CCA
Common Component Architecture

# Writing Components

**CCA Forum Tutorial Working Group**
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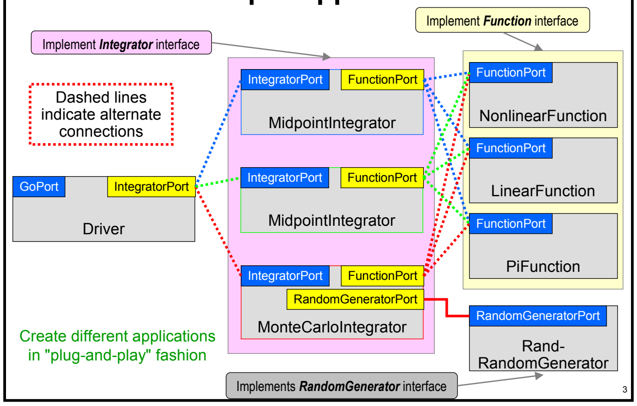
## Module Overview

- Goal: present a step-by-step approach to creating CCA components
- Example application
- Steps involved in writing CCA components
  1. Interface definition; ports
  2. Component implementation
     1. Framework interactions
     2. Component interactions: uses and provides ports
  3. Compiling
  4. Running

## Example Applications



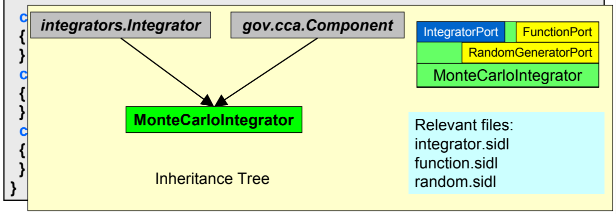
Create different applications in "plug-and-play" fashion

## Interface Definition

- Component functionality:
  - Integrator
    - Computes the integral of a scalar function
  - Random number generator
    - Generates a pseudo-random number
  - Function
    - Computes a scalar function
  - Driver
    - Entry point into the application

## Integrator Port

```
package integrators version 1.0 {

  interface Integrator extends gov.cca.Port
  {
    double integrate(in double lowBound,
                     in double upBound, in int count);
  }

  c
  {
  }
  c
  {
  }
  c
  {
  }
}
```



Relevant files:
integrator.sidl
function.sidl
random.sidl

## Using Babel to Create The Repository

- A repository containing XML versions of the SIDL definition is created first; it will be used for name resolution later
- Makefile fragment (for all SIDL definitions in

```
SIDLFILES = cca.sidl integrator.sidl function.sidl \
      random.sidl driver.sidl

.repository: $(SIDLFILES)
      rm -f repository/*.xml \
      babel --xml --repository-path=repository \
      --output-directory=repository $(SIDLFILES)
      touch .repository
```

## MonteCarloIntegrator Component

The next slides show two possible, semantically identical, implementations:

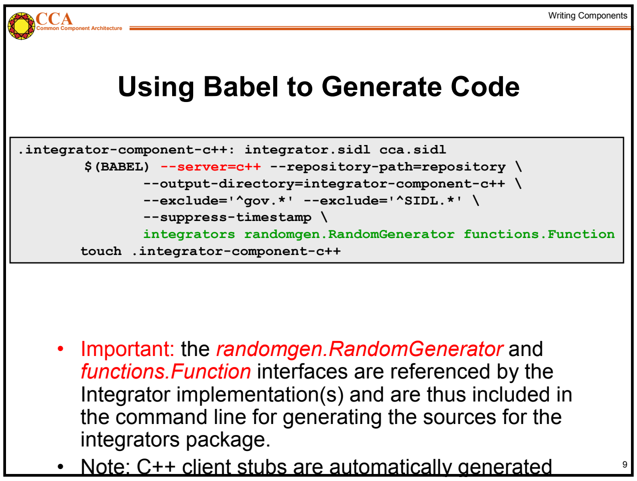
- C++
- Fortran 90

The two are shown for demonstration purposes; in real applications, the same functionality will not be re-implemented in multiple languages.

The tutorial example source code contains equivalent implementations of some components in C++, Fortran 90, Fortran 77, and Python.

## MonteCarloIntegrator Component (C++ Implementation)

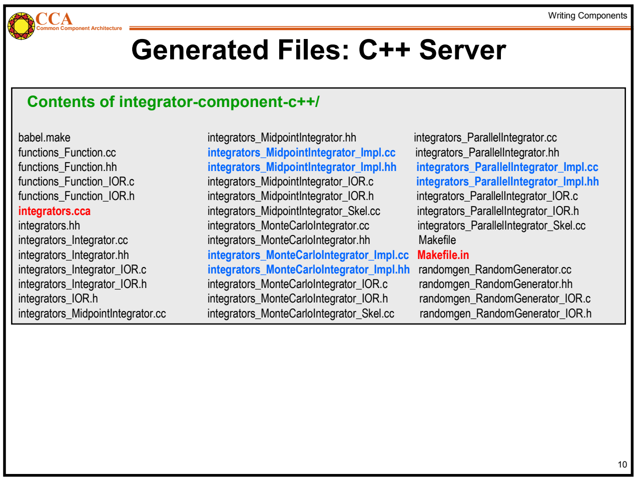
1. Use Babel to generate C++ skeletons and implementation files for integrator.sidl
2. Fill in implementation details in integrator-component-c++/:
   - integrators_MonteCarloIntegrator_Impl.hh
   - integrators_MonteCarloIntegrator_Impl.cc
3. Create makefile and build dynamic library
   - Makefile.in
   - libIntegrator-component-c++.so
4. Create integrators.cca (Ccaffeine-specific)



# Using Babel to Generate Code

```
.integrator-component-c++: integrator.sidl cca.sidl
        $(BABEL) --server=c++ --repository-path=repository \
               --output-directory=integrator-component-c++ \
               --exclude='^gov.*' --exclude='^SIDL.*' \
               --suppress-timestamp \
               integrators randomgen.RandomGenerator functions.Function
       touch .integrator-component-c++
```

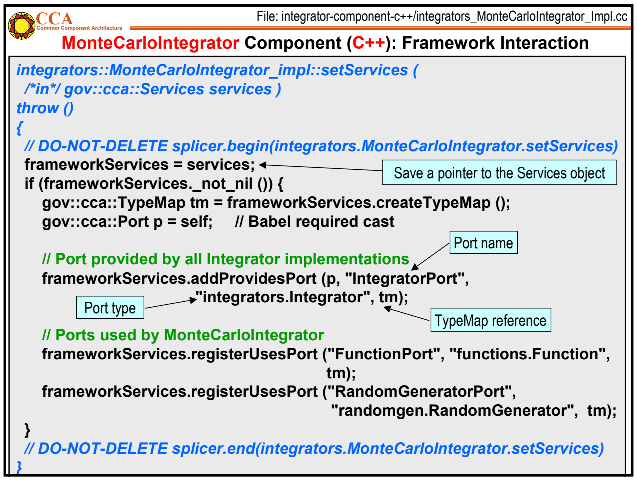
- Important: the *randomgen.RandomGenerator* and *functions.Function* interfaces are referenced by the Integrator implementation(s) and are thus included in the command line for generating the sources for the integrators package.
- Note: C++ client stubs are automatically generated



