Principles of Safe Autonomy ECE 498 SM
Lecture 2: RightHook Simulator

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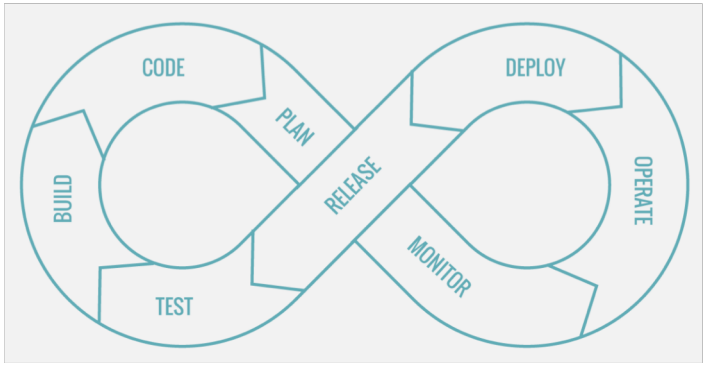
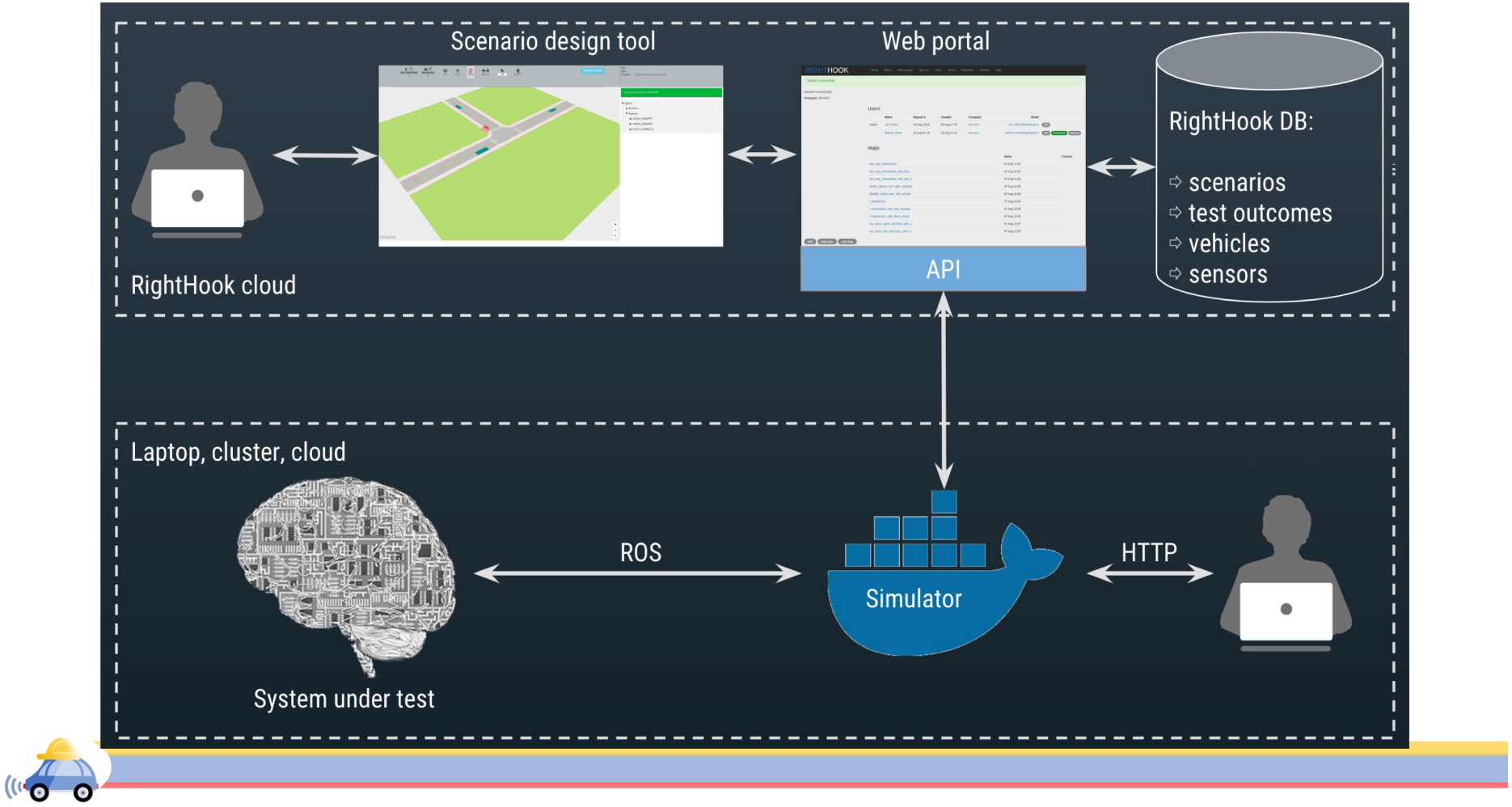
Lecture outline

- RightHook Simulator
- FastX, Docker
- ROS

RightHook Simulator

- Righthook Demo
- Closed loop testing environment with deterministic results
- Real world testing is expensive and time consuming




Scenario design tool
Web portal
RightHook DB:
scenarios
test outcomes
vehicles
sensors
RightHook cloud
API
Laptop, cluster, cloud
ROS
HTTP
Simulator
System under test

Virtual Machine

- Virtual machines(VM) are emulation programs of operating systems(OS)
- VM provides virtual hardware to run multiple instances of different OS
- We use VMs in this class to get access to GPU recourses

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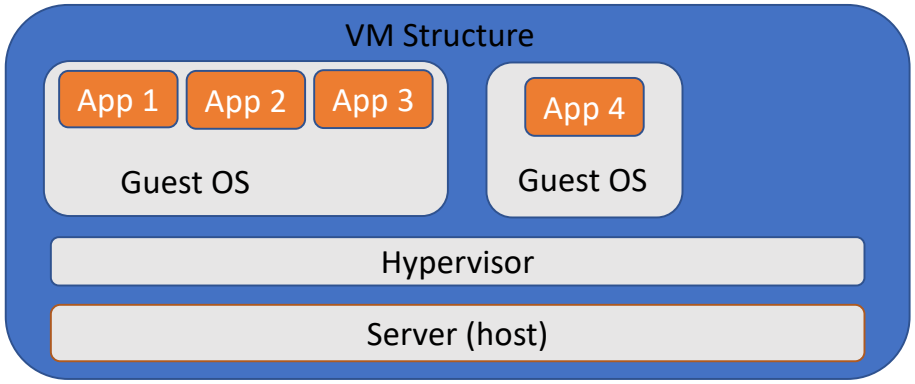

