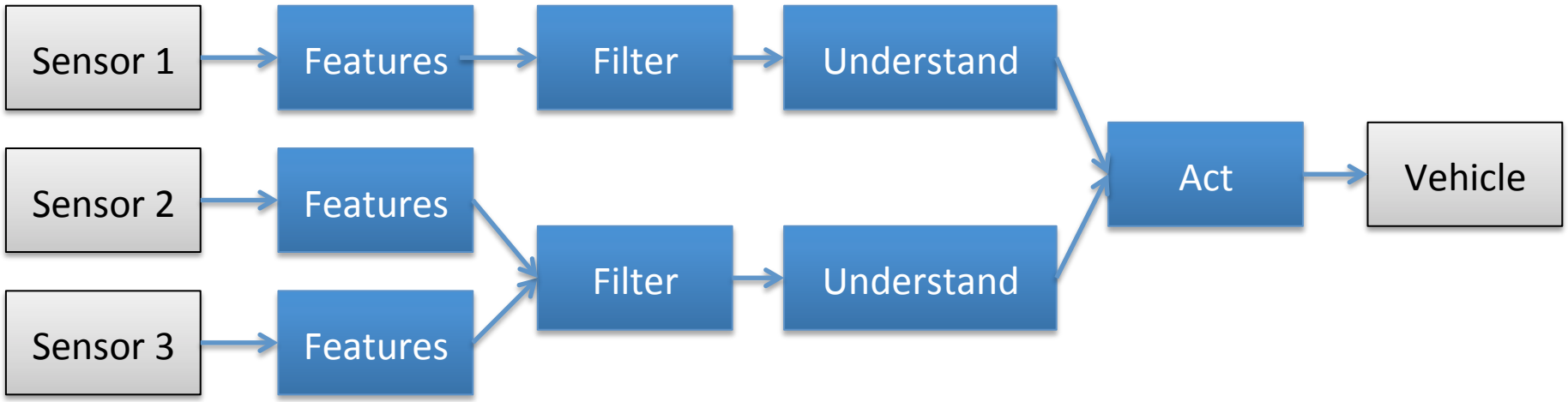
Smart Vehicles

OpenDaVINCI

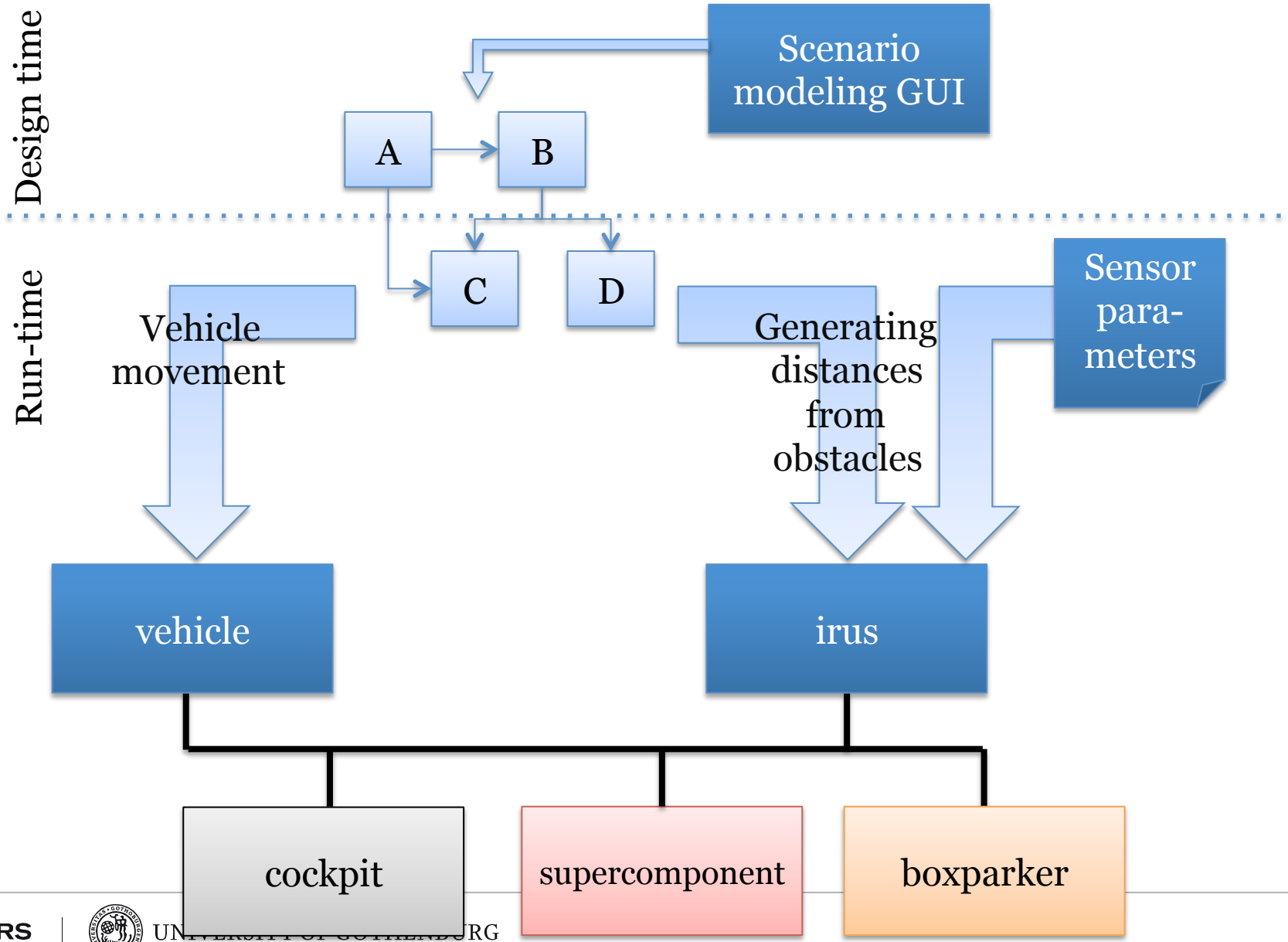
OpenDaVINCI is a lean realtime-capable software development and runtime environment written entirely in standard C++ running on a variety of POSIX-compatible OS and hardware platforms.