# Generated Files: C++ Server

**Contents of integrator-component-c++/**

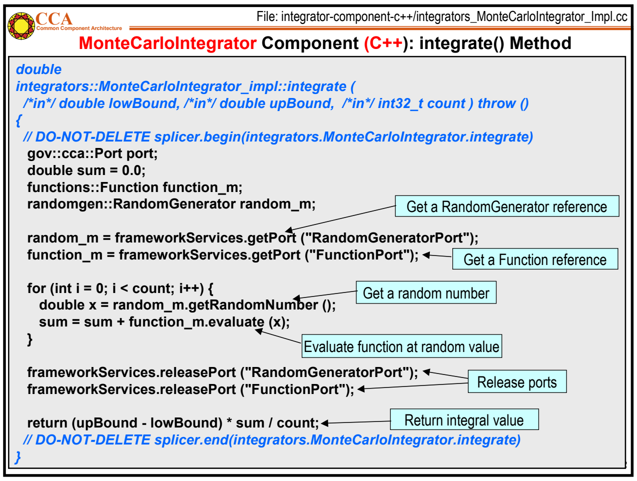
babel.make
functions_Function.cc
functions_Function.hh
functions_Function_IOR.c
functions_Function_IOR.h
**integrators.cca**
integrators.hh
integrators_Integrator.cc
integrators_Integrator.hh
integrators_Integrator_IOR.c
integrators_Integrator_IOR.h
integrators_IOR.h
integrators_MidpointIntegrator.cc
integrators_MidpointIntegrator.hh
**integrators_MidpointIntegrator_Impl.cc**
**integrators_MidpointIntegrator_Impl.hh**
integrators_MidpointIntegrator_IOR.c
integrators_MidpointIntegrator_IOR.h
integrators_MidpointIntegrator_Skel.cc
integrators_MonteCarloIntegrator.cc
integrators_MonteCarloIntegrator.hh
**integrators_MonteCarloIntegrator_Impl.cc**
**integrators_MonteCarloIntegrator_Impl.hh**
integrators_MonteCarloIntegrator_IOR.c
integrators_MonteCarloIntegrator_IOR.h
integrators_MonteCarloIntegrator_Skel.cc
integrators_ParallelIntegrator.cc
integrators_ParallelIntegrator.hh
**integrators_ParallelIntegrator_Impl.cc**
**integrators_ParallelIntegrator_Impl.hh**
integrators_ParallelIntegrator_IOR.c
integrators_ParallelIntegrator_IOR.h
integrators_ParallelIntegrator_Skel.cc
Makefile
**Makefile.in**
randomgen_RandomGenerator.cc
randomgen_RandomGenerator.hh
randomgen_RandomGenerator_IOR.c
randomgen_RandomGenerator_IOR.h



# MonteCarloIntegrator Component (C++): Framework Interaction

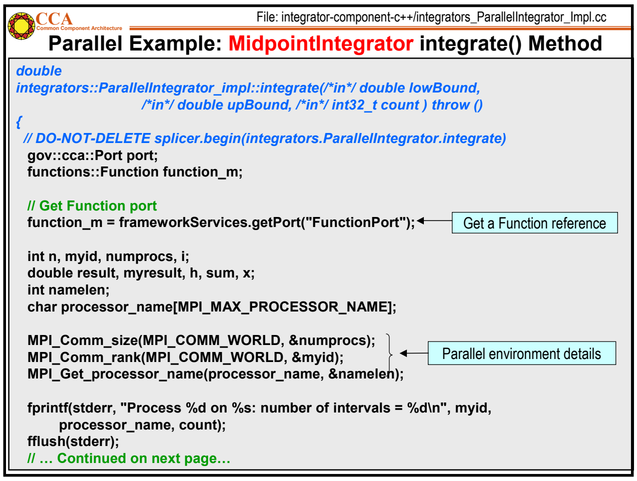
```
integrators::MonteCarloIntegrator_impl::setServices (
 /*in*/ gov::cca::Services services )
throw ()
{
 // DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.setServices)
 frameworkServices = services;
 if (frameworkServices._not_nil ()) {
    gov::cca::TypeMap tm = frameworkServices.createTypeMap ();
    gov::cca::Port p = self;     // Babel required cast

    // Port provided by all Integrator implementations
    frameworkServices.addProvidesPort (p, "IntegratorPort",
                         "integrators.Integrator", tm);

    // Ports used by MonteCarloIntegrator
    frameworkServices.registerUsesPort ("FunctionPort", "functions.Function",
                                                  tm);
    frameworkServices.registerUsesPort ("RandomGeneratorPort",
                                                   "randomgen.RandomGenerator",  tm);
 }
 // DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.setServices)
}
```

Save a pointer to the Services object
Port name
Port type
TypeMap reference



# MonteCarloIntegrator Component (C++): integrate() Method

```
double
integrators::MonteCarloIntegrator_impl::integrate (
 /*in*/ double lowBound, /*in*/ double upBound,  /*in*/ int32_t count ) throw ()
{
 // DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.integrate)
  gov::cca::Port port;
  double sum = 0.0;
  functions::Function function_m;
  randomgen::RandomGenerator random_m;

  random_m = frameworkServices.getPort ("RandomGeneratorPort");
  function_m = frameworkServices.getPort ("FunctionPort");

  for (int i = 0; i < count; i++) {
    double x = random_m.getRandomNumber ();
    sum = sum + function_m.evaluate (x);
  }

  frameworkServices.releasePort ("RandomGeneratorPort");
  frameworkServices.releasePort ("FunctionPort");

  return (upBound - lowBound) * sum / count;
 // DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.integrate)
}
```



CCA Common Component Architecture

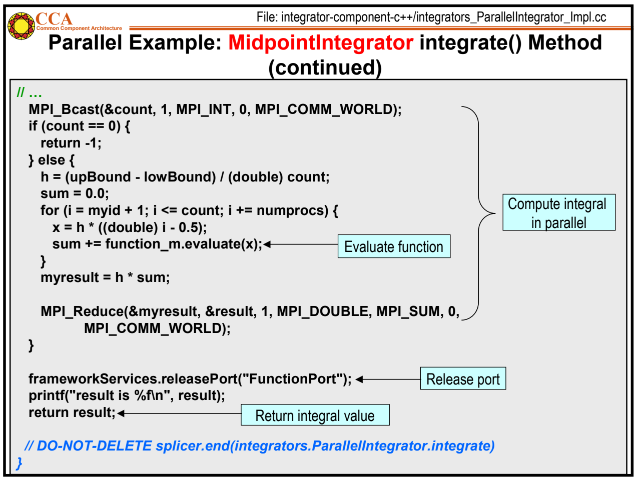
File: integrator-component-c++/integrators_ParallelIntegrator_Impl.cc

## Parallel Example: MidpointIntegrator integrate() Method

```
double
integrators::ParallelIntegrator_impl::integrate(/*in*/ double lowBound,
                        /*in*/ double upBound, /*in*/ int32_t count ) throw ()
{
  // DO-NOT-DELETE splicer.begin(integrators.ParallelIntegrator.integrate)
   gov::cca::Port port;
   functions::Function function_m;

   // Get Function port
   function_m = frameworkServices.getPort("FunctionPort");

   int n, myid, numprocs, i;
   double result, myresult, h, sum, x;
   int namelen;
   char processor_name[MPI_MAX_PROCESSOR_NAME];

   MPI_Comm_size(MPI_COMM_WORLD, &numprocs);
   MPI_Comm_rank(MPI_COMM_WORLD, &myid);
   MPI_Get_processor_name(processor_name, &namelen);

   fprintf(stderr, "Process %d on %s: number of intervals = %d\n", myid,
        processor_name, count);
   fflush(stderr);
   // … Continued on next page…
```