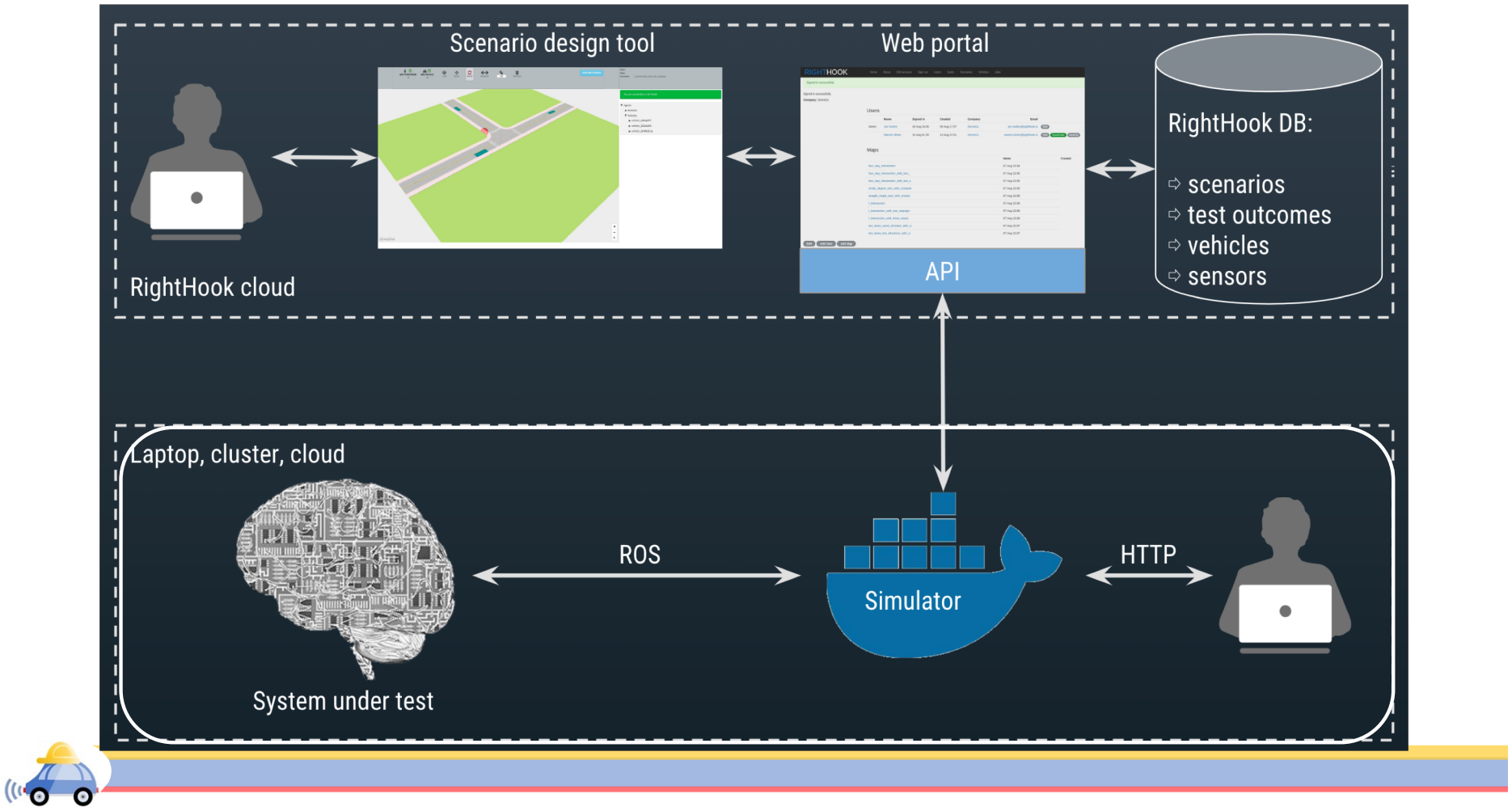
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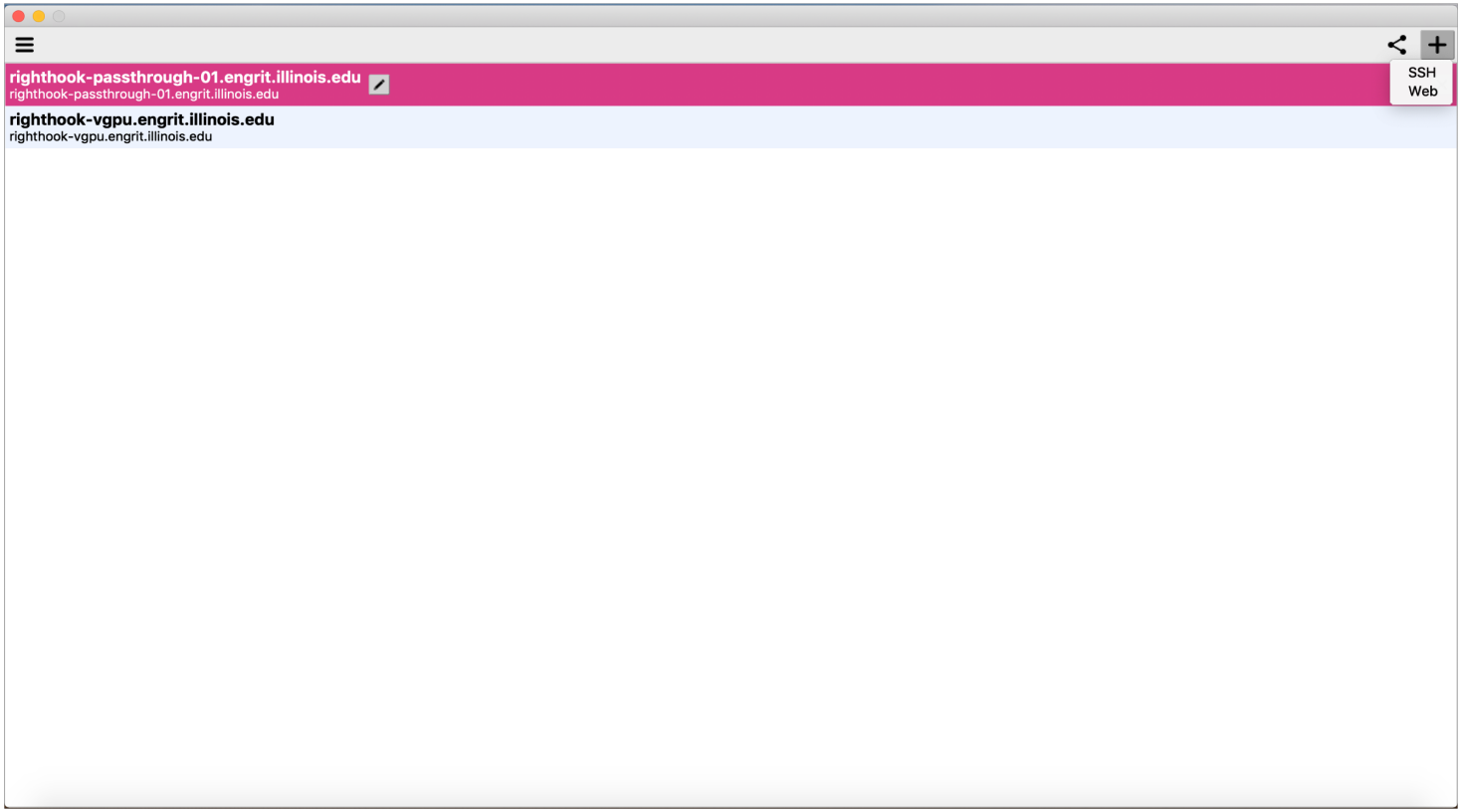
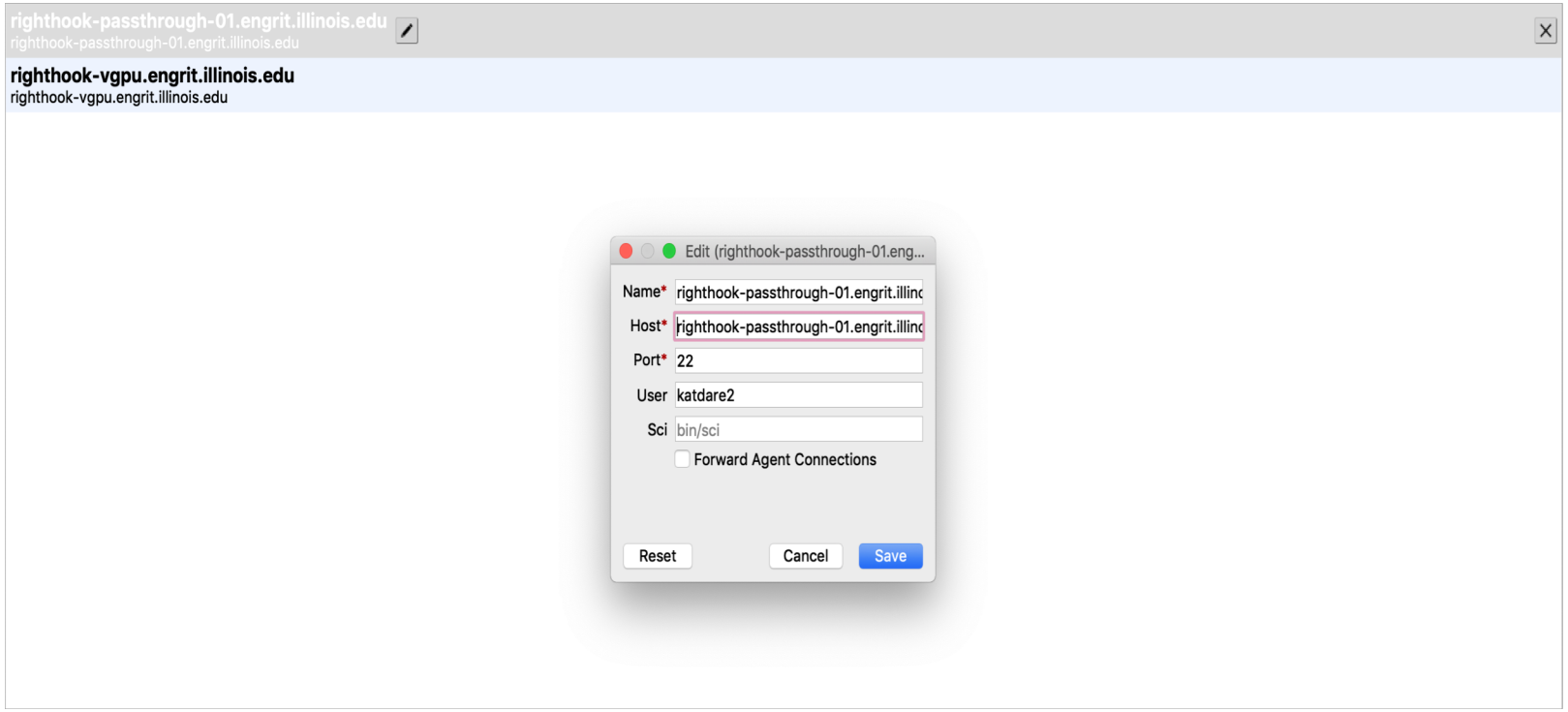
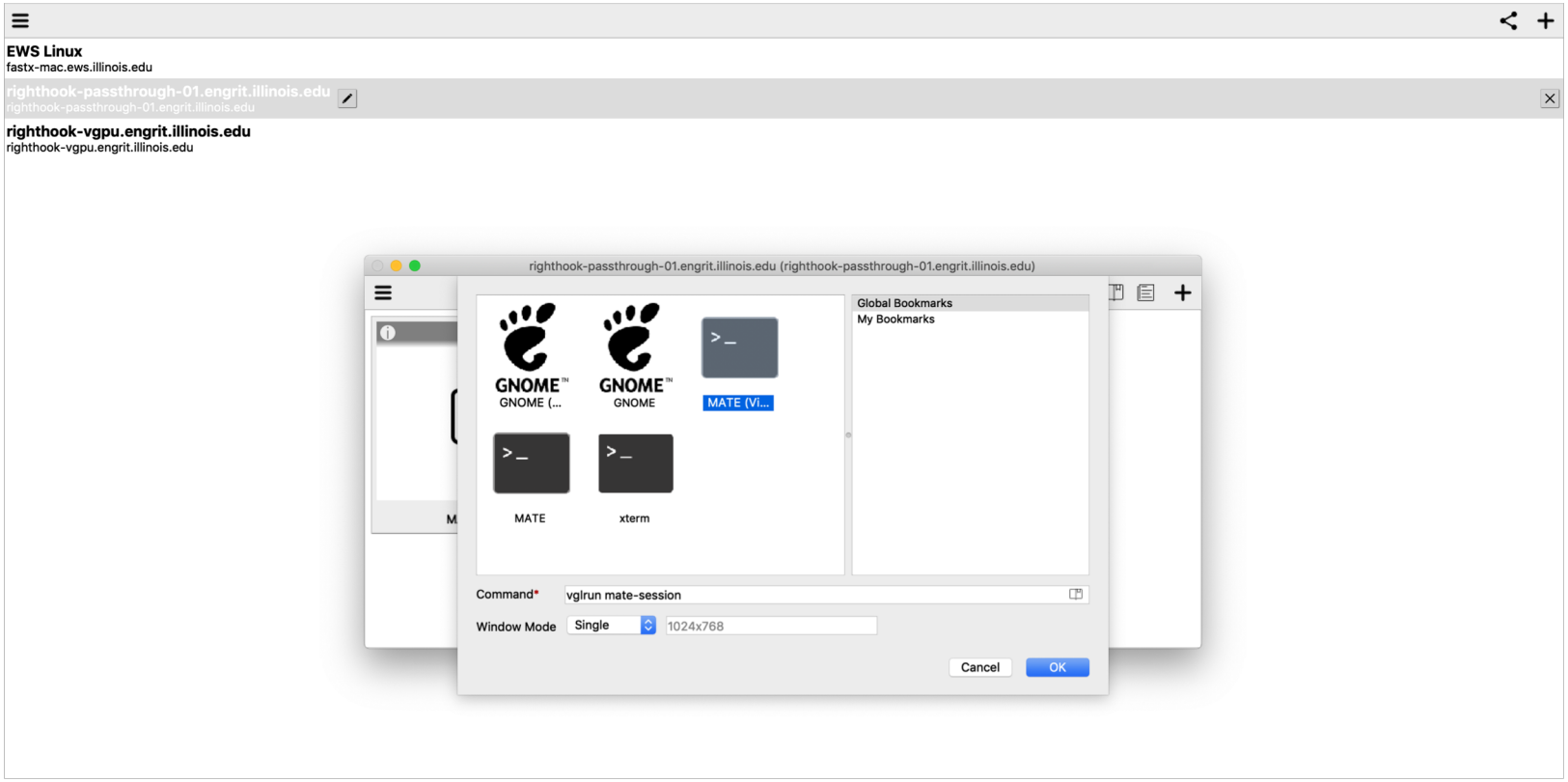
FastX

