
Designing a Distributed System for Smart Vehicles

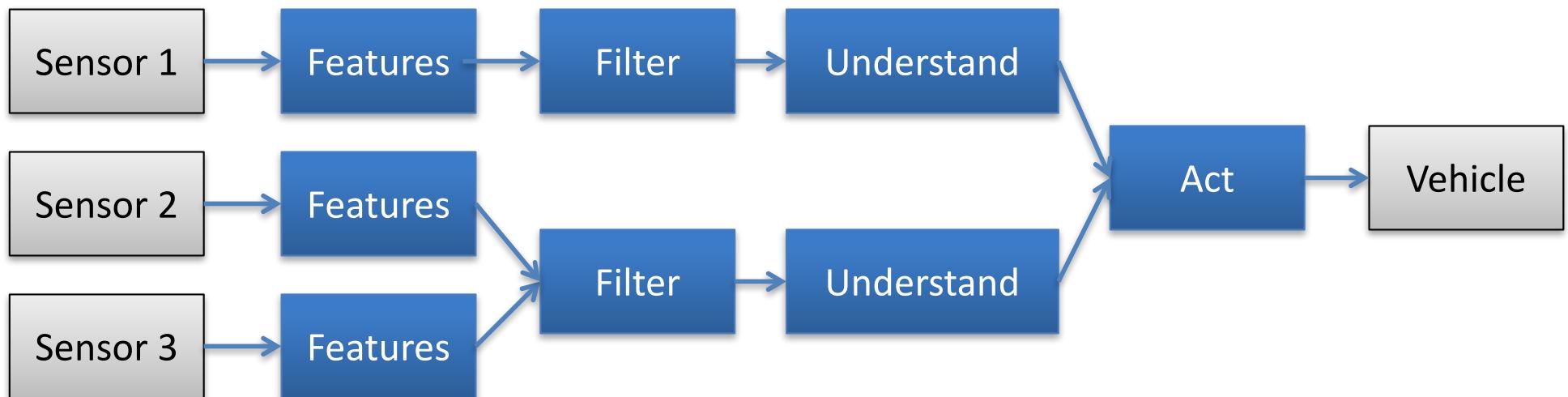
Recap: OpenDaVINCI + OpenDLV

OpenDaVINCI is a lean realtime-capable software development and runtime environment written entirely in standard C++ running on a variety of POSIX-compatible OS and hardware platforms.

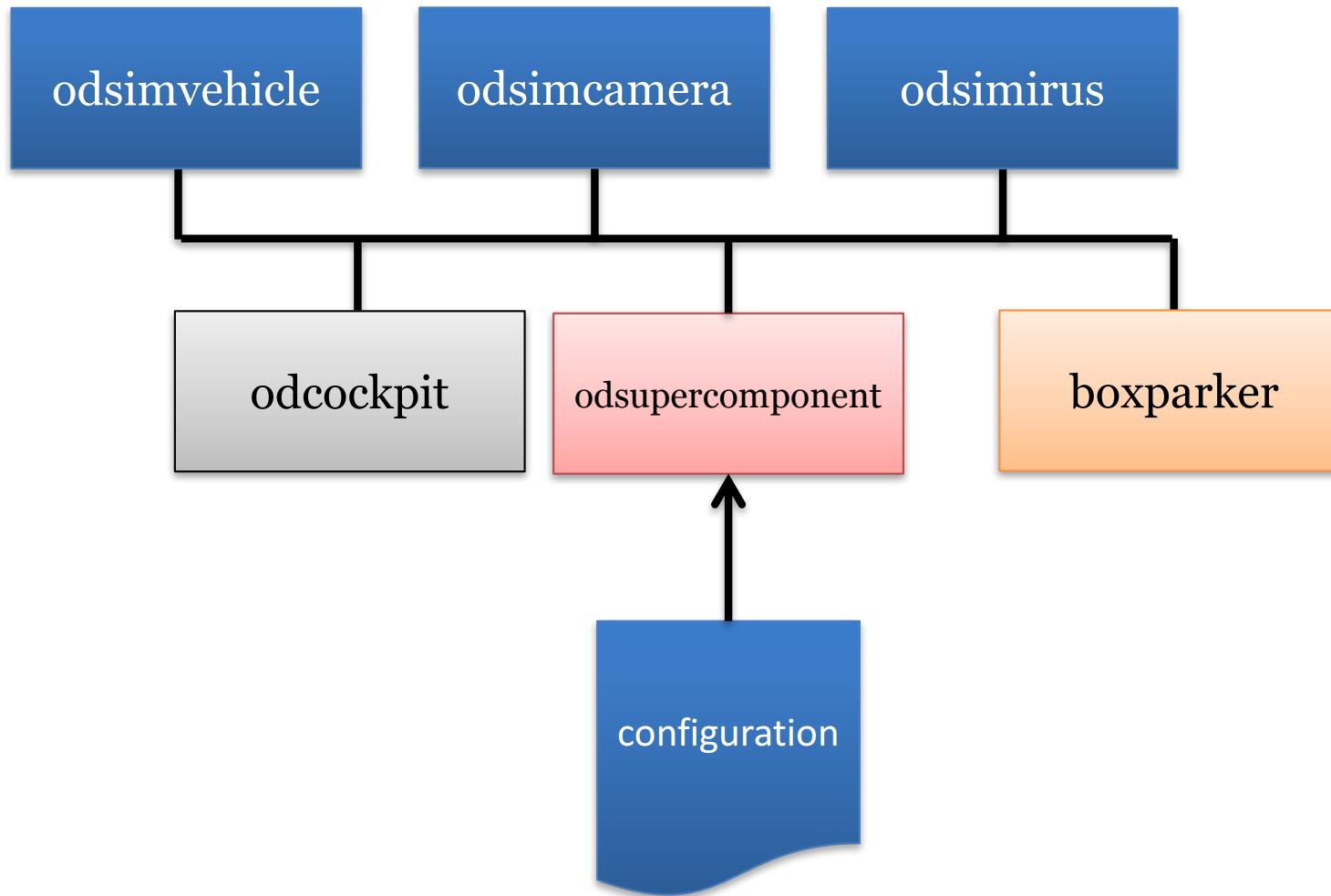
Features:

- Distributed data processing software modules in realtime environments.
- Time- or data-triggered software modules.
- Centrally maintained dynamic software module configuration protocol (DMCP).
- Publish/subscribe and directed communication.
- Transparent monitoring, logging, and replaying - including unstructured BLOBs like video streams.
- Built-in supervised execution with transparent control of communication, time, and scheduling.

OpenDLV provides low-level HW/SW interfaces to sensors and actuators and contains biologically inspired algorithms for self-driving vehicles.



Recap: OpenDaVINCI + OpenDLV



Recap: Running the Virtual World

Downloading the scenario and configuration:

```
$ cd && wget http://www.cse.chalmers.se/~bergerc/DIT-168.zip
```

Unpack to \$HOME/DIT-168:

```
$ cd && unzip DIT-168.zip
```

Get our latest Docker image (latest: v4.6.1):

```
$ docker pull sereresearch/opendavinci-ubuntu-16.04-complete:latest
```

Terminal 1: Run odsupercomponent:

```
$ docker run -ti --rm --net=host -v $HOME/DIT-168:/opt/configuration -w /opt/configuration  
sereresearch/opendavinci-ubuntu-16.04-complete:latest /opt/od4/bin/odsupercomponent --cid=111 --  
verbose=1
```

Terminal 2: Run odsimvehicle:

```
$ docker run -ti --rm --net=host sereresearch/opendavinci-ubuntu-16.04-complete:latest  
/opt/od4/bin/odsimvehicle --cid=111 --freq=10
```

Terminal 3: Run odsimirus:

```
$ docker run -ti --rm --net=host -v $HOME/DIT-168:/opt/configuration -w /opt/configuration  
sereresearch/opendavinci-ubuntu-16.04-complete:latest /opt/od4/bin/odsimirus --cid=111 --freq=10
```

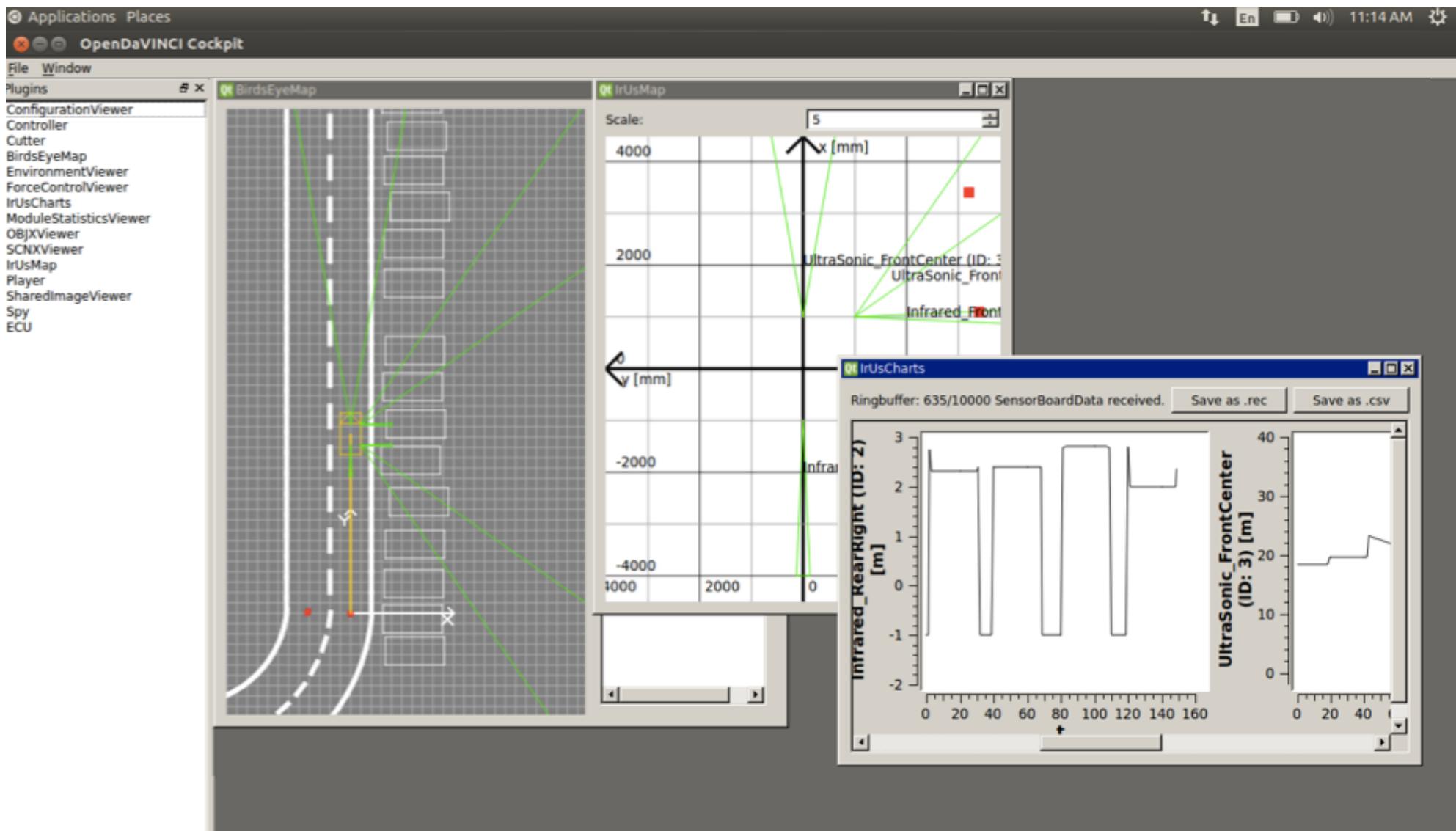
Terminal 4: Run odcockpit:

```
$ xhost +  
$ docker run -ti --rm --net=host --ipc=host -e DISPLAY=$DISPLAY -v /tmp/.X11-unix:/tmp/.X11-unix -v  
$HOME/DIT-168:/opt/configuration -w /opt/configuration sereresearch/opendavinci-ubuntu-16.04-  
complete:latest /opt/od4/bin/odcockpit --cid=111
```