Get a Function reference

Parallel environment details



CCA Common Component Architecture

File: integrator-component-c++/integrators_ParallelIntegrator_Impl.cc

## Parallel Example: MidpointIntegrator integrate() Method (continued)

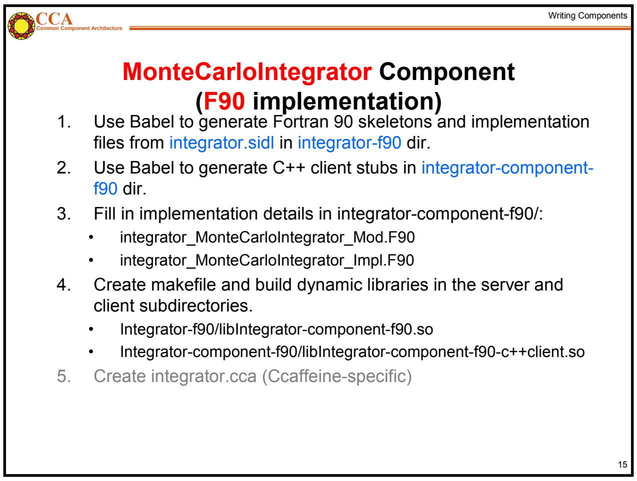
```
// …
  MPI_Bcast(&count, 1, MPI_INT, 0, MPI_COMM_WORLD);
  if (count == 0) {
    return -1;
  } else {
    h = (upBound - lowBound) / (double) count;
    sum = 0.0;
    for (i = myid + 1; i <= count; i += numprocs) {
      x = h * ((double) i - 0.5);
      sum += function_m.evaluate(x);
    }
    myresult = h * sum;

    MPI_Reduce(&myresult, &result, 1, MPI_DOUBLE, MPI_SUM, 0,
           MPI_COMM_WORLD);
  }

  frameworkServices.releasePort("FunctionPort");
  printf("result is %f\n", result);
  return result;

 // DO-NOT-DELETE splicer.end(integrators.ParallelIntegrator.integrate)
}
```

Compute integral in parallel

Evaluate function

Release port

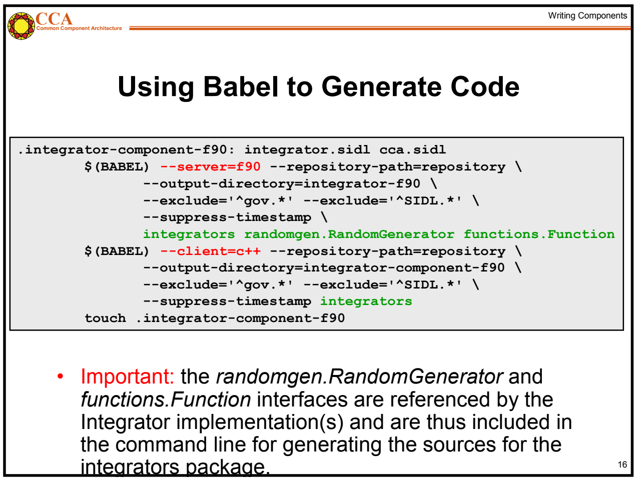
Return integral value



CCA Common Component Architecture

## MonteCarloIntegrator Component (F90 implementation)

1. Use Babel to generate Fortran 90 skeletons and implementation files from integrator.sidl in integrator-f90 dir.
2. Use Babel to generate C++ client stubs in integrator-component-f90 dir.
3. Fill in implementation details in integrator-component-f90/:
   - integrator_MonteCarloIntegrator_Mod.F90
   - integrator_MonteCarloIntegrator_Impl.F90
4. Create makefile and build dynamic libraries in the server and client subdirectories.
   - Integrator-f90/libIntegrator-component-f90.so
   - Integrator-component-f90/libIntegrator-component-f90-c++client.so
5. Create integrator.cca (Ccaffeine-specific)



CCA Common Component Architecture

## Using Babel to Generate Code

```
.integrator-component-f90: integrator.sidl cca.sidl
        $(BABEL) --server=f90 --repository-path=repository \
               --output-directory=integrator-f90 \
               --exclude='^gov.*' --exclude='^SIDL.*' \
               --suppress-timestamp \
               integrators randomgen.RandomGenerator functions.Function
        $(BABEL) --client=c++ --repository-path=repository \
               --output-directory=integrator-component-f90 \
               --exclude='^gov.*' --exclude='^SIDL.*' \
               --suppress-timestamp integrators
        touch .integrator-component-f90
```

- Important: the *randomgen.RandomGenerator* and *functions.Function* interfaces are referenced by the Integrator implementation(s) and are thus included in the command line for generating the sources for the integrators package.

# Generated Files: Fortran90 Server

Contents of integrator-f90/

babel.make
functions_Function_array.F90
functions_Function.F90
functions_Function_fAbbrev.h
functions_Function_fStub.c
functions_Function_IOR.c
functions_Function_IOR.h
functions_Function_type.F90
integrators_Integrator_array.F90
integrators_Integrator.F90
integrators_Integrator_fAbbrev.h
integrators_Integrator_fStub.c
integrators_Integrator_IOR.c
integrators_Integrator_IOR.h
integrators_Integrator_type.F90
integrators_IOR.h
integrators_MidpointIntegrator_array.F90
integrators_MidpointIntegrator.F90
integrators_MidpointIntegrator_fAbbrev.h
integrators_MidpointIntegrator_fSkel.c
integrators_MidpointIntegrator_fStub.c
integrators_MidpointIntegrator_Impl.F90
integrators_MidpointIntegrator_IOR.c
integrators_MidpointIntegrator_IOR.h
integrators_MidpointIntegrator_Mod.F90
integrators_MidpointIntegrator_type.F90
integrators_MonteCarloIntegrator_array.F90
integrators_MonteCarloIntegrator.F90
integrators_MonteCarloIntegrator_fAbbrev.h
integrators_MonteCarloIntegrator_fSkel.c
integrators_MonteCarloIntegrator_fStub.c
integrators_MonteCarloIntegrator_Impl.F90
integrators_MonteCarloIntegrator_IOR.c
integrators_MonteCarloIntegrator_IOR.h
integrators_MonteCarloIntegrator_Mod.F90
integrators_MonteCarloIntegrator_type.F90
integrators_ParallelIntegrator_array.F90
integrators_ParallelIntegrator.F90
integrators_ParallelIntegrator_fAbbrev.h
integrators_ParallelIntegrator_fSkel.c
integrators_ParallelIntegrator_fStub.c
integrators_ParallelIntegrator_Impl.F90
integrators_ParallelIntegrator_IOR.c
integrators_ParallelIntegrator_IOR.h
integrators_ParallelIntegrator_Mod.F90
integrators_ParallelIntegrator_type.F90
Makefile.in
randomgen_RandomGenerator_array.F90
randomgen_RandomGenerator.F90
randomgen_RandomGenerator_fAbbrev.h
randomgen_RandomGenerator_fStub.c
randomgen_RandomGenerator_IOR.c
randomgen_RandomGenerator_IOR.h
randomgen_RandomGenerator_type.F90
SIDL_bool_array.F90
SIDL_char_array.F90
SIDL_dcomplex_array.F90
SIDL_double_array.F90
SIDL_fcomplex_array.F90
SIDL_float_array.F90
SIDL_int_array.F90
SIDL_long_array.F90
SIDL_opaque_array.F90
SIDL_string_array.F90

# Generated Files: C++ Client

Contents of integrator-component-f90/

babel.make
integrators.cca
integrators.hh
integrators_Integrator.cc
integrators_Integrator.hh
integrators_Integrator_IOR.c
integrators_Integrator_IOR.h
integrators_IOR.h
integrators_MidpointIntegrator.cc
integrators_MidpointIntegrator.hh
integrators_MidpointIntegrator_IOR.c
integrators_MidpointIntegrator_IOR.h
integrators_MonteCarloIntegrator.cc
integrators_MonteCarloIntegrator.hh
integrators_MonteCarloIntegrator_IOR.c
integrators_MonteCarloIntegrator_IOR.h
integrators_ParallelIntegrator.cc
integrators_ParallelIntegrator.hh
integrators_ParallelIntegrator_IOR.c
integrators_ParallelIntegrator_IOR.h
Makefile
Makefile.in