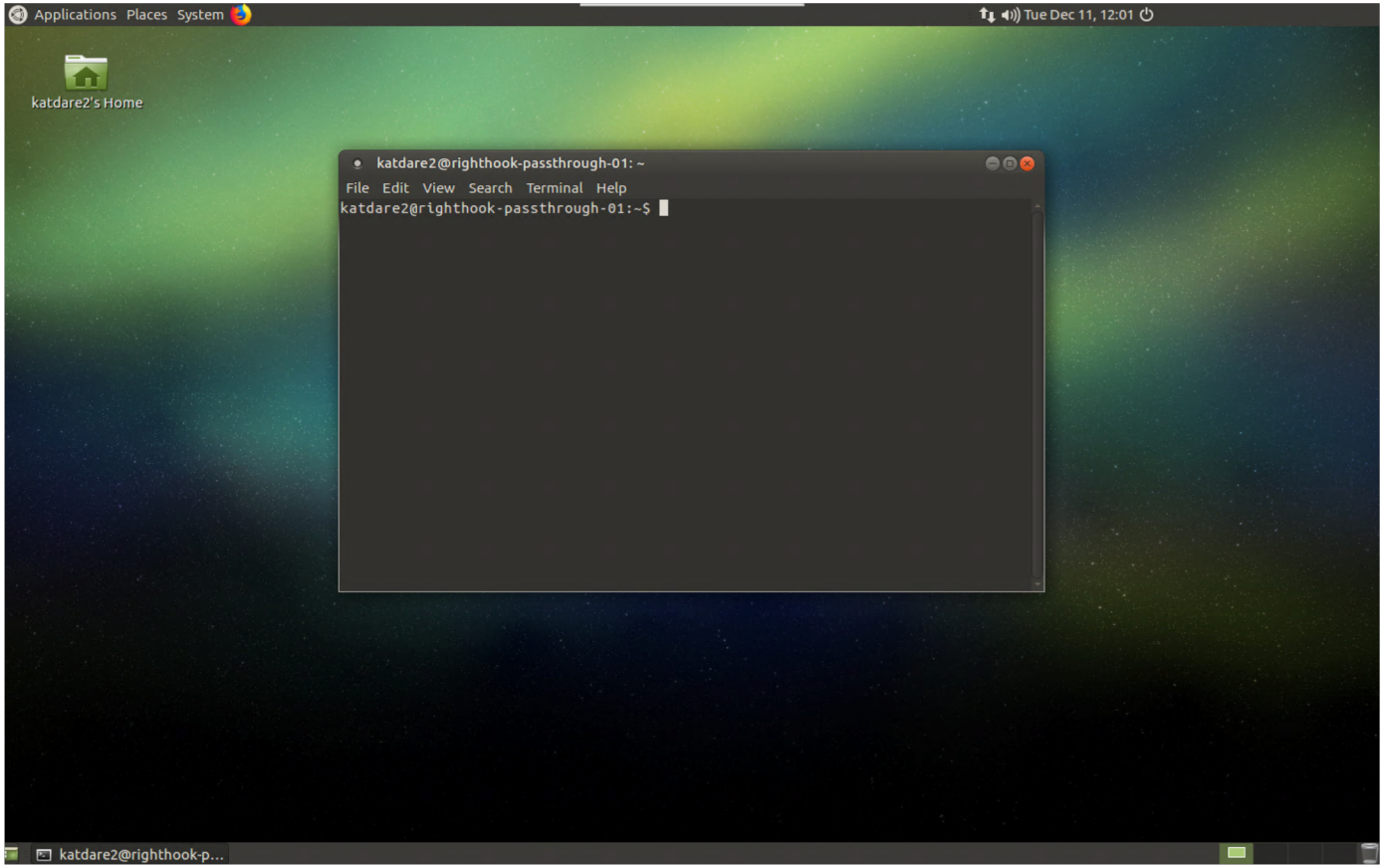
- We want visualization for simulation scenarios
- FastX offers a virtual desktop of EWS Linux virtual machine
- Before accessing our VM through FastX, make sure you are connecting to illinois.net WiFi or using a EWS machine (either actual or virtual) or connecting through university VPN.
- When launch a new VM session, choose MATE(VirtualGL).