Features:

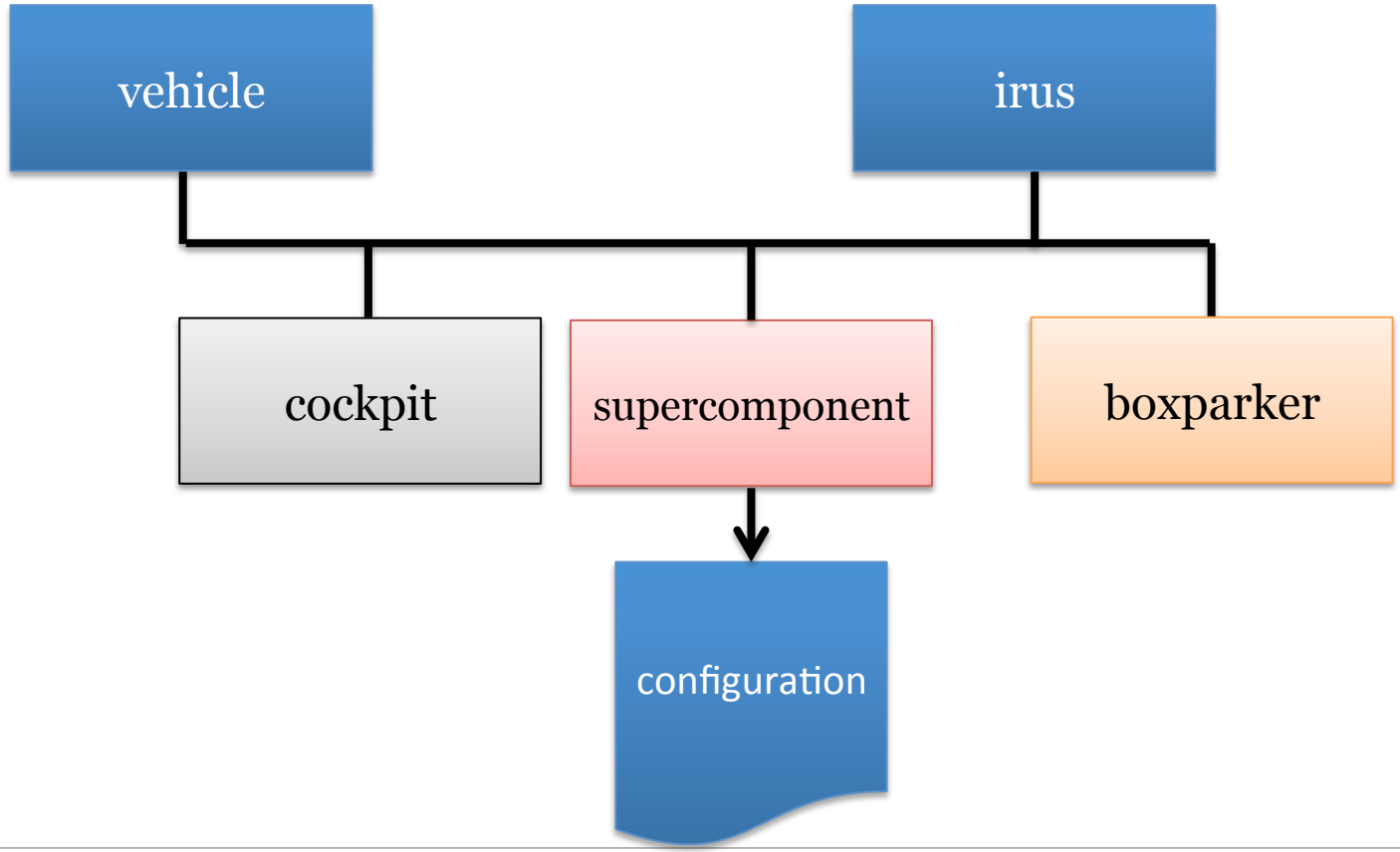
- Distributed data processing software modules in realtime environments.
- Time- or data-triggered software modules.
- Centrally maintained dynamic software module configuration protocol (DMCP).
- Publish/subscribe and directed communication.
- Transparent monitoring, logging, and replaying - including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