Terminal 5: Run boxparker example:

```
$ docker run -ti --rm --net=host sereresearch/opendavinci-ubuntu-16.04-complete:latest  
/opt/od4/bin/miniatuure/boxparker --cid=111 --freq=10
```

Recap: Running the Virtual World



Recap: Compiling the Template Repository

Create a fork from OpenDLV.scaledcars and clone your fork.

Get base image to build OpenDLV.scaledcars:

```
$ cd docker && make updateDockerBaseImage
```

(a) Building source tree (in folder docker):

```
$ make buildComplete
```

(b) Incrementally building source tree (for each subsequent change to the sources, in folder docker):

```
$ make buildIncremental
```

Create Docker image with the most recent binaries (in folder docker):

```
$ make createDockerImage
```

Show newly created Docker image:

```
$ docker images
```

```
...
```

seresearch/scaledcars-on-opendlv-on-opendlv-core-on-opendavinci-ubuntu-16.04-complete	latest	d18001326a06
About a minute ago	1.649 GB	

Recap: Running Code from the Template Repository

Running example code (time-triggered example):

```
$ docker run -ti --rm --net=host seresearch/scaledcars-on-
opendlv-on-opendlv-core-on-opendavinci-ubuntu-16.04-
complete:latest /opt/opendlv.scaledcars/bin/scaledcars-
control-example --cid=111 --freq=10
```

Recap: Running Code from the Template Repository

Running example code (time-triggered example):

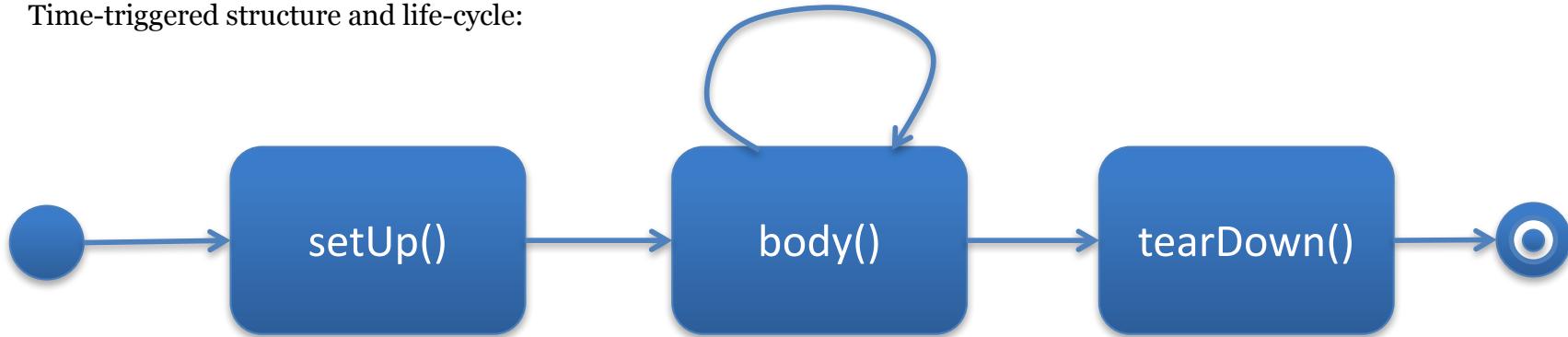
```
$ docker run -ti --rm --net=host sereresearch/scaledcars-on-opendlv-on-opendlv-core-on-opendavinci-ubuntu-16.04-complete:latest /opt/opendlv.scaledcars/bin/scaledcars-control-example --cid=111 --freq=10
```

Running example code (data-triggered example + OpenCV):

```
$ docker run -ti --rm --net=host --ipc=host -e DISPLAY=$DISPLAY -v /tmp/.X11-unix:/tmp/.X11-unix sereresearch/scaledcars-on-opendlv-on-opendlv-core-on-opendavinci-ubuntu-16.04-complete:latest /opt/opendlv.scaledcars/bin/scaledcars-perception-example --cid=111
```

Platform-Independent Layer – Component

Time-triggered structure and life-cycle:



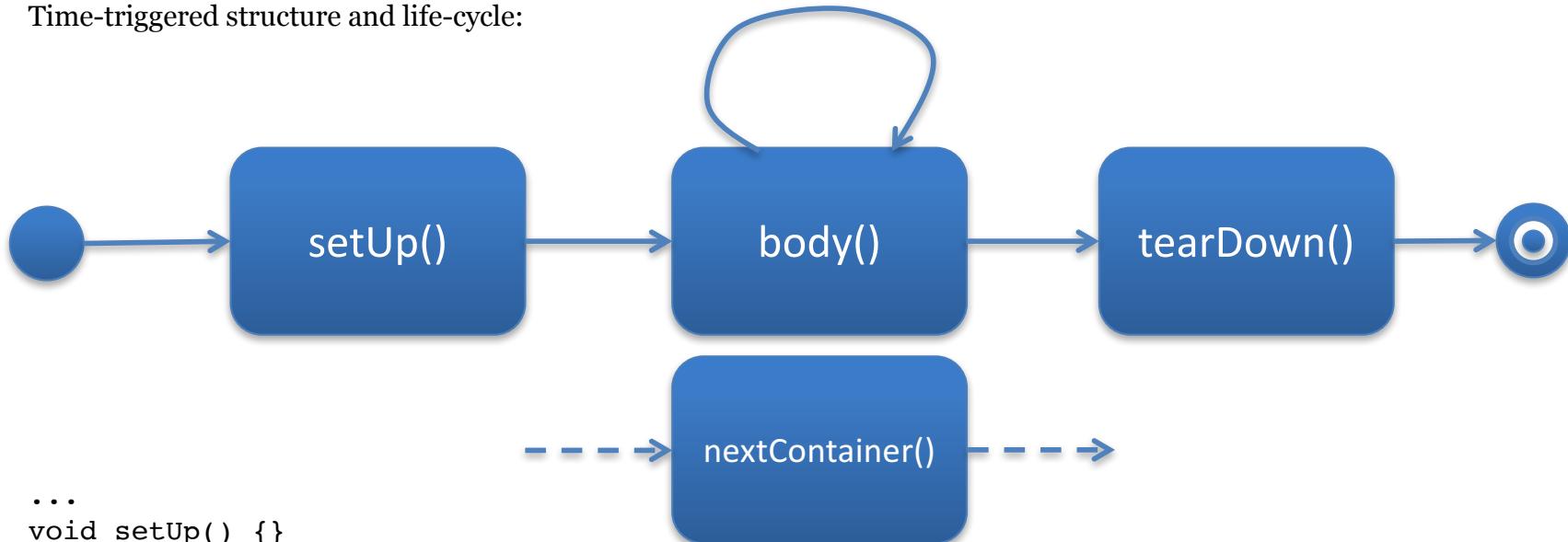
```
...
void setUp() {}

void tearDown() {
```

```
void body() {
    while (getModuleStateAndWaitForRemainingTimeInTimeslice() ==
odcore::data::dmcp::ModuleStateMessage::RUNNING) {
        // do stuff
    }
}
```

Platform-Independent Layer – Component

Time-triggered structure and life-cycle:



```
...
void setUp() {}

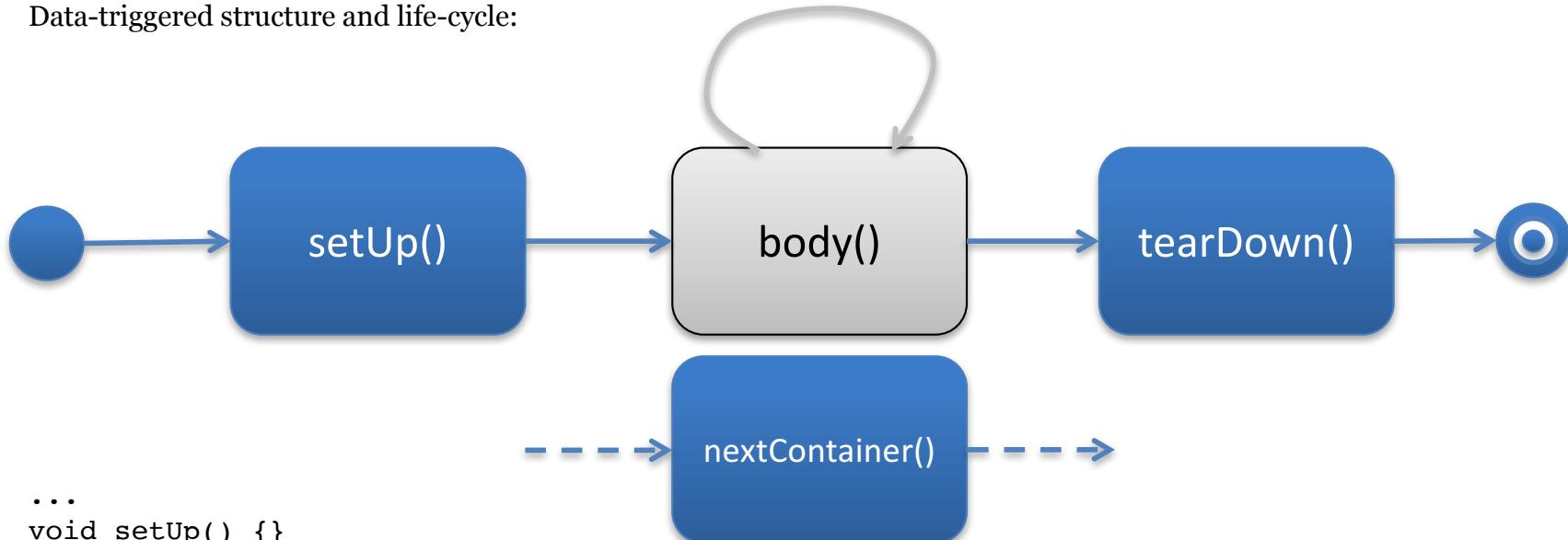
void tearDown() {}

void nextContainer(odcore::data::Container &c) {
    if (c.getDataType() == Namespace::Data::ID()) {
        Namespace::Data instance = c.getData<Namespace::Data>();
        ...
    }
}

void body() {
    while (getModuleStateAndWaitForRemainingTimeInTimeslice() ==
odcore::data::dmcp::ModuleStateMessage::RUNNING) {
        // do stuff
    }
}
```