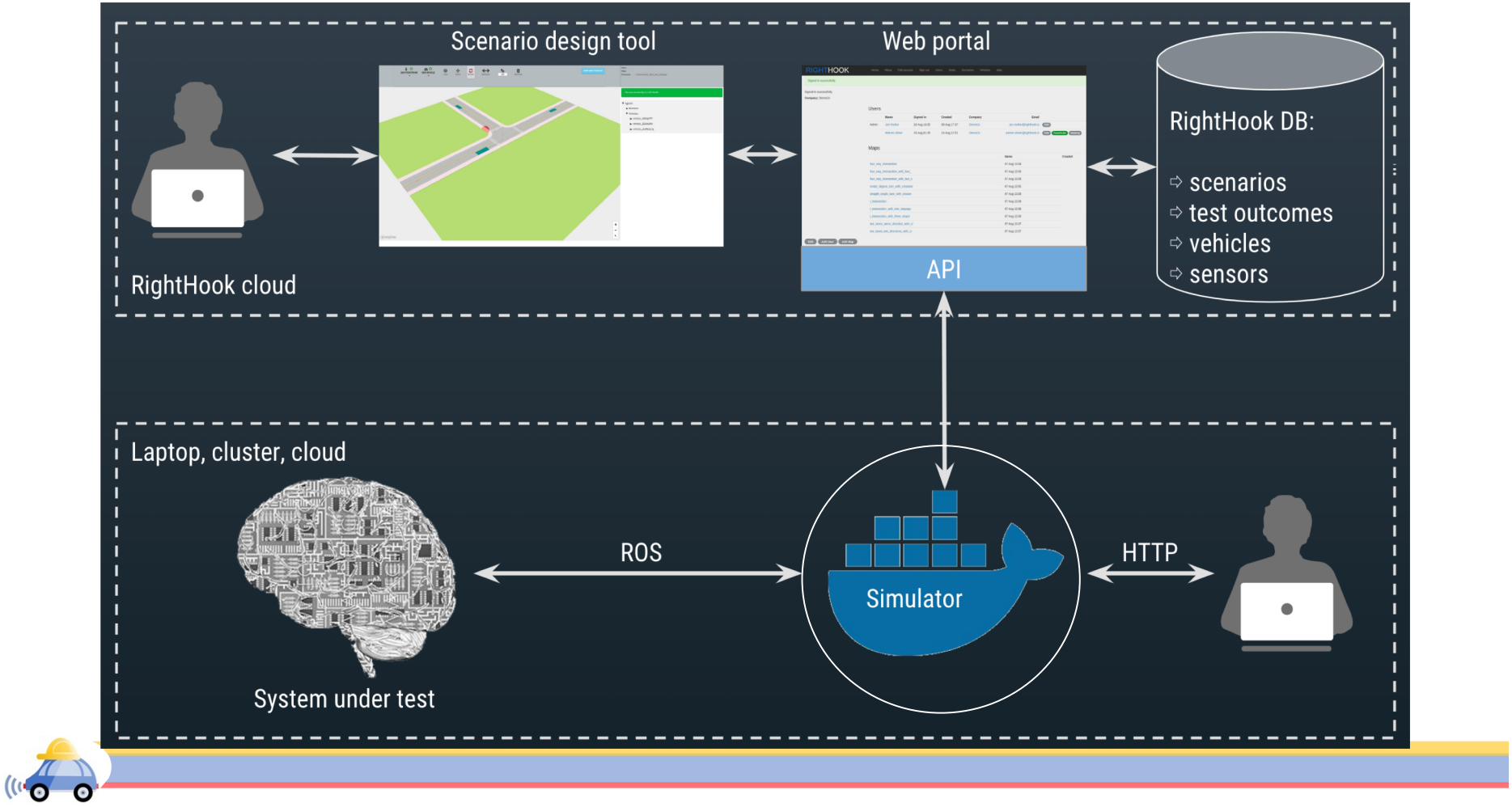

righthook-passthrough-01.engrit.illinois.edu
righthook-passthrough-01.engrit.illinois.edu
righthook-vgpu.engrit.illinois.edu
righthook-vgpu.engrit.illinois.edu
SSH
Web



01 is the VM number. You will be assigned a number later.