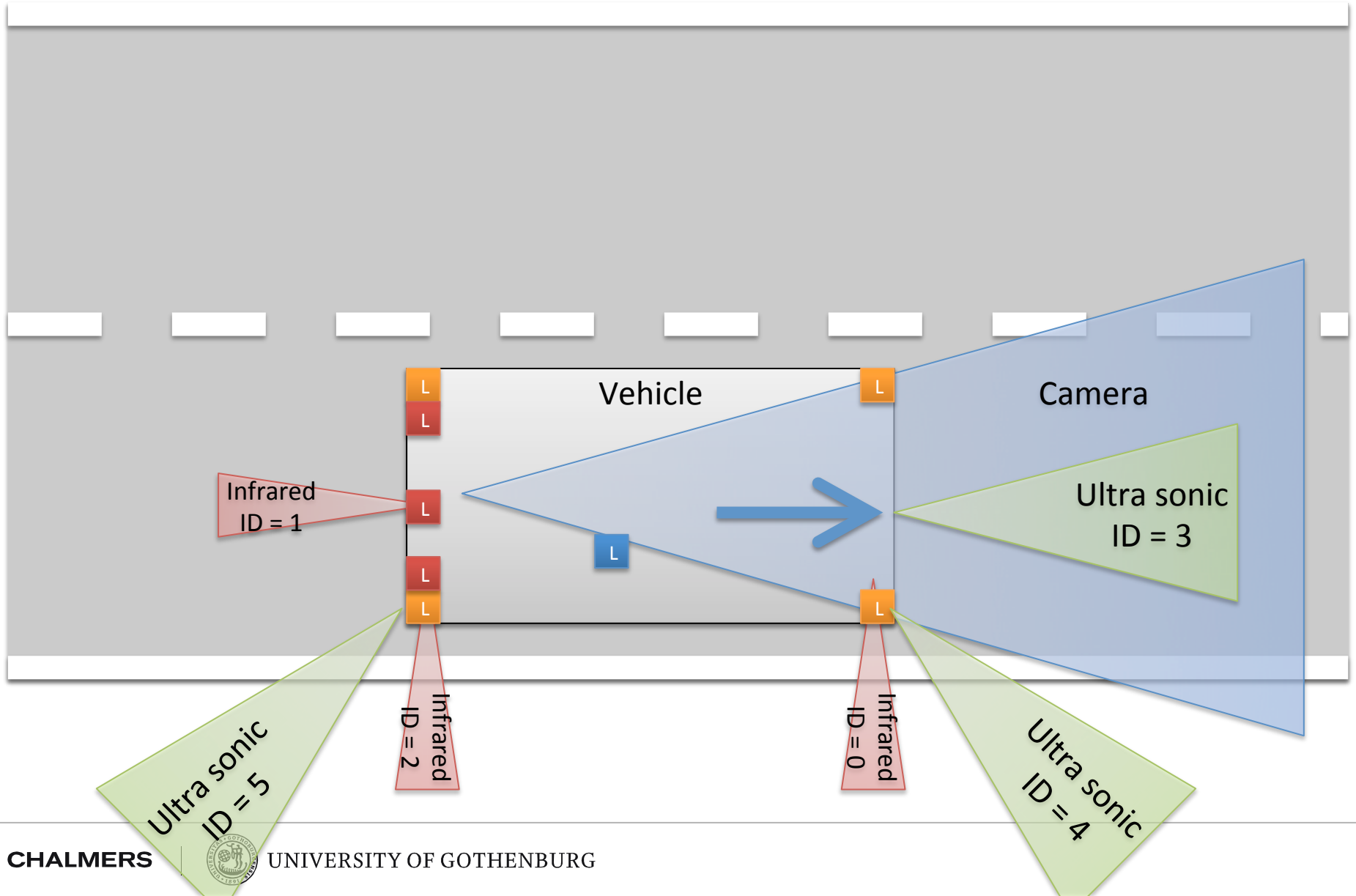
OpenDaVINCI



OpenDaVINCI



Sensor Layout – Configuration



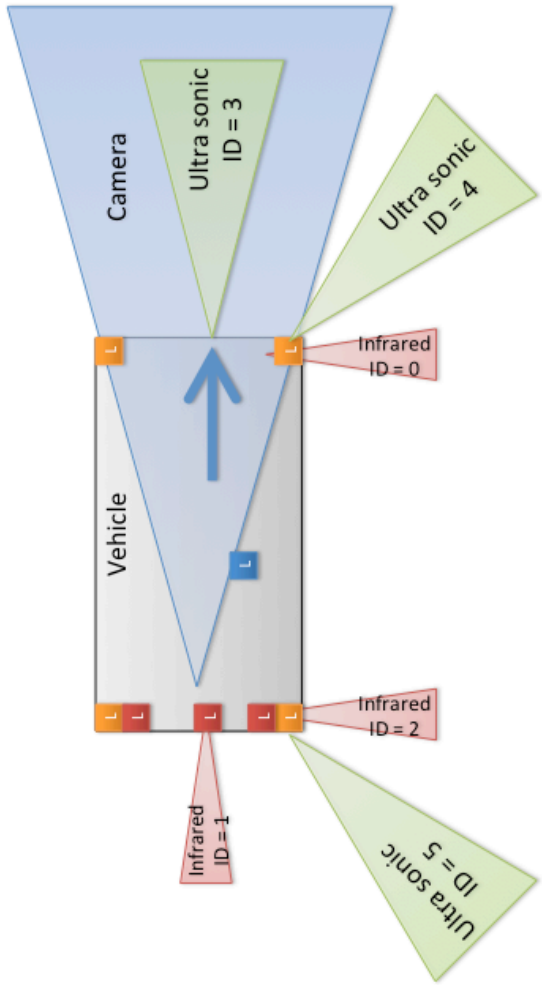
Sensor Layout – Configuration

```
global.scenario = file://Parking-boxes-1.scnx

irus.numberOfSensors = 6
irus.showPolygons = 1

irus.sensor0.id = 0
irus.sensor0.name = Infrared_FrontRight
irus.sensor0.rotZ = -90
irus.sensor0.translation = (1.0;-1.0;0.0)
irus.sensor0.angleFOV = 5
irus.sensor0.distanceFOV = 3
irus.sensor0.clampDistance = 2.9
irus.sensor0.showFOV = 1

irus.sensor1.id = 1
irus.sensor1.name = Infrared_Rear
irus.sensor1.rotZ = -180
irus.sensor1.translation = (-1.0;0.0;0.0)
irus.sensor1.angleFOV = 5
irus.sensor1.distanceFOV = 3
irus.sensor1.clampDistance = 2.9
irus.sensor1.showFOV = 1
...
```