Platform-Independent Layer – Component

Data-triggered structure and life-cycle:



```
...
void setUp() {}

void tearDown() {}

void nextContainer(odcore::data::Container &c) {
    if (c.getDataType() == Namespace::Data::ID()) {
        Namespace::Data instance = c.getData<Namespace::Data>();
        ...
    }
}
```

Platform-Independent Layer – Data Structures

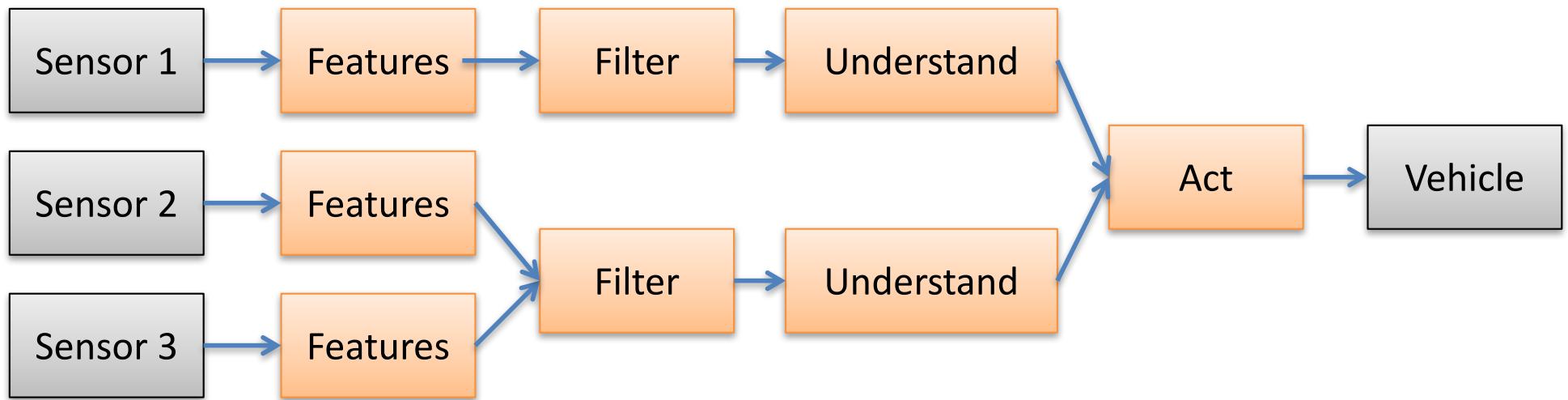
Sending data:

```
...
void body() {
    while (getModuleStateAndWaitForRemainingTimeInTimeslice() ==
odcore::data::dmcp::ModuleStateMessage::RUNNING) {
    ...
    VehicleControl vc;
    vc.setSpeed(0.4);
    vc.setSteeringWheelAngle(1.57);

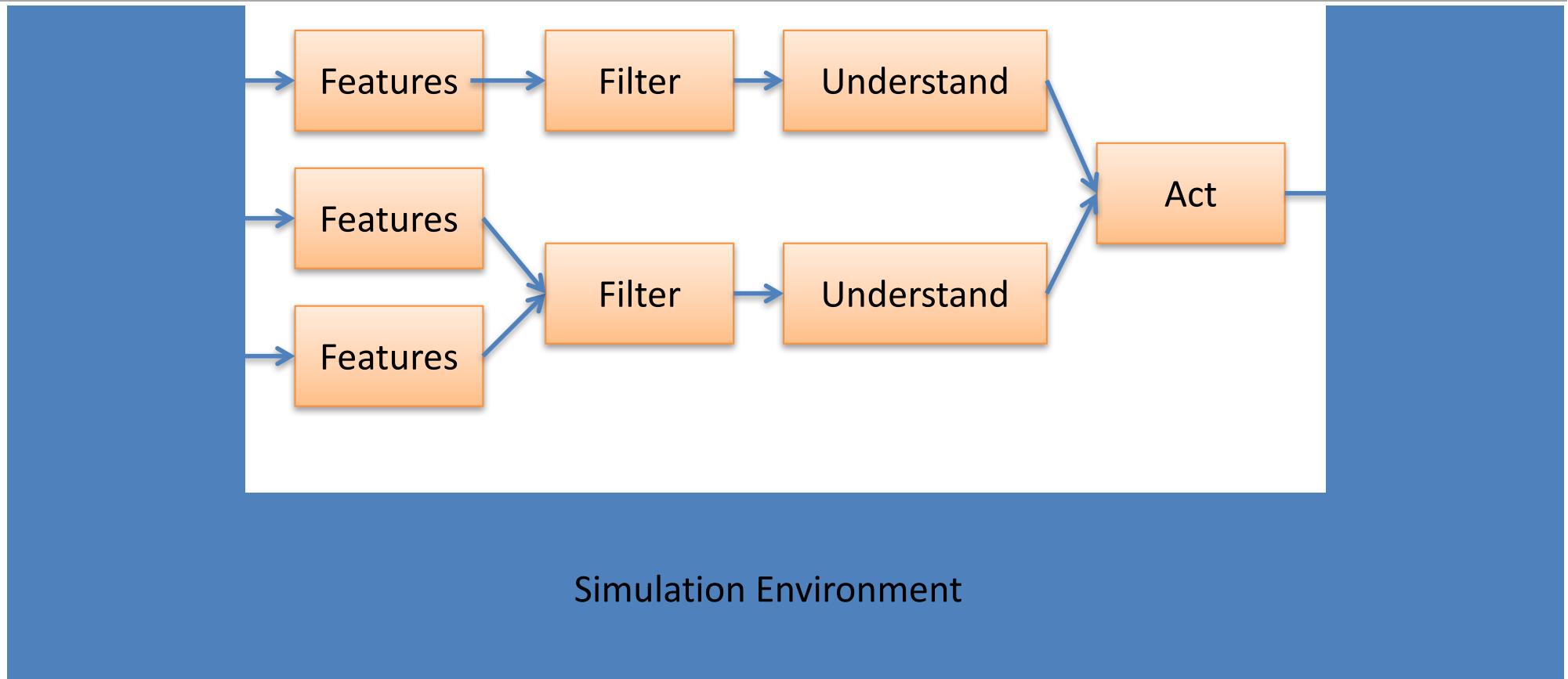
    Container c(vc);
    getConference().send(c);
    ...

}
}
```