EWS Linux
fastx-mac.ews.illinois.edu
righthook-passthrough-01.engrit.illinois.edu
righthook-passthrough-01.engrit.illinois.edu
righthook-vgpu.engrit.illinois.edu
righthook-vgpu.engrit.illinois.edu
righthook-passthrough-01.engrit.illinois.edu (righthook-passthrough-01.engrit.illinois.edu)
GNOME
GNOME (...
GNOME
GNOME
MATE (Vi...
MATE
xterm
Global Bookmarks
My Bookmarks
Command*
vglrun mate-session
Window Mode
Single
1024x768
Cancel
OK


Applications Places System
Tue Dec 11, 12:01
katdare2's Home
katdare2@righthook-passthrough-01: ~
File Edit View Search Terminal Help
katdare2@righthook-passthrough-01:~$
katdare2@righthook-p...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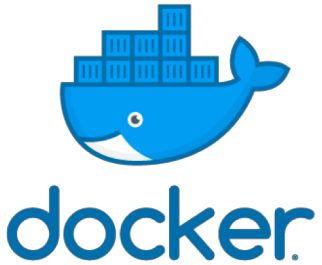
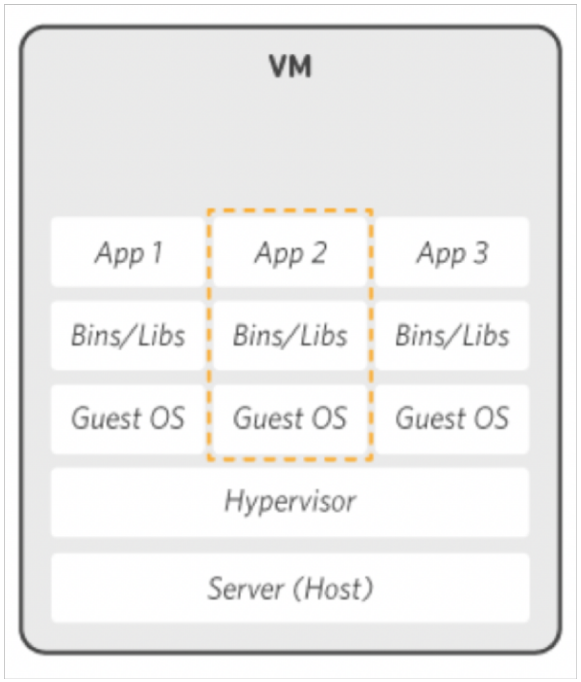
Docker



- Docker offers virtual environment on operating system level
- Applications run in docker containers, which allow us to package all dependencies in one docker image and ensures compatibility on different OS.
- Applications are isolated from each other and the operating system
- RightHook simulator runs inside docker container.

Why Dockerize Everything?

- Easy to develop/deploy applications on different platforms
- Performance increase
- Container orchestration(Kubernetes)



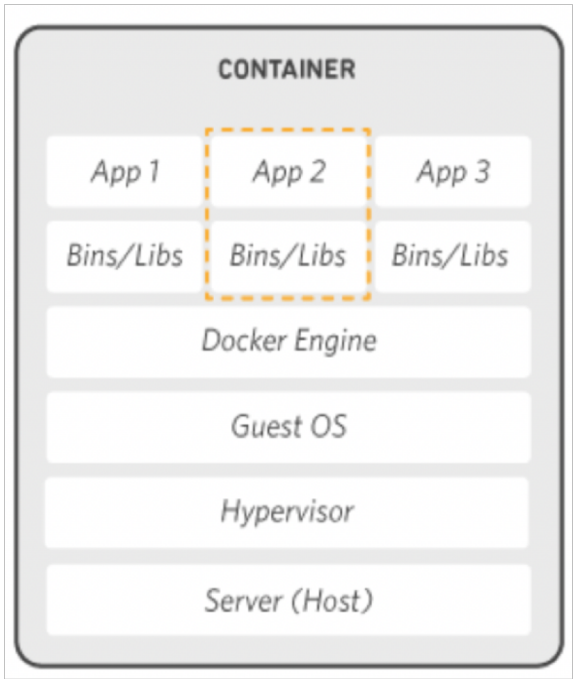
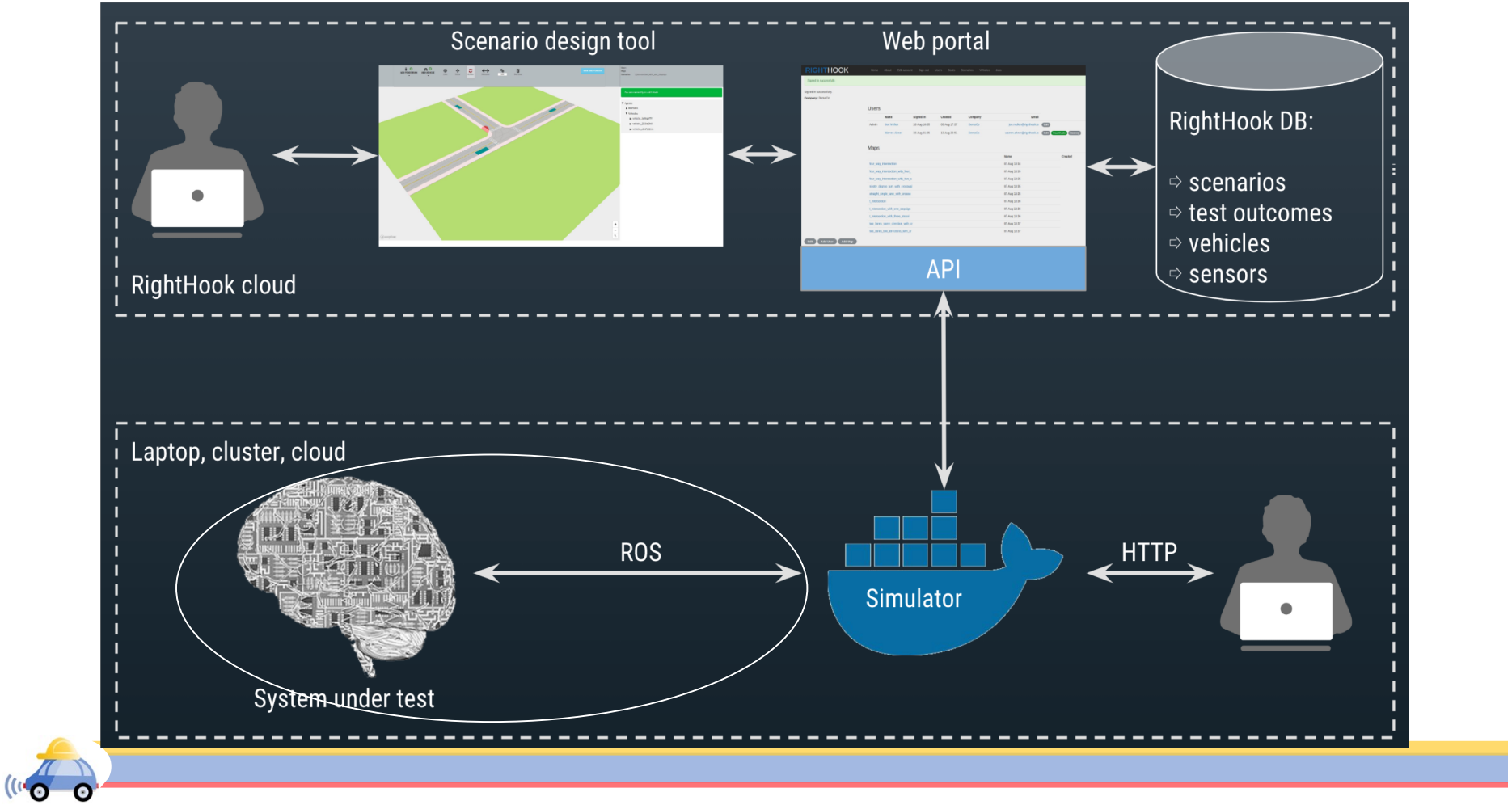