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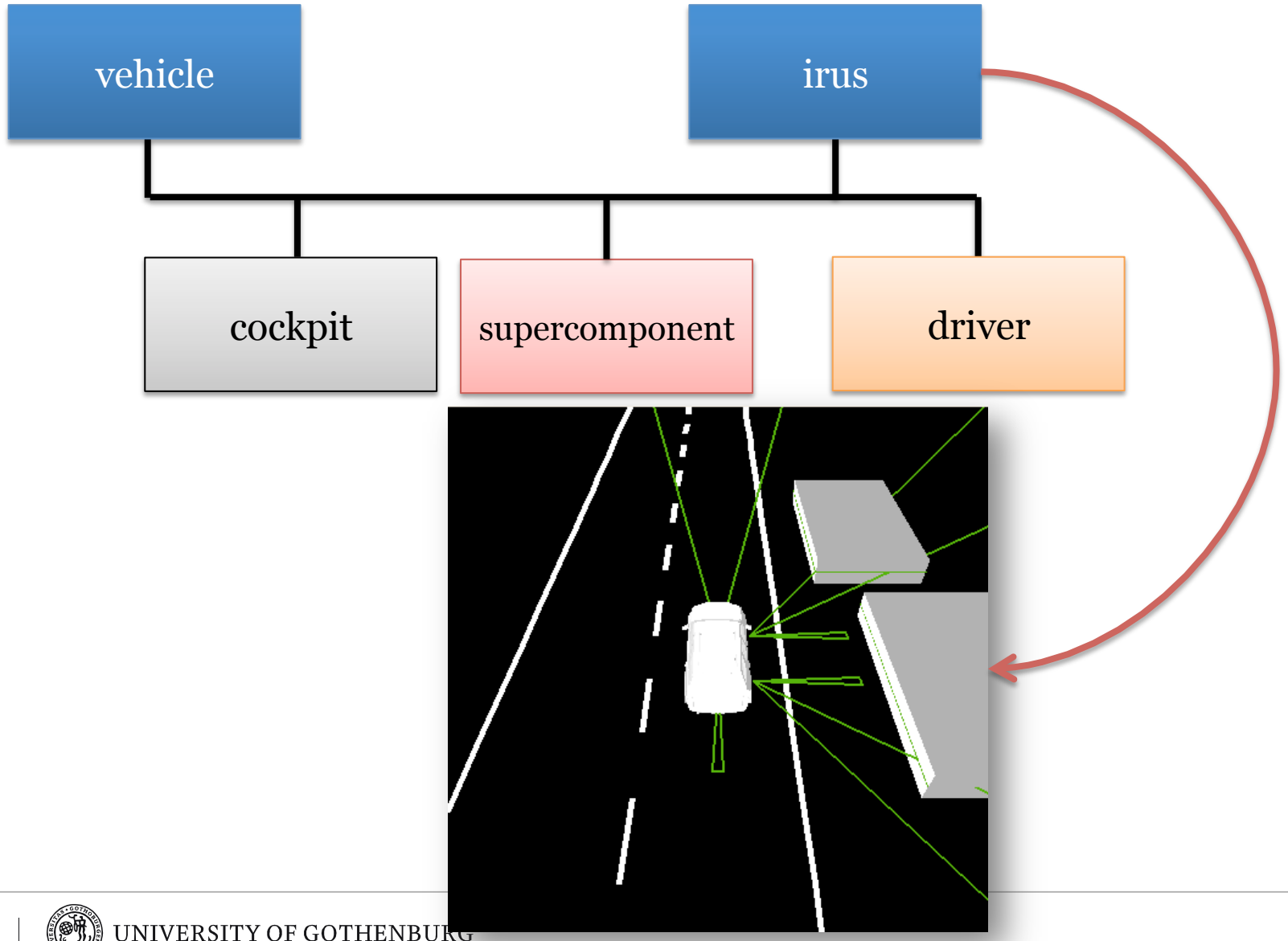

“How to…” – Guide

1. Please install Docker according to https://docs.docker.com/installation/ubuntulinux/

2. Install the basic build environment:sudo apt-get install build-essential cmake

3. Download OpenDaVINCI including the parking template from http://www.cse.chalmers.se/~bergerc/parking/2015-02-02_OpenDaVINCI.tar.gz.

4. Untar the content to /home/$USER/OpenDaVINCI

5. Create an installation directory, say /opt/parking and make sure that it is writeable from your user account.

6. Build the software:

```
cd /home/$USER/OpenDaVINCI
mkdir build && cd build
cmake -D CMAKE_INSTALL_PREFIX=/opt/parking ..
make && make test
make install
```

7. Download the configuration and scenario data from http://www.cse.chalmers.se/~bergerc/parking/config.tar.gz.

8. Untar the content to /home/$USER/config

9. Start the supercomponent in Docker:

10. Start the vehicle simulation in Docker:

11. Start the irus sensor simulation that uses the scenario data (.scnx file) in Docker:

12. Enable access to X11 from anywhere to run visualization environment cockpit:

13. Start visualization environment cockpit:

14. Start the visualization plugin “BirdsEyeMap” to watch the simulation.

15. Start the boxparker demo: /opt/parking/bin/boxparker --cid=111

supercomponent

```
$ sudo docker run --rm=true --net host -v /home/$USER/
config:/opt/data -w "/opt/data" -t -i seresearch/
parking:v12 /opt/sim/bin/supercomponent --cid=111 --freq=10
--managed=simulation_rt


Creating multicast UDP receiver at 225.0.0.111:19751.
(supercomponent) Parsing configuration file...
(supercomponent) Server information: IP: 0.0.0.0, Port:
19866, managedLevel: 5
(supercomponent) Creating discoverer server...
Creating multicast UDP receiver at 225.0.0.111:19750.
(supercomponent) Creating connection server...
Creating multicast UDP receiver at 225.0.0.111:12175.
(supercomponent) Ready - managed level 5
```