File: integrator-component-f90/integrators_MonteCarloIntegrator_Mod.F90

# MonteCarloIntegrator Component: F90 Module

```
#include"integrators_MonteCarloIntegrator_fAbbrev.h"
module integrators_MonteCarloIntegrator_impl

! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.use)
! Insert use statements here...
! Framework Services module
use gov_cca_Services
! DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.use)

type integrators_MonteCarloIntegrator_private
  sequence
  ! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.private_data)
  ! integer :: place_holder ! replace with your private data
  type(gov_cca_Services_t) :: myservices
  ! DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.private_data)
end type integrators_MonteCarloIntegrator_private

type integrators_MonteCarloIntegrator_wrap
  sequence
  type(integrators_MonteCarloIntegrator_private), pointer :: d_private_data
end type integrators_MonteCarloIntegrator_wrap

end module integrators_MonteCarloIntegrator_impl
```

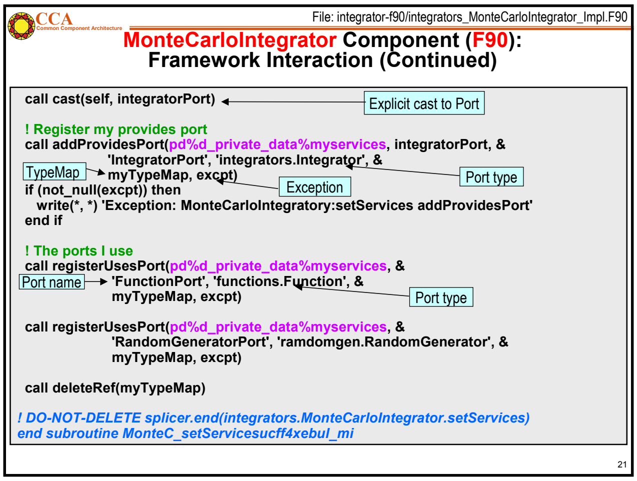
Reference to framework Services object

File: integrator-f90/integrators_MonteCarloIntegrator_Impl.F90

# MonteCarloIntegrator Component (F90): Framework Interaction

```
recursive subroutine MonteC_setServicesucff4xebul_mi(self, services)
 use integrators_MonteCarloIntegrator
 use gov_cca_Services
 use integrators_MonteCarloIntegrator_impl
 ! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.setServices.use)
 ! Insert use statements here...
 use gov_cca_TypeMap
 use gov_cca_Port
 use SIDL_BaseException
 ! DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.setServices.use)
 implicit none
 type(integrators_MonteCarloIntegrator_t) :: self
 type(gov_cca_Services_t) :: services
 ! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.setServices)
 type(gov_cca_TypeMap_t)             :: myTypeMap
 type(gov_cca_Port_t)                :: integratorPort
 type(SIDL_BaseException_t)          :: excpt
 ! Access private data
 type(integrators_MonteCarloIntegrator_wrap) :: pd
 external integrators_MonteCarloIntegrator__get_data_m
 call integrators_MonteCarloIntegrator__get_data_m(self, pd)
 ! Set my reference to the services handle
 pd%d_private_data%myservices = services
 call addRef(services)
 ! Create a TypeMap with my properties
 call createTypeMap(pd%d_private_data%myservices, myTypeMap, excpt)
```

Save a handle to the Services object



File: integrator-f90/integrators_MonteCarloIntegrator_Impl.F90

## MonteCarloIntegrator Component (F90): Framework Interaction (Continued)

```
call cast(self, integratorPort)

! Register my provides port
call addProvidesPort(pd%d_private_data%myservices, integratorPort, &
                'IntegratorPort', 'integrators.Integrator', &
                myTypeMap, excpt)
if (not_null(excpt)) then
  write(*, *) 'Exception: MonteCarloIntegratory:setServices addProvidesPort'
end if

! The ports I use
call registerUsesPort(pd%d_private_data%myservices, &
                 'FunctionPort', 'functions.Function', &
                 myTypeMap, excpt)

call registerUsesPort(pd%d_private_data%myservices, &
                 'RandomGeneratorPort', 'ramdomgen.RandomGenerator', &
                 myTypeMap, excpt)

call deleteRef(myTypeMap)

! DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.setServices)
end subroutine MonteC_setServicesucff4xebul_mi
```

Explicit cast to Port

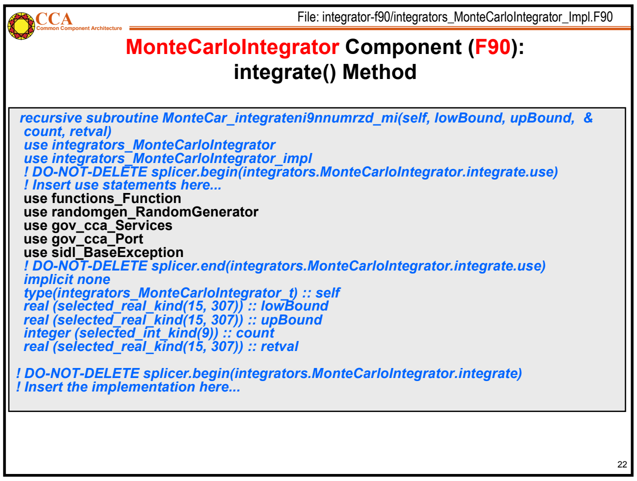
TypeMap

Port type

Exception

Port name

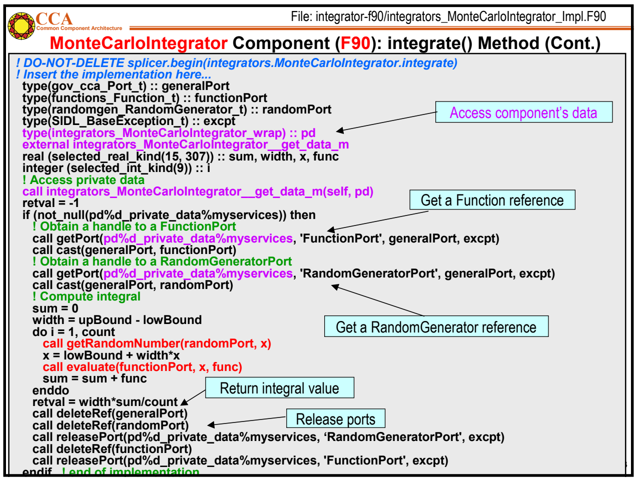
Port type



File: integrator-f90/integrators_MonteCarloIntegrator_Impl.F90

## MonteCarloIntegrator Component (F90): integrate() Method

```
recursive subroutine MonteCar_integrateni9nnumrzd_mi(self, lowBound, upBound,  &
 count, retval)
 use integrators_MonteCarloIntegrator
 use integrators_MonteCarloIntegrator_impl
 ! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.integrate.use)
 ! Insert use statements here...
 use functions_Function
 use randomgen_RandomGenerator
 use gov_cca_Services
 use gov_cca_Port
 use sidl_BaseException
 ! DO-NOT-DELETE splicer.end(integrators.MonteCarloIntegrator.integrate.use)
 implicit none
 type(integrators_MonteCarloIntegrator_t) :: self
 real (selected_real_kind(15, 307)) :: lowBound
 real (selected_real_kind(15, 307)) :: upBound
 integer (selected_int_kind(9)) :: count
 real (selected_real_kind(15, 307)) :: retval

! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.integrate)
! Insert the implementation here...
```