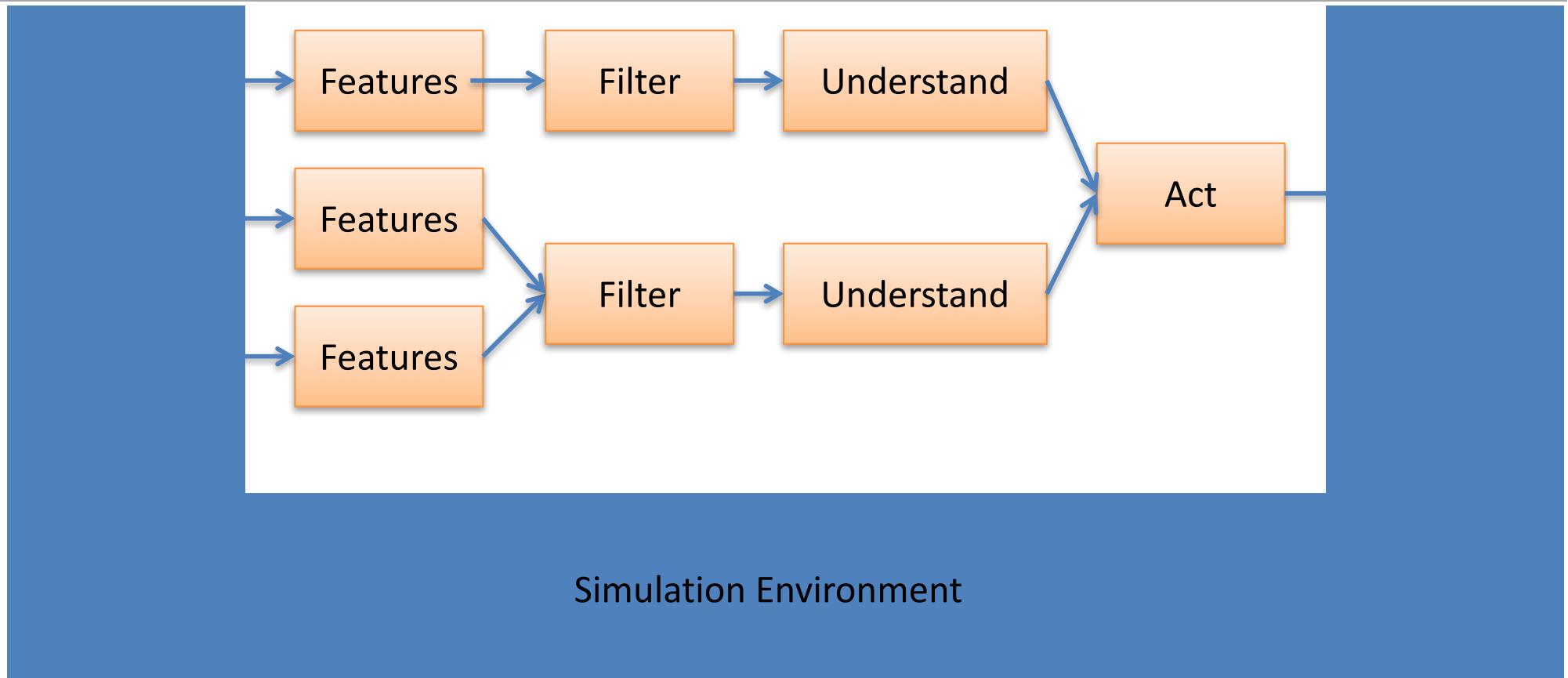
OpenDaVINCI & Simulation



OpenDaVINCI & Simulation



OpenDaVINCI & Simulation

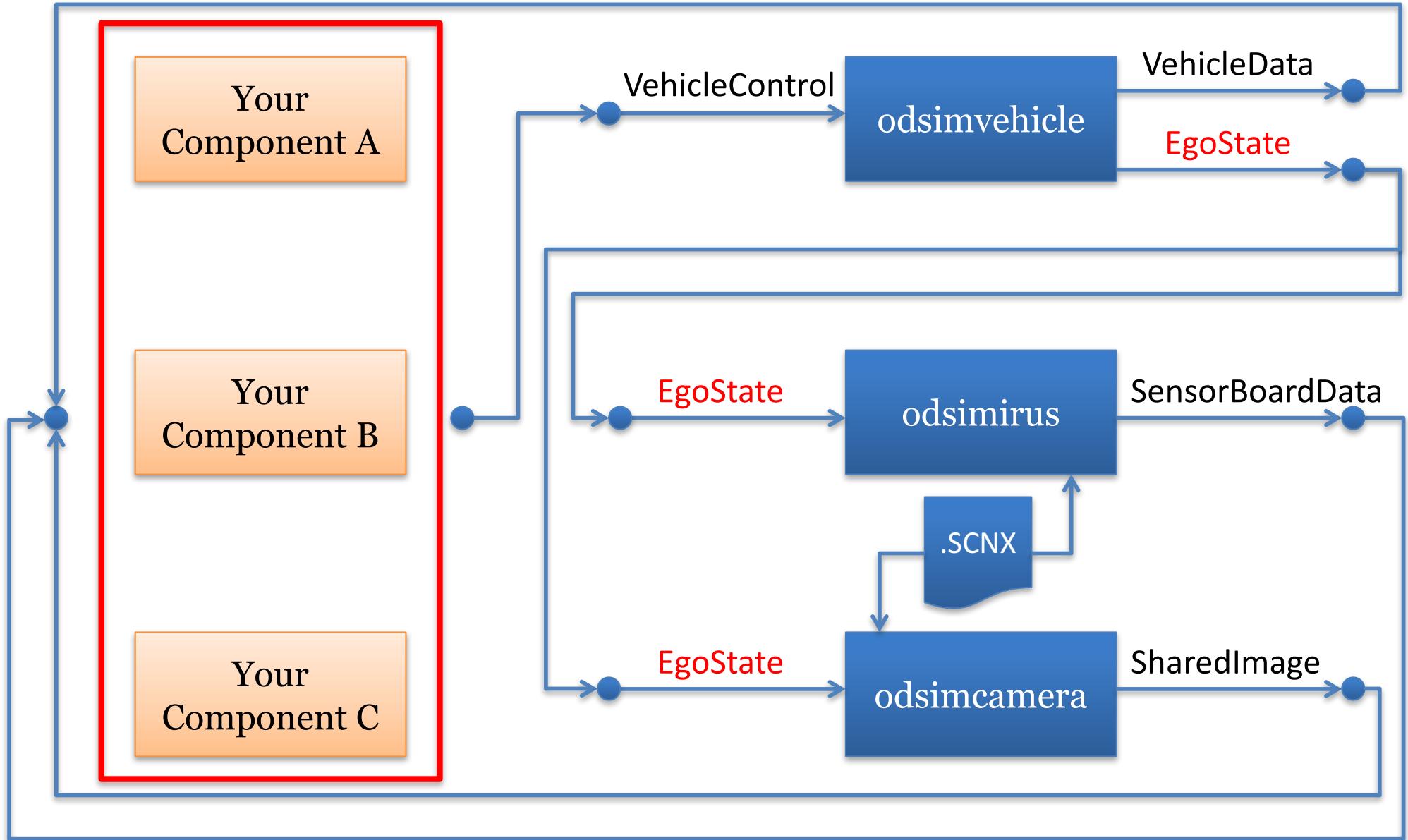


odsimvehicle

odsimcamera

odsimirus

Platform-Independent Layer



Platform-Independent Layer – Data Structures

```
automotive::VehicleData:
```

```
...
```

```
double getHeading() const;  
double getAbsTraveledPath() const;  
double getRelTraveledPath() const;
```

Platform-Independent Layer – Data Structures

```
automotive::VehicleControl:  
  
...  
void setSpeed(const double &s);  
  
void setSteeringWheelAngle(const double &f);  
  
void setBrakeLights(const bool &on);  
  
void setLeftFlashingLights(const bool &on);  
void setRightFlashingLights(const bool &on);
```

Platform-Independent Layer – Data Structures

```
coredata::image::SharedImage:  
  
...  
const string getName() const;  
uint32_t getWidth() const;  
uint32_t getHeight() const;  
uint32_t getBytesPerPixel() const;
```

Platform-Independent Layer – Data Structures

```
automotive::miniature::SensorBoardData:

message automotive.miniture.SensorBoardData {
    uint32 numberOfSensors;
    map<uint32, double> distances;
}

uint32_t getNumberOfSensors() const;

uint32_t getSize_MapOfDistances() const;
bool isEmpty_MapOfDistances() const;
bool containsKey_MapOfDistances(const uint32_t &key) const;
double getValueForKey_MapOfDistances(const uint32_t &key);
```

Layout OpenDLV.scaledcars Repository

cmake.Modules	→ Modules for Cmake
code	→ Sources and example code
docker	→ Scripts to build sources
resources	→ .odvd files for own messages
scripts	→ Code maintenance
thirdparty	→ CxxTest
usecases	→ docker-compose environments

Data Structures

```
resources/odvd/ODVDScaledCarsDataModel.odvd:  
  
message chalmersrevere.scaledcars.ExampleMessage [id = 801] {  
    uint32 field1    [id = 1];  
  
}
```

Data Structures

```
resources/odvd/ODVDScaledCarsDataModel.odvd:
```

```
message chalmersrevere.scaledcars.ExampleMessage [id = 801] {
    uint32 field1 [id = 1];
}
```