vehicle

```
$ sudo docker run --rm=true --net host -t -i seresearch/
parking:v12 /opt/sim/bin/vehicle --cid=111

No runtime frequency set. Assuming a frequency of 1 Hz.
Creating multicast UDP receiver at 225.0.0.111:12175.
Creating multicast UDP receiver at 225.0.0.111:19751.
(ClientModule) discovering supercomponent...
(ClientModule) supercomponent found at IP: 10.0.2.15, Port:
19866, managedLevel: 5
(ClientModule) connecting to supercomponent...
(DMCP-ConnectionClient) sending configuration request...IP:
10.0.2.15, Port: 19866, managedLevel: 5
(DMCP-Client) Received Configuration
global.buffer.memorysegmentsize=2800000
global.buffer.numberofmemorysegments=20
global.car=Scenarios/Models/FordEscape.objx
global.scenario=file://Parking-boxes-1.scnx
global.showgrid=0
vehicle.headingdeg=90
...
```

irus

```
$ sudo docker run --rm=true --net host -w "/opt/data" -t -i -v /
home/$USER/config:/opt/data seresearch/parking:v12 /opt/sim/bin/
irus --cid=111

No runtime frequency set. Assuming a frequency of 1 Hz.
Creating multicast UDP receiver at 225.0.0.111:12175.
Creating multicast UDP receiver at 225.0.0.111:19751.
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global.buffer.memorysegmentsize=2800000
global.buffer.numberofmemorysegments=20
global.car=Scenarios/Models/FordEscape.objx
global.scenario=file://Parking-boxes-1.scnx
global.showgrid=0
irus.numberofsensors=6
...
```

cockpit

```
$ xhost +
$ sudo docker run --rm=true --net host -w "/opt/data" -t -i -e
DISPLAY=$DISPLAY -e QT_X11_NO_MITSHM=1 -v /home/$USER/config:/
opt/data -v /tmp/.X11-unix:/tmp/.X11-unix seresearch/
parking:v12 /opt/sim/bin/cockpit --cid=111

No runtime frequency set. Assuming a frequency of 1 Hz.
Creating multicast UDP receiver at 225.0.0.111:12175.
Creating multicast UDP receiver at 225.0.0.111:19751.
(ClientModule) discovering supercomponent...
(ClientModule) supercomponent found at IP: 10.0.2.15, Port:
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global.buffer.numberofmemorysegments=20
global.car=Scenarios/Models/FordEscape.objx
global.scenario=file://Parking-boxes-1.scnx
global.showgrid=0
...
```
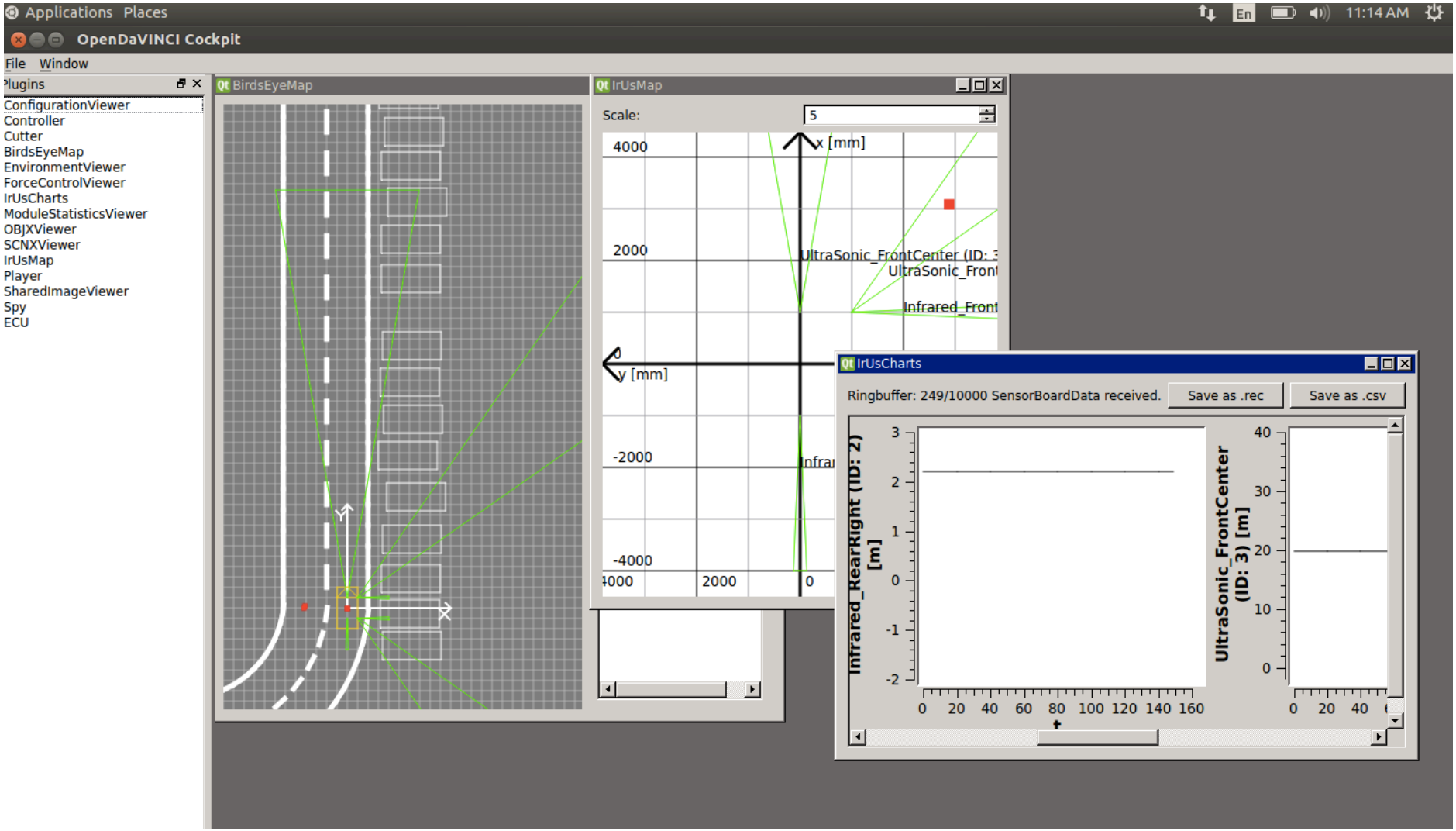