File: integrator-f90/integrators_MonteCarloIntegrator_Impl.F90

## MonteCarloIntegrator Component (F90): integrate() Method (Cont.)

```
! DO-NOT-DELETE splicer.begin(integrators.MonteCarloIntegrator.integrate)
! Insert the implementation here...
  type(gov_cca_Port_t) :: generalPort
  type(functions_Function_t) :: functionPort
  type(randomgen_RandomGenerator_t) :: randomPort
  type(SIDL_BaseException_t) :: excpt
  type(integrators_MonteCarloIntegrator_wrap) :: pd
  external integrators_MonteCarloIntegrator__get_data_m
  real (selected_real_kind(15, 307)) :: sum, width, x, func
  integer (selected_int_kind(9)) :: i
  ! Access private data
  call integrators_MonteCarloIntegrator__get_data_m(self, pd)
  retval = -1
  if (not_null(pd%d_private_data%myservices)) then
    ! Obtain a handle to a FunctionPort
    call getPort(pd%d_private_data%myservices, 'FunctionPort', generalPort, excpt)
    call cast(generalPort, functionPort)
    ! Obtain a handle to a RandomGeneratorPort
    call getPort(pd%d_private_data%myservices, 'RandomGeneratorPort', generalPort, excpt)
    call cast(generalPort, randomPort)
    ! Compute integral
    sum = 0
    width = upBound - lowBound
    do i = 1, count
      call getRandomNumber(randomPort, x)
      x = lowBound + width*x
      call evaluate(functionPort, x, func)
      sum = sum + func
    enddo
    retval = width*sum/count
    call deleteRef(generalPort)
    call deleteRef(randomPort)
    call releasePort(pd%d_private_data%myservices, ‘RandomGeneratorPort', excpt)
    call deleteRef(functionPort)
    call releasePort(pd%d_private_data%myservices, 'FunctionPort', excpt)
  endif  ! end of implementation
```

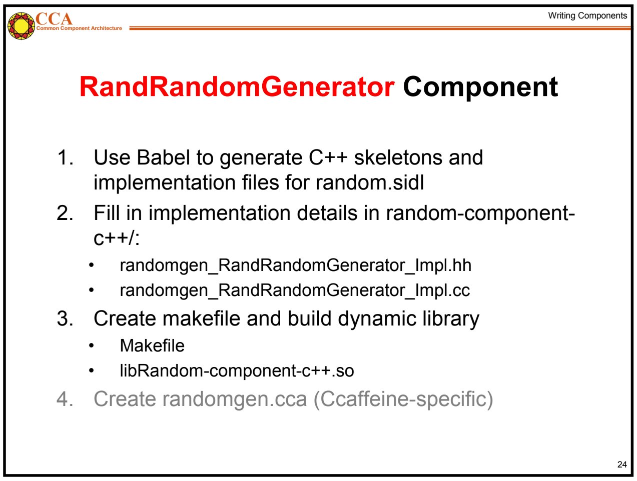
Access component’s data

Get a Function reference

Get a RandomGenerator reference

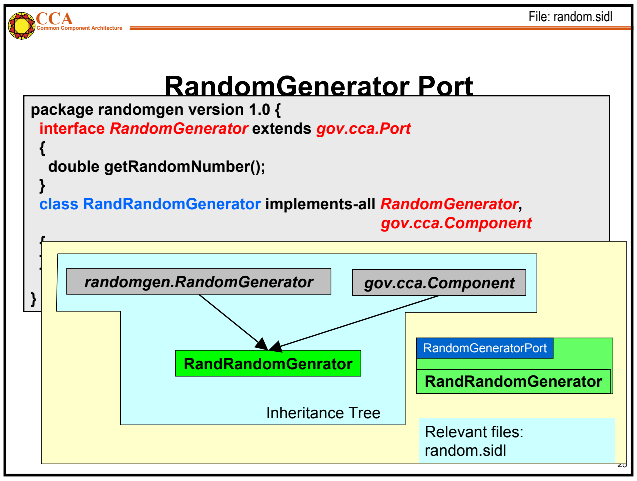
Return integral value

Release ports



## RandRandomGenerator Component

1. Use Babel to generate C++ skeletons and implementation files for random.sidl
2. Fill in implementation details in random-component-c++/:
   - randomgen_RandRandomGenerator_Impl.hh
   - randomgen_RandRandomGenerator_Impl.cc
3. Create makefile and build dynamic library
   - Makefile
   - libRandom-component-c++.so
4. Create randomgen.cca (Ccaffeine-specific)

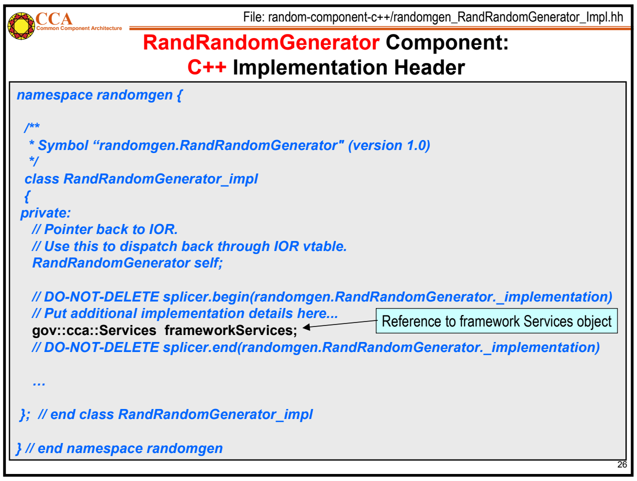


File: random.sidl

## RandomGenerator Port

```
package randomgen version 1.0 {
  interface RandomGenerator extends gov.cca.Port
  {
    double getRandomNumber();
  }
  class RandRandomGenerator implements-all RandomGenerator,
                                           gov.cca.Component
  {
  }
}
```

Relevant files:
random.sidl

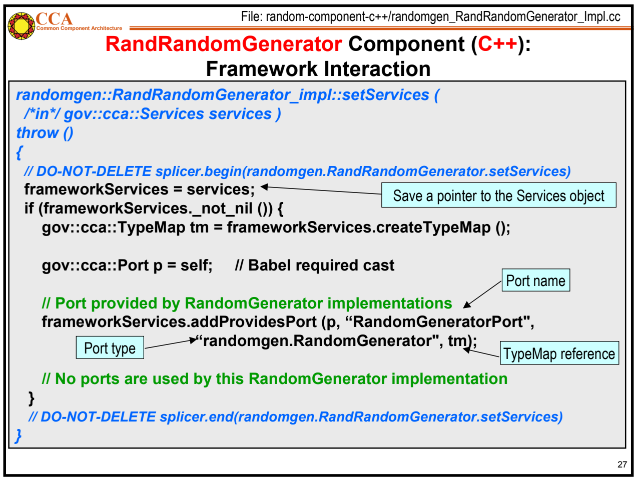


File: random-component-c++/randomgen_RandRandomGenerator_Impl.hh

## RandRandomGenerator Component: C++ Implementation Header

```
namespace randomgen {

  /**
   * Symbol “randomgen.RandRandomGenerator" (version 1.0)
   */
  class RandRandomGenerator_impl
  {
 private:
    // Pointer back to IOR.
    // Use this to dispatch back through IOR vtable.
    RandRandomGenerator self;

    // DO-NOT-DELETE splicer.begin(randomgen.RandRandomGenerator._implementation)
    // Put additional implementation details here...
    gov::cca::Services  frameworkServices;
    // DO-NOT-DELETE splicer.end(randomgen.RandRandomGenerator._implementation)

    …

 };  // end class RandRandomGenerator_impl

} // end namespace randomgen
```

