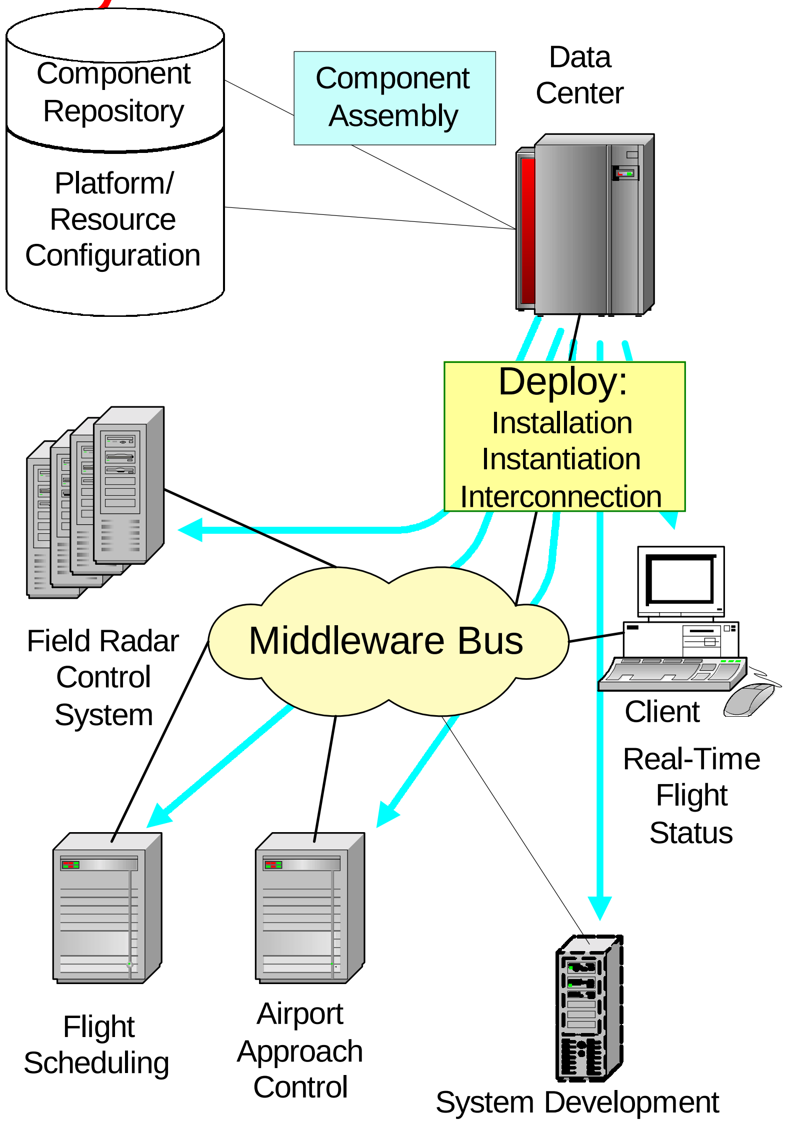
Deployment Stage



- Deploy: Realization of a single component or an assembly specification

Application Deployment

- Deployment tools
  - Have knowledge of target platforms
  - Map locations in assembly to physical nodes
  - Manage available resources for applications
  - Use standard CCM interfaces defined in module **`Components::Deployment`** to realize an assembly



Where Do We Go from Here?

Summary

- The CORBA Component Model
  - Extend CORBA object model to support application development via composition
  - CIF defines ways to automate the implementation of many component features
  - Defines standard runtime environment with Containers and Component Servers
  - Specifies packaging and deployment framework
- Separating configuration concerns
  - Server configuration
  - Object/service configuration
  - Application configuration
  - Object/service deployment

CCM Status

- Available CCM Implementations
  - Component Integrated ACE ORB (CIAO) by Washington University and Vanderbilt University
  - Enterprise Java CORBA Component Model (EJCCM) by Computational Physics, Inc.
  - K2 CCM by iCMG (commercial product)
  - MICO CCM by Frank Pilhofer
  - QoS Enabled Distributed Object (Qedo) by FOKUS
  - OpenCCM by ObjectWeb (Java based)
- Modeling and Assembling tools
  - Cadena from Kansas State University
  - GME from ISIS, Vanderbilt University

CCM Related Specifications

- Light Weight CCM hosted by RTESS
  - realtime/03-05-05
- QoS for CCM RFP hosted by MARS
  - mars/03-06-12
- Stream for CCM RFP hosted by MARS
  - mars/03-06-11
- UML Profile for CCM hosted by MARS
  - mars/03-05-09
- Deployment and Configuration hosted by MARS
  - ptc/03-06-03

- CCM for distributed, real-time and embedded applications
  - CIAO and Qedo
  - Light weight CCM