cockpit


Applications Places
En
11:14 AM
OpenDaVINCI Cockpit
File Window
Plugins
ConfigurationViewer
Controller
Cutter
BirdsEyeMap
EnvironmentViewer
ForceControlViewer
IrUsCharts
ModuleStatisticsViewer
OBJXViewer
SCNXViewer
IrUsMap
Player
SharedImageViewer
Spy
ECU

cockpit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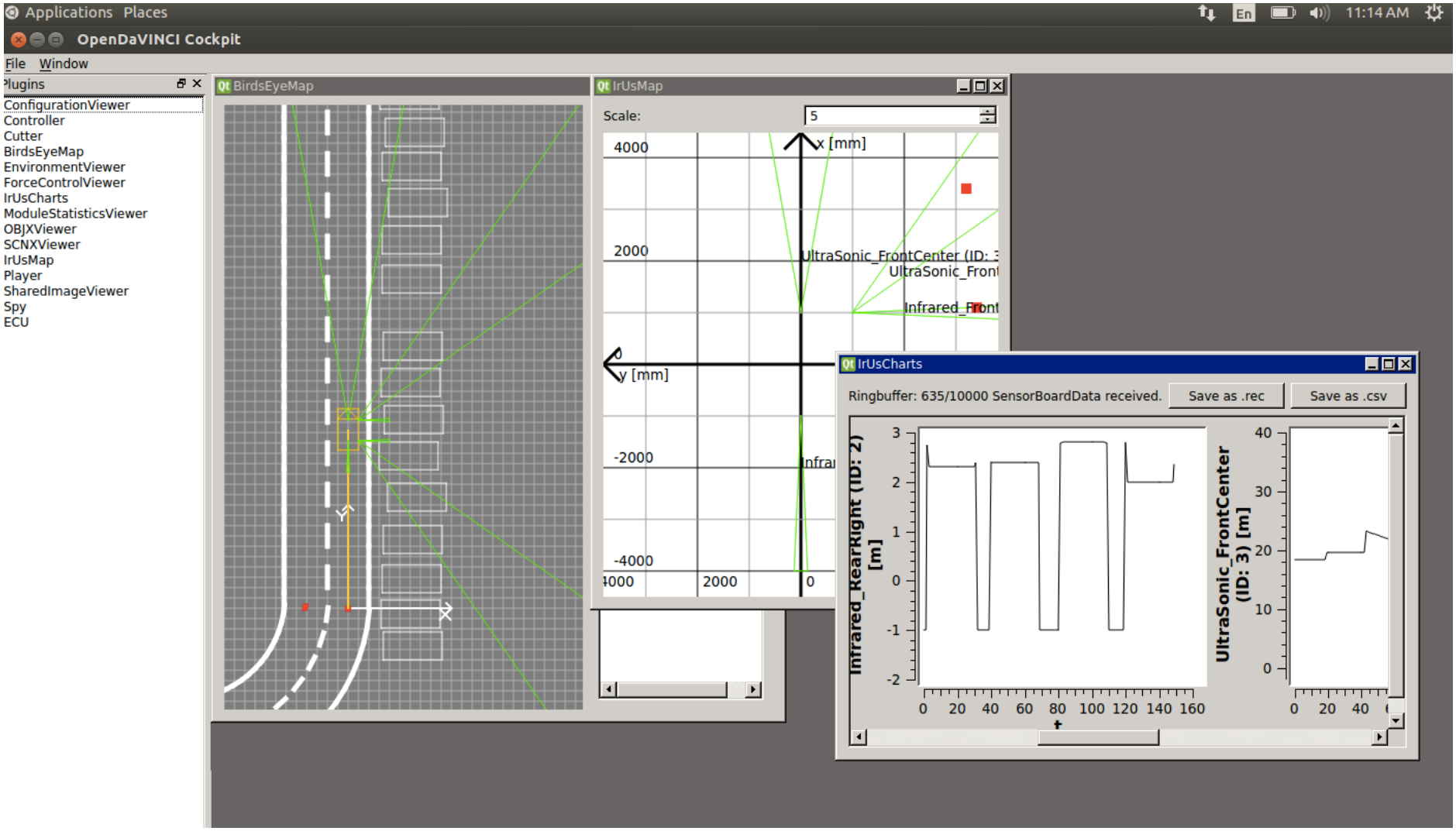
OBJXViewer
SCNXViewer
IrUsMap
Player
SharedImageViewer
Spy
ECU
BirdsEyeMap
IrUsMap
Scale:
5
4000
2000
-2000
-4000
x [mm]
y [mm]
UltraSonic_FrontCenter (ID: 3
UltraSonic_Front
Infrared_Front
IrUsCharts
Ringbuffer: 249/10000 SensorBoardData received.
Save as .rec
Save as .csv
Infrared_RearRight (ID: 2) [m]
UltraSonic_FrontCenter (ID: 3) [m]
t