Reference to framework Services object



File: random-component-c++/randomgen_RandRandomGenerator_Impl.cc

## RandRandomGenerator Component (C++): Framework Interaction

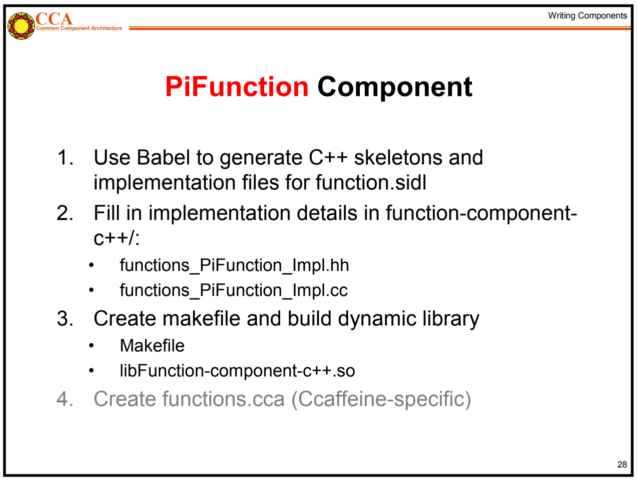
```
randomgen::RandRandomGenerator_impl::setServices (
  /*in*/ gov::cca::Services services )
throw ()
{
  // DO-NOT-DELETE splicer.begin(randomgen.RandRandomGenerator.setServices)
  frameworkServices = services;
  if (frameworkServices._not_nil ()) {
     gov::cca::TypeMap tm = frameworkServices.createTypeMap ();

     gov::cca::Port p = self;     // Babel required cast

     // Port provided by RandomGenerator implementations
     frameworkServices.addProvidesPort (p, “RandomGeneratorPort",
                    “randomgen.RandomGenerator", tm);

     // No ports are used by this RandomGenerator implementation
  }
   // DO-NOT-DELETE splicer.end(randomgen.RandRandomGenerator.setServices)
}
```

Save a pointer to the Services object

Port name

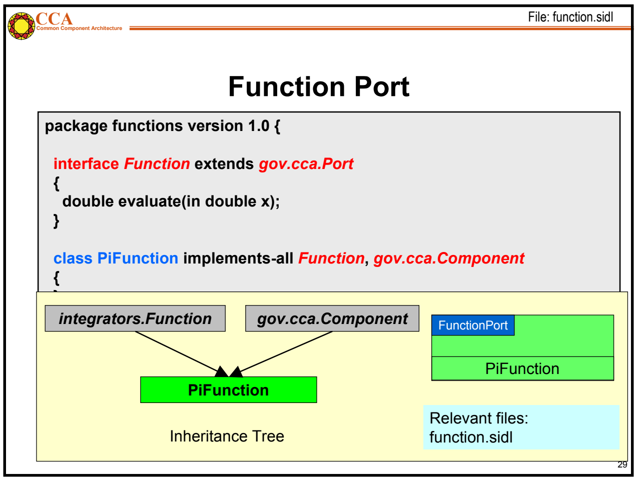
Port type

TypeMap reference



## PiFunction Component

1. Use Babel to generate C++ skeletons and implementation files for function.sidl
2. Fill in implementation details in function-component-c++/:
   - functions_PiFunction_Impl.hh
   - functions_PiFunction_Impl.cc
3. Create makefile and build dynamic library
   - Makefile
   - libFunction-component-c++.so
4. Create functions.cca (Ccaffeine-specific)



File: function.sidl

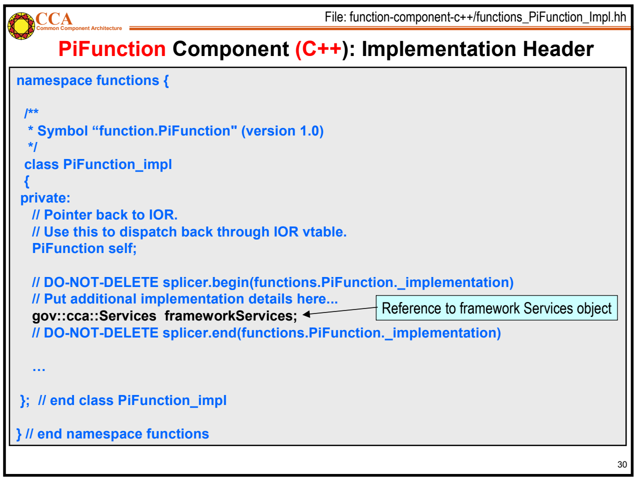
# Function Port

```
package functions version 1.0 {

  interface Function extends gov.cca.Port
  {
    double evaluate(in double x);
  }

  class PiFunction implements-all Function, gov.cca.Component
  {
```

integrators.Function
gov.cca.Component
PiFunction
FunctionPort
PiFunction

Inheritance Tree

Relevant files:
function.sidl

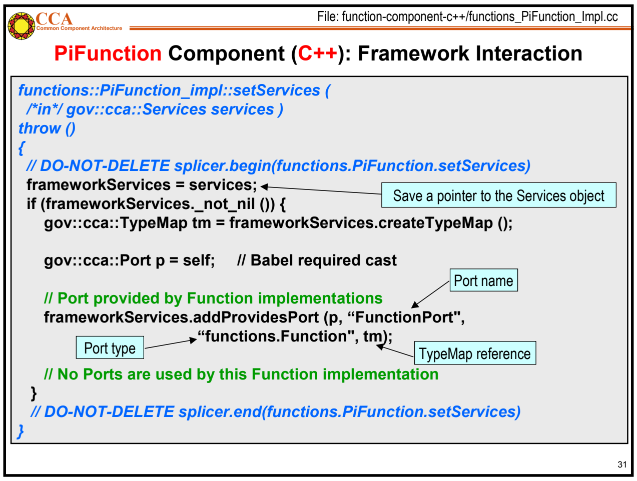


File: function-component-c++/functions_PiFunction_Impl.hh

## PiFunction Component (C++): Implementation Header

```
namespace functions {

  /**
   * Symbol “function.PiFunction" (version 1.0)
   */
  class PiFunction_impl
  {
 private:
   // Pointer back to IOR.
   // Use this to dispatch back through IOR vtable.
   PiFunction self;

   // DO-NOT-DELETE splicer.begin(functions.PiFunction._implementation)
   // Put additional implementation details here...
   gov::cca::Services  frameworkServices;
   // DO-NOT-DELETE splicer.end(functions.PiFunction._implementation)

   …

 };  // end class PiFunction_impl

} // end namespace functions
```

Reference to framework Services object



File: function-component-c++/functions_PiFunction_Impl.cc

## PiFunction Component (C++): Framework Interaction

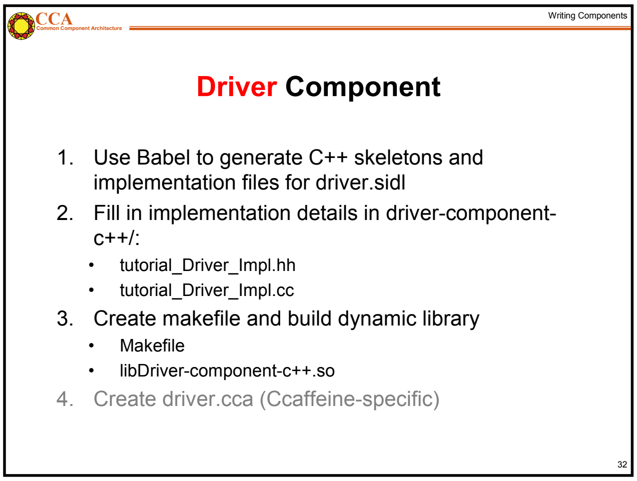
```
functions::PiFunction_impl::setServices (
  /*in*/ gov::cca::Services services )
throw ()
{
  // DO-NOT-DELETE splicer.begin(functions.PiFunction.setServices)
  frameworkServices = services;
  if (frameworkServices._not_nil ()) {
     gov::cca::TypeMap tm = frameworkServices.createTypeMap ();

     gov::cca::Port p = self;     // Babel required cast

     // Port provided by Function implementations
     frameworkServices.addProvidesPort (p, “FunctionPort",
                                   “functions.Function", tm);
     // No Ports are used by this Function implementation
   }
   // DO-NOT-DELETE splicer.end(functions.PiFunction.setServices)
}
```