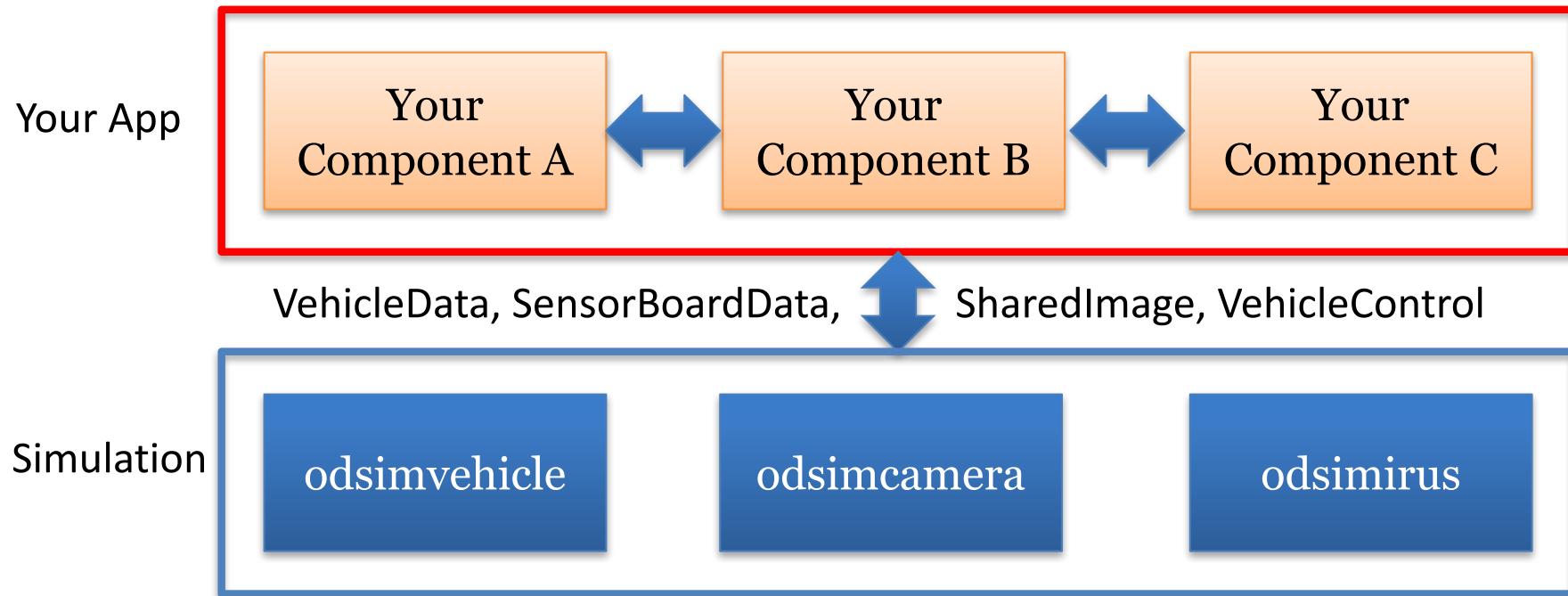
Creating

```
'libodvdscaledcarsdatamodel/include/odvdscaledcarsdatamodel/generated/chalmersrevere/scaledcars/ExampleMessage.h' done.Creating
'libodvdscaledcarsdatamodel/src/generated/chalmersrevere/scaledcars/ExampleMessage.cpp' done.Creating
'libodvdscaledcarsdatamodel/testsuites/chalmersrevere_scaledcars_ExampleMessageTestSuite.h' done.Creating
'libodvdscaledcarsdatamodel/proto/odvdscaledcarsdatamodel.proto' done.Creating
'libodvdscaledcarsdatamodel/include/odvdscaledcarsdatamodel/GeneratedHeaders_ODVDScaledCarsDataModel.h' done.Creating
'libodvdscaledcarsdatamodel/include/odvdscaledcarsdatamodel/GeneratedHeaders_ODVDScaledCarsDataModel_Helper.h' done.Creating
'libodvdscaledcarsdatamodel/src/GeneratedHeaders_ODVDScaledCarsDataModel_Helper.cpp' done.Creating 'libodvdscaledcarsdatamodel/CMakeLists.txt' done.Creating
'libodvdscaledcarsdatamodel/cmake.Modules' done.Creating
'libodvdscaledcarsdatamodel/cmake.Modules/CompileFlags.cmake' done.Creating
'libodvdscaledcarsdatamodel/cmake.Modules/CheckCxxTestEnvironment.cmake' done.Creating
'libodvdscaledcarsdatamodel/cmake.Modules/FindODVDScaledCarsDataModel.cmake' done.
```

Data Structures

```
resources/odvd/ODVDScaledCarsDataModel.odvd:  
  
message chalmersrevere.scaledcars.ExampleMessage [id = 801] {  
    uint32 field1    [id = 1];  
    float field2     [id = 2];  
    double field3    [id = 3];  
    ...  
}
```

Platform-Independent Layer



OpenDaVINCI – Useful Classes

automotive::miniature::SensorBoardData

automotive::VehicleControl

automotive::VehicleData

core::data::image::SharedImage

cartesian::Constants

core::data::TimeStamp

Code smells:

~~getTimeOfDay()~~

~~sleep()~~

~~goto~~

Feedback

Group	will get feedback from	Presentation slot on Feb. 14
1	3, 4	1:20pm
3	4, 5	1:32pm
4	5, 6	1:44pm
5	6, 7	1:56pm
6	7, 8	2:08pm
7	8, 9	2:20pm
8	9, 10	2:32pm
9	10, 1	2:44pm
10	1, 3	2:52pm

10 min presentation + 2min questions

Test your laptops for the presentations beforehand!

Thank you.