Image from: https://aws.amazon.com/docker/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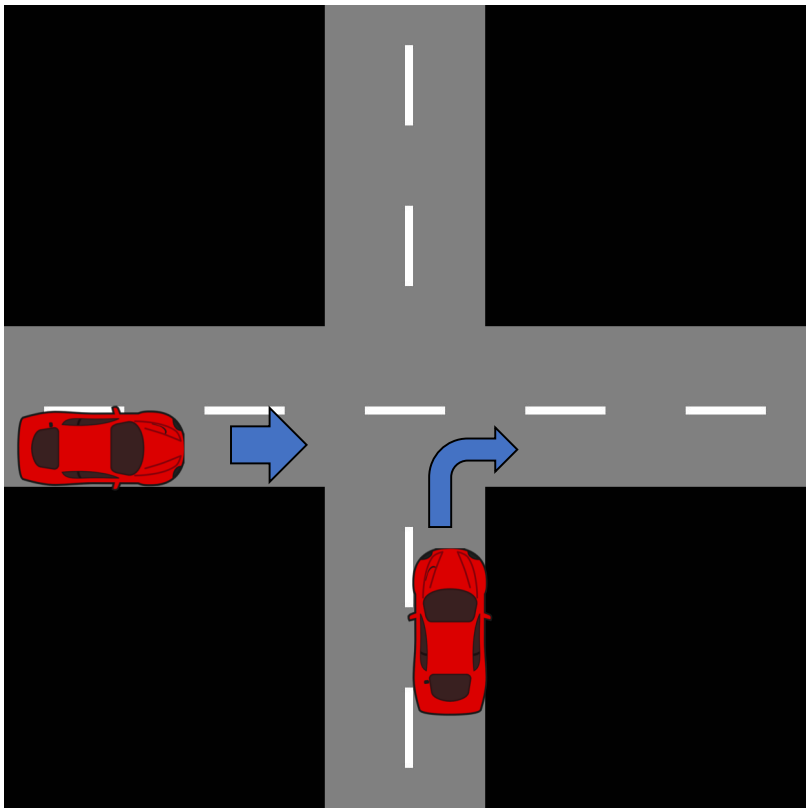
Robotics Operating System (ROS)

- Developed in 2007, ROS was developed by Stanford Artificial Intelligence Lab (SAIL) to build modular software stack for robotics project
- ROS is very suitable in cases wherein you have multiple robot modules that are needed to run in sync with each other

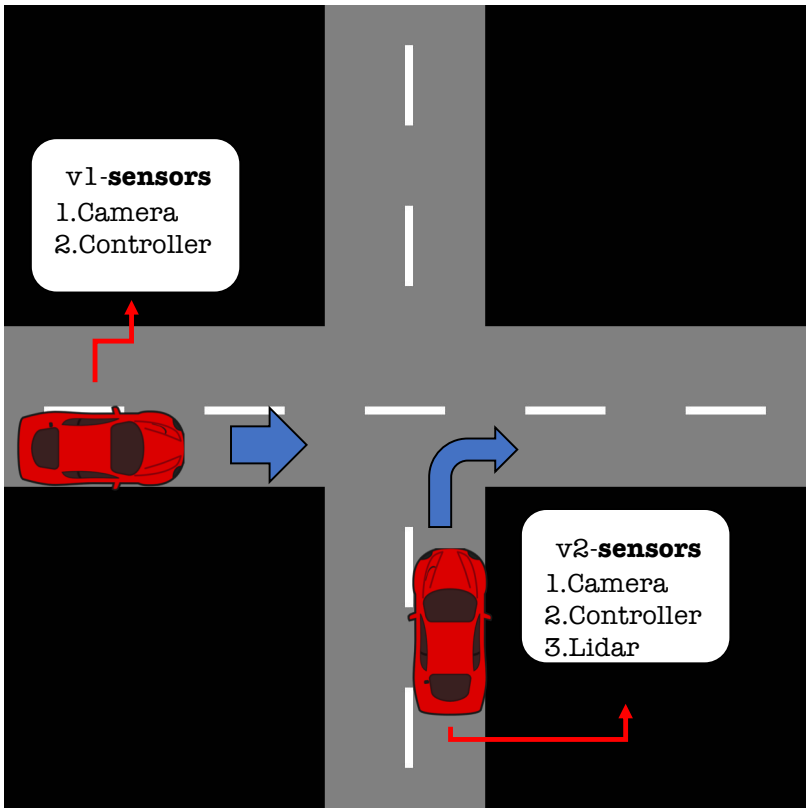
Software Architecture

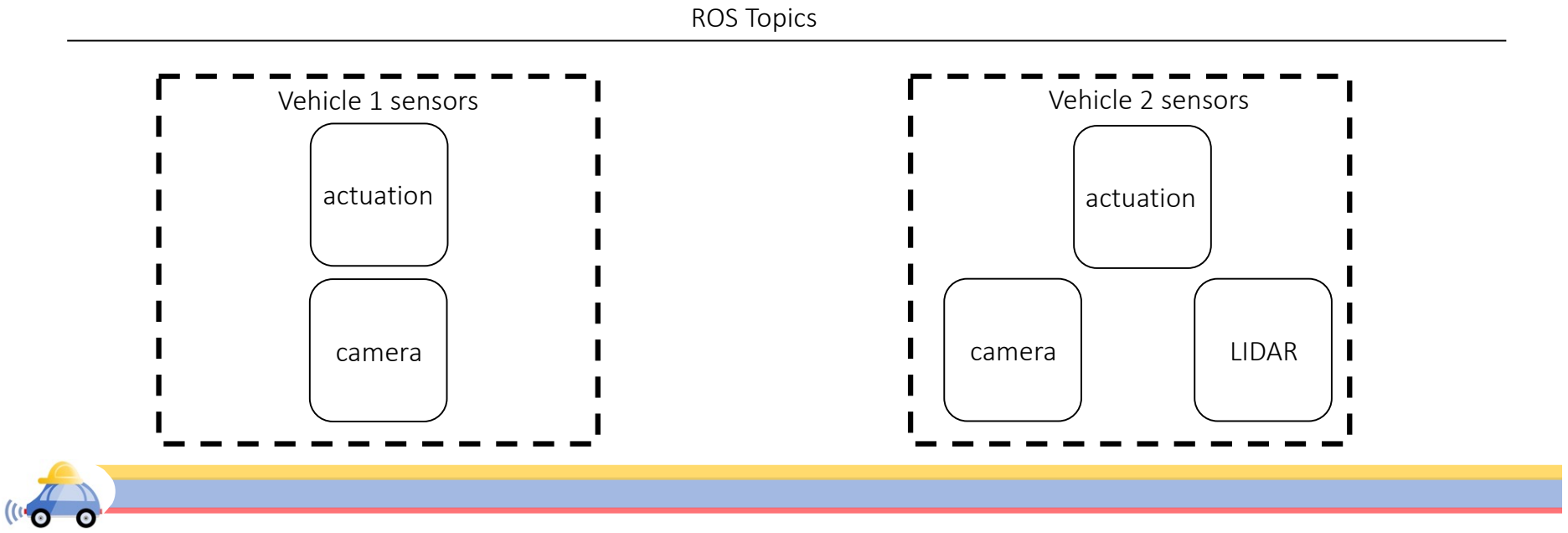
- **Node**: Executable code is called nodes
- **Topics**: Communication protocol in ROS
- **Messages**: data structure expected by ros-topics is called ros-messages