Save a pointer to the Services object

Port name

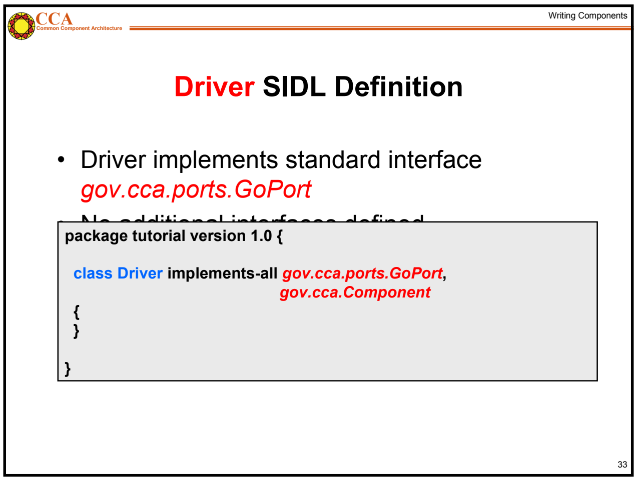
Port type

TypeMap reference



## Driver Component

1. Use Babel to generate C++ skeletons and implementation files for driver.sidl
2. Fill in implementation details in driver-component-c++/:
   - tutorial_Driver_Impl.hh
   - tutorial_Driver_Impl.cc
3. Create makefile and build dynamic library
   - Makefile
   - libDriver-component-c++.so
4. Create driver.cca (Ccaffeine-specific)



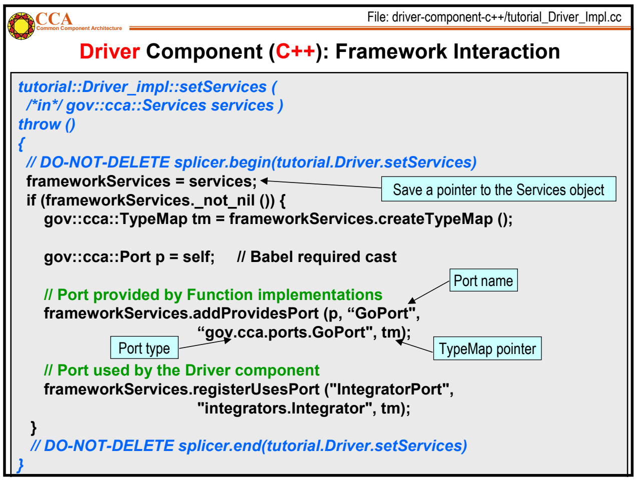
CCA Common Component Architecture

Writing Components

## Driver SIDL Definition

- Driver implements standard interface *gov.cca.ports.GoPort*
- No additional interfaces defined

```
package tutorial version 1.0 {

  class Driver implements-all gov.cca.ports.GoPort,
                                 gov.cca.Component
  {
  }

}
```



CCA Common Component Architecture

File: driver-component-c++/tutorial_Driver_Impl.cc

## Driver Component (C++): Framework Interaction

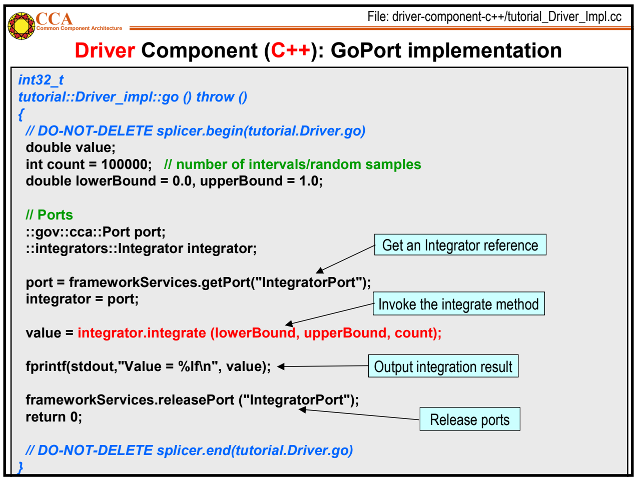
```
tutorial::Driver_impl::setServices (
 /*in*/ gov::cca::Services services )
throw ()
{
 // DO-NOT-DELETE splicer.begin(tutorial.Driver.setServices)
 frameworkServices = services;
 if (frameworkServices._not_nil ()) {
   gov::cca::TypeMap tm = frameworkServices.createTypeMap ();

   gov::cca::Port p = self;     // Babel required cast

   // Port provided by Function implementations
   frameworkServices.addProvidesPort (p, “GoPort",
                                 “gov.cca.ports.GoPort", tm);
   // Port used by the Driver component
   frameworkServices.registerUsesPort ("IntegratorPort",
                                 "integrators.Integrator", tm);
 }
  // DO-NOT-DELETE splicer.end(tutorial.Driver.setServices)
}
```

Save a pointer to the Services object

Port name

Port type

TypeMap pointer



CCA Common Component Architecture

File: driver-component-c++/tutorial_Driver_Impl.cc

## Driver Component (C++): GoPort implementation

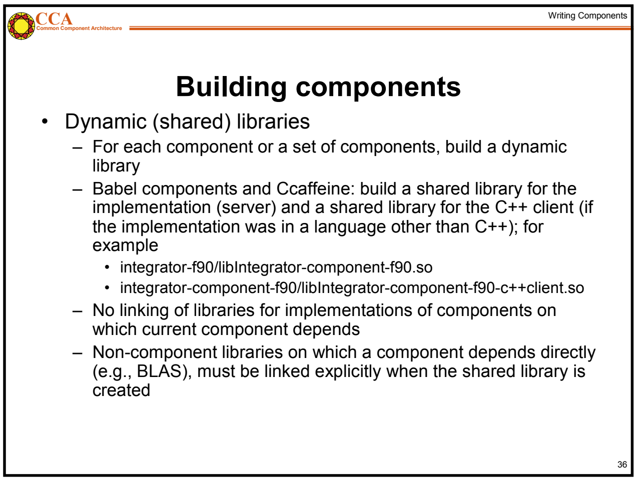
```
int32_t
tutorial::Driver_impl::go () throw ()
{
 // DO-NOT-DELETE splicer.begin(tutorial.Driver.go)
 double value;
 int count = 100000;   // number of intervals/random samples
 double lowerBound = 0.0, upperBound = 1.0;

 // Ports
 ::gov::cca::Port port;
 ::integrators::Integrator integrator;

 port = frameworkServices.getPort("IntegratorPort");
 integrator = port;

 value = integrator.integrate (lowerBound, upperBound, count);

 fprintf(stdout,"Value = %lf\n", value);

 frameworkServices.releasePort ("IntegratorPort");
 return 0;

 // DO-NOT-DELETE splicer.end(tutorial.Driver.go)
}
```