cockpit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SCNXViewer
IrUsMap
Player
SharedImageViewer
Spy
ECU
BirdsEyeMap
IrUsMap
Scale:
5
4000
2000
-2000
-4000
x [mm]
y [mm]
UltraSonic_FrontCenter (ID: 3
UltraSonic_Front
Infrared_Front
IrUsCharts
Ringbuffer: 635/10000 SensorBoardData received.
Save as .rec
Save as .csv
Infrared_RearRight (ID: 2) [m]
UltraSonic_FrontCenter (ID: 3) [m]
t

boxparker

```
/opt/parking/bin$ ./boxparker --cid=111
No runtime frequency set.
Assuming a frequency of 1 Hz.
Creating multicast UDP receiver at 225.0.0.111:12175.
Creating multicast UDP receiver at 225.0.0.111:19751.(ClientModule) discovering supercomponent...
(ClientModule) supercomponent found at IP: 10.0.2.15, Port: 19866, managedLevel: 5
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(DMCP-ConnectionClient) sending configuration request...IP: 10.0.2.15, Port: 19866, managedLevel: 5
(DMCP-Client) Received Configuration
global.buffer.memorysegmentsize=2800000
global.buffer.numberofmemorysegments=20
global.car=Scenarios/Models/FordEscape.objx
global.scenario=file://Parking-boxes-1.scnxglobal.showgrid=0
(ClientModule) connecting to supercomponent...done - managed level: 5
Existing ContainerConference disabled and ContainerListener redirected to localContainerConference.
Size = 0.403339
Size = 0.806678
Size = 1.21002
Size = 1.00835
Size = 0.504174
Size = 0.705844
Size = 0.605009
Size = 3.52922
Calling disposal service...
Cleaning up regular removal queue... done.
Cleaning up final removal queue... done....
```

File is available here:
OpenDaVINCI/apps/boxparker/src

Under the Hood

Reading odometer data:

```
// 1. Get most recent vehicle data:
Container containerVehicleData =
getKeyValueDataStore().get(Container::VEHICLEDATA);
VehicleData vd = containerVehicleData.getData<VehicleData> ();
```

Interface:

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

Under the Hood

Reading sensor data:

```
// 2. Get most recent sensor board data:
Container containerSensorBoardData =
getKeyValueDataStore().get(Container::USER_DATA_0);
SensorBoardData sbd = containerSensorBoardData.getData<SensorBoardData>
();
```

Interface:

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

Under the Hood

Writing vehicle control:

```
VehicleControl vc;
...
// Create container for finally sending the data.
Container c(Container::VEHICLECONTROL, vc);
// Send container.
getConference().send(c);
```

Interface:

```
vc.setSpeed(-2); // Positive → forward, negative → backward
vc.setSteeringWheelAngle(25); // Positive → to the right, negative → to the left
```

Thank you.

More material:

C. Berger, *"From a Competition for Self-Driving Miniature Cars to a Standardized Experimental Platform: Concept, Models, Architecture, and Evaluation,"* in Journal of Software Engineering for Robotics, vol. 5, no. 1, 2014, pp. 63-79 (arXiv: 1406.7768).