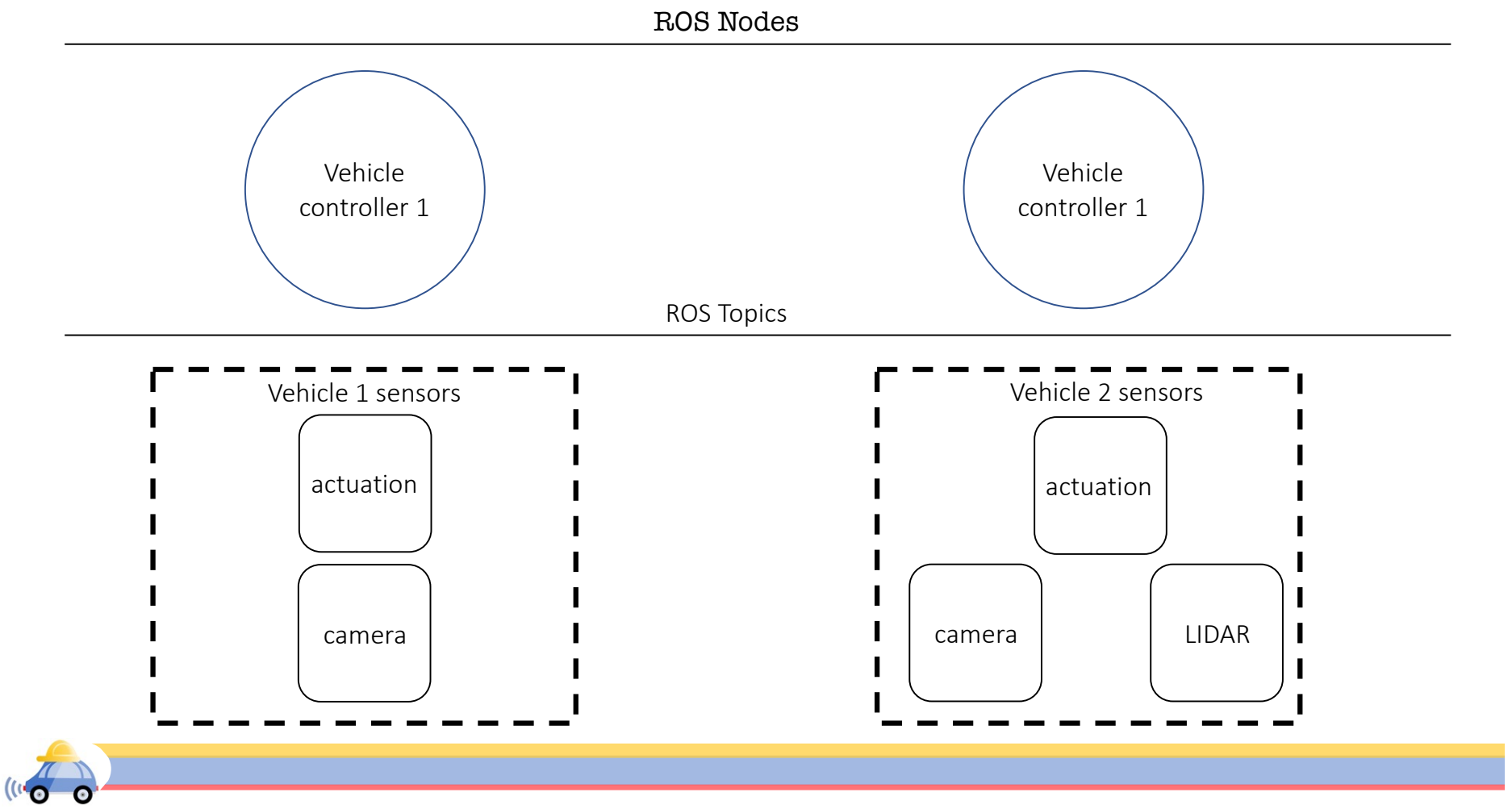
Example:

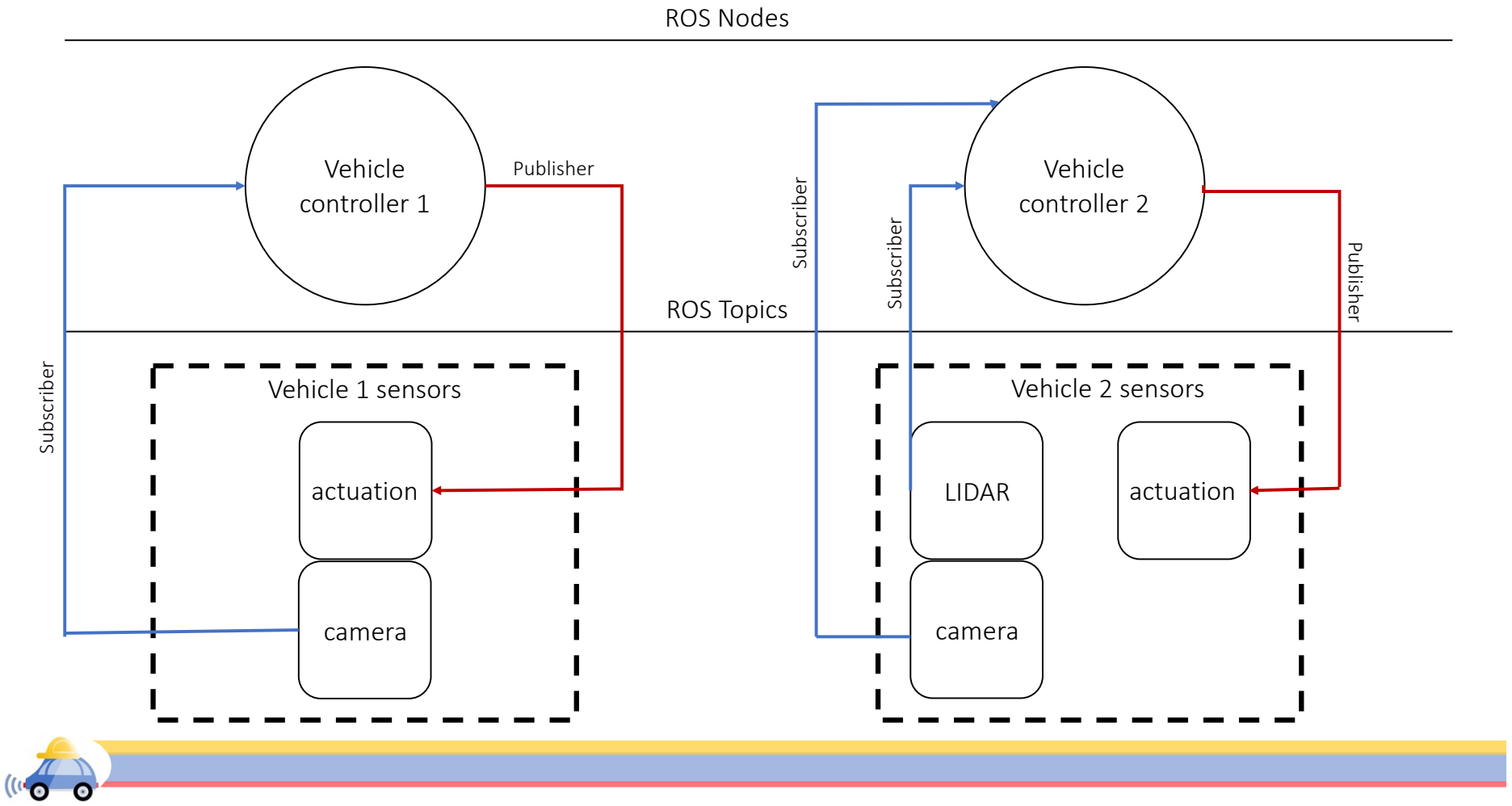


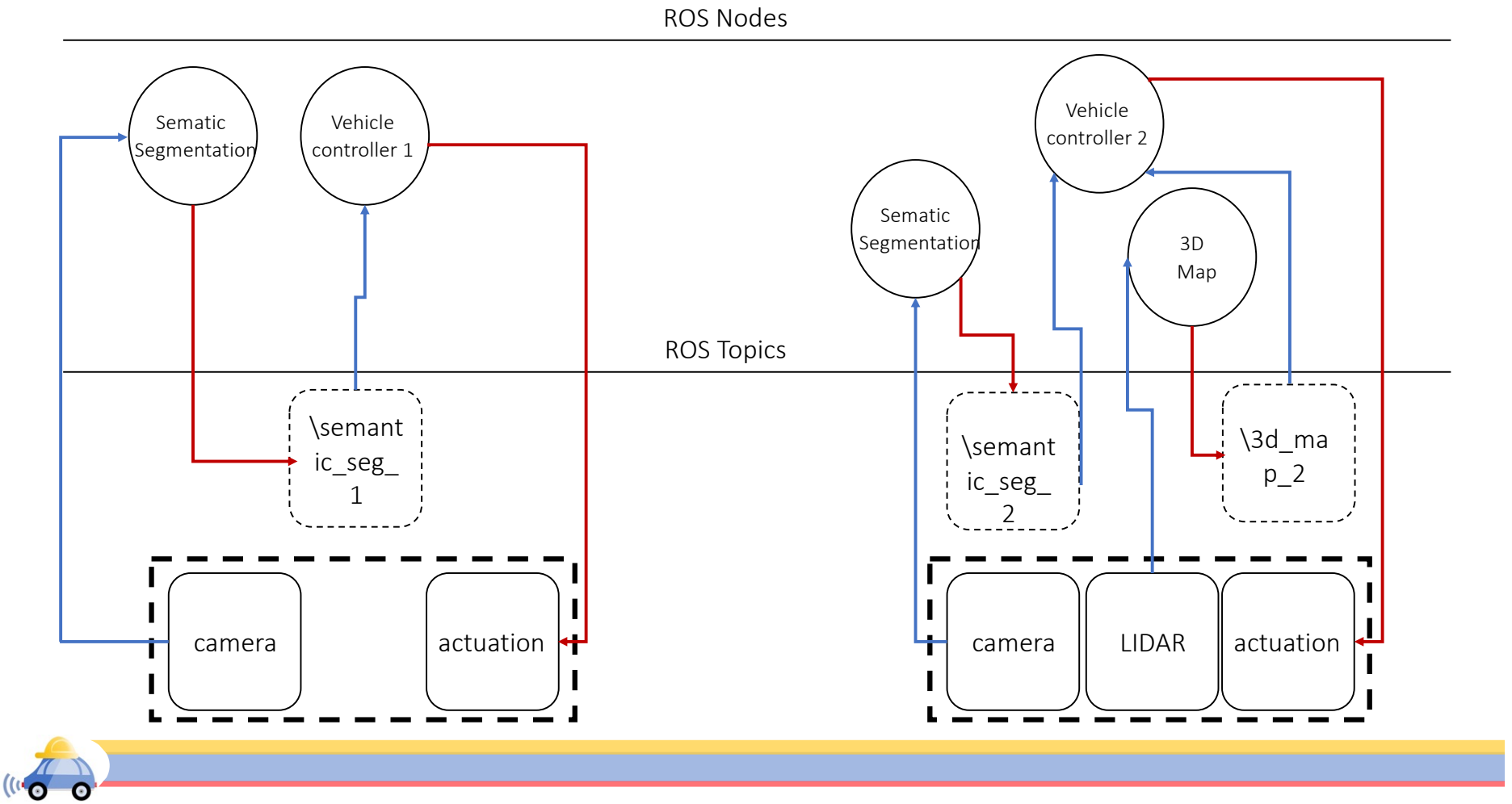
Example:


v1-sensors
1.Camera
2.Controller
v2-sensors
1.Camera
2.Controller
3.Lidar


ROS Topics
Vehicle 1 sensors
actuation
camera
Vehicle 2 sensors
actuation
camera
LIDAR

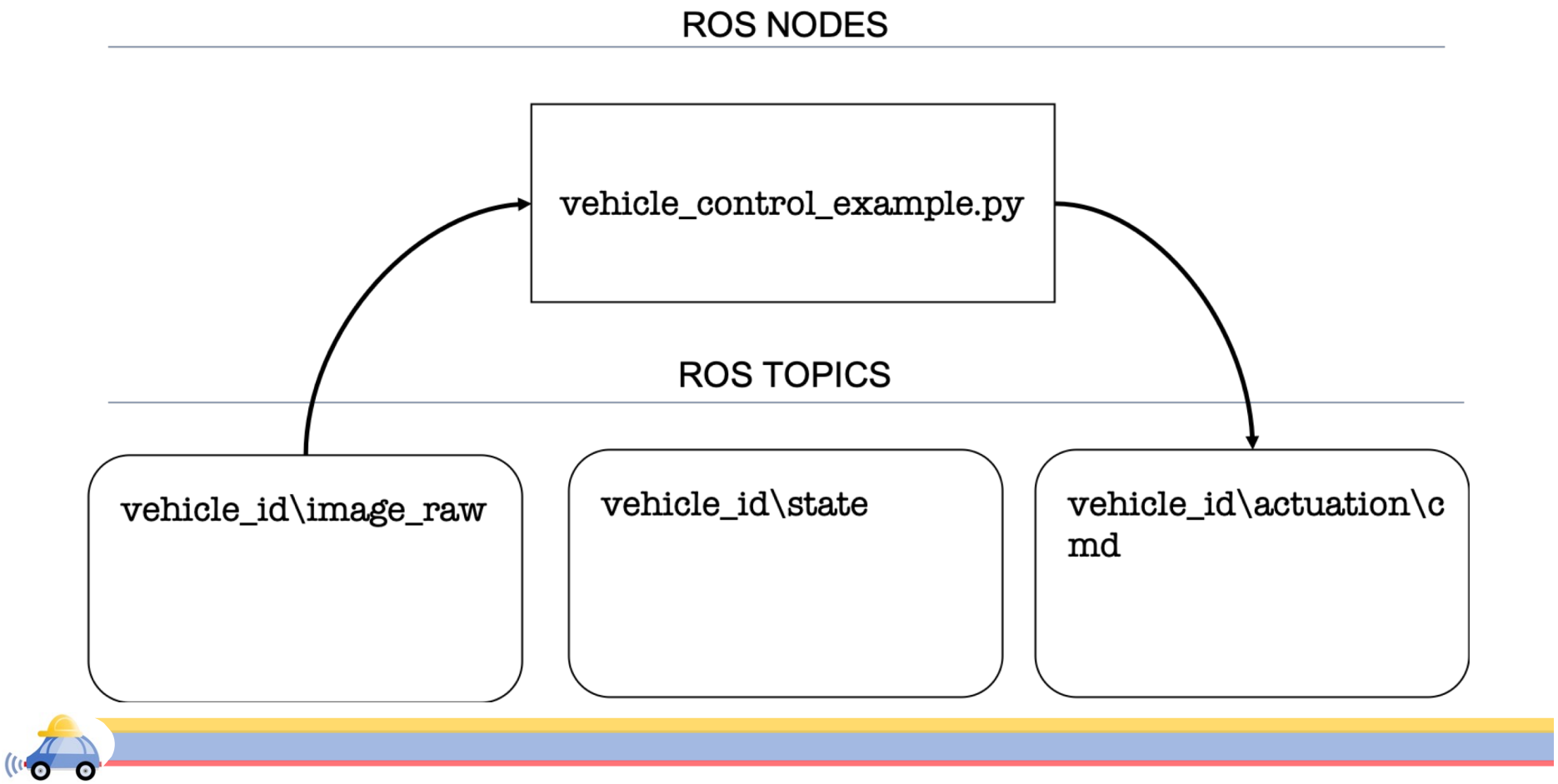

ROS Nodes
Vehicle controller 1
Vehicle controller 1
ROS Topics
Vehicle 1 sensors
actuation
camera
Vehicle 2 sensors
actuation
camera
LIDAR


ROS Nodes
Vehicle controller 1
Publisher
Subscriber
Subscriber
Vehicle controller 2
Publisher