Get an Integrator reference

Invoke the integrate method

Output integration result

Release ports

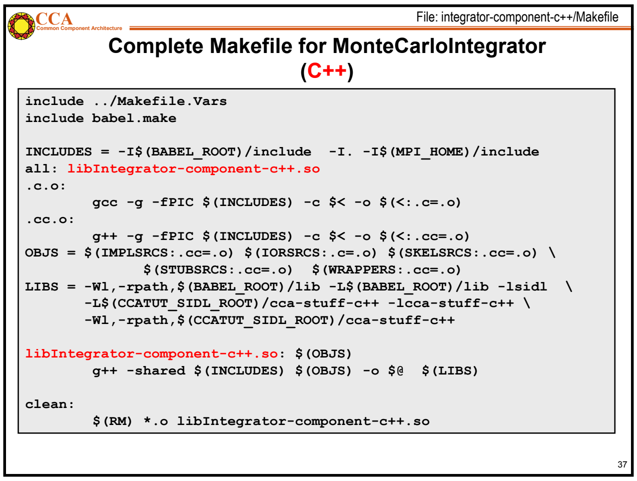


CCA Common Component Architecture

Writing Components

## Building components

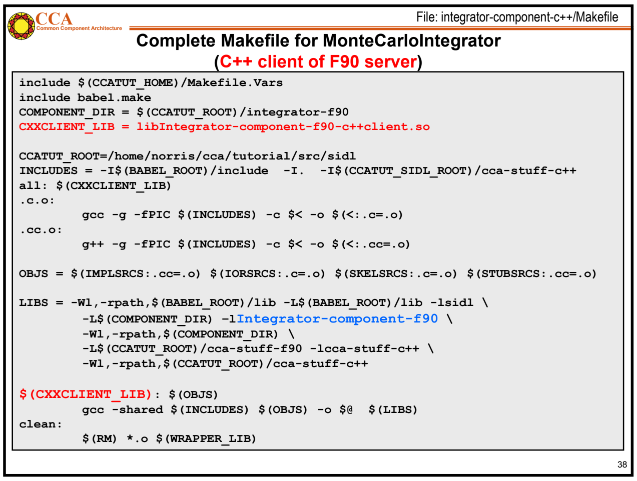
- Dynamic (shared) libraries
  - For each component or a set of components, build a dynamic library
  - Babel components and Ccaffeine: build a shared library for the implementation (server) and a shared library for the C++ client (if the implementation was in a language other than C++); for example
    - integrator-f90/libIntegrator-component-f90.so
    - integrator-component-f90/libIntegrator-component-f90-c++client.so
  - No linking of libraries for implementations of components on which current component depends
  - Non-component libraries on which a component depends directly (e.g., BLAS), must be linked explicitly when the shared library is created



File: integrator-component-c++/Makefile

## Complete Makefile for MonteCarloIntegrator (C++)

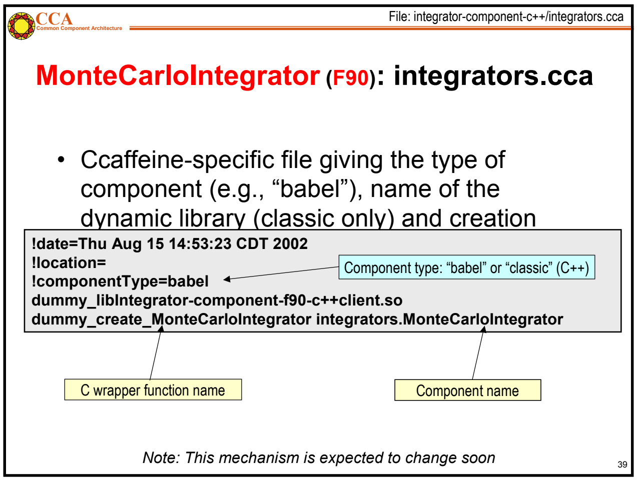
```
include ../Makefile.Vars
include babel.make

INCLUDES = -I$(BABEL_ROOT)/include  -I. -I$(MPI_HOME)/include
all: libIntegrator-component-c++.so
.c.o:
        gcc -g -fPIC $(INCLUDES) -c $< -o $(<:.c=.o)
.cc.o:
        g++ -g -fPIC $(INCLUDES) -c $< -o $(<:.cc=.o)
OBJS = $(IMPLSRCS:.cc=.o) $(IORSRCS:.c=.o) $(SKELSRCS:.cc=.o) \
              $(STUBSRCS:.cc=.o)  $(WRAPPERS:.cc=.o)
LIBS = -Wl,-rpath,$(BABEL_ROOT)/lib -L$(BABEL_ROOT)/lib -lsidl  \
       -L$(CCATUT_SIDL_ROOT)/cca-stuff-c++ -lcca-stuff-c++ \
       -Wl,-rpath,$(CCATUT_SIDL_ROOT)/cca-stuff-c++

libIntegrator-component-c++.so: $(OBJS)
        g++ -shared $(INCLUDES) $(OBJS) -o $@  $(LIBS)

clean:
        $(RM) *.o libIntegrator-component-c++.so
```



File: integrator-component-c++/Makefile

## Complete Makefile for MonteCarloIntegrator (C++ client of F90 server)

```
include $(CCATUT_HOME)/Makefile.Vars
include babel.make
COMPONENT_DIR = $(CCATUT_ROOT)/integrator-f90
CXXCLIENT_LIB = libIntegrator-component-f90-c++client.so

CCATUT_ROOT=/home/norris/cca/tutorial/src/sidl
INCLUDES = -I$(BABEL_ROOT)/include  -I.  -I$(CCATUT_SIDL_ROOT)/cca-stuff-c++
all: $(CXXCLIENT_LIB)
.c.o:
        gcc -g -fPIC $(INCLUDES) -c $< -o $(<:.c=.o)
.cc.o:
        g++ -g -fPIC $(INCLUDES) -c $< -o $(<:.cc=.o)

OBJS = $(IMPLSRCS:.cc=.o) $(IORSRCS:.c=.o) $(SKELSRCS:.c=.o) $(STUBSRCS:.cc=.o)

LIBS = -Wl,-rpath,$(BABEL_ROOT)/lib -L$(BABEL_ROOT)/lib -lsidl \
        -L$(COMPONENT_DIR) -lIntegrator-component-f90 \
        -Wl,-rpath,$(COMPONENT_DIR) \
        -L$(CCATUT_ROOT)/cca-stuff-f90 -lcca-stuff-c++ \
        -Wl,-rpath,$(CCATUT_ROOT)/cca-stuff-c++

$(CXXCLIENT_LIB): $(OBJS)
        gcc -shared $(INCLUDES) $(OBJS) -o $@  $(LIBS)
clean:
        $(RM) *.o $(WRAPPER_LIB)
```



File: integrator-component-c++/integrators.cca

## MonteCarloIntegrator (F90): integrators.cca

- Ccaffeine-specific file giving the type of component (e.g., "babel"), name of the dynamic library (classic only) and creation

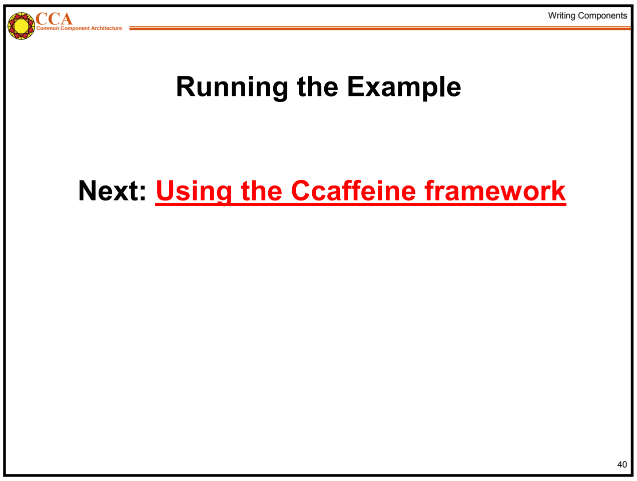
```
!date=Thu Aug 15 14:53:23 CDT 2002
!location=
!componentType=babel
dummy_libIntegrator-component-f90-c++client.so
dummy_create_MonteCarloIntegrator integrators.MonteCarloIntegrator
```

Component type: "babel" or "classic" (C++)

C wrapper function name

Component name

*Note: This mechanism is expected to change soon*



Writing Components

## Running the Example

**Next: Using the Ccaffeine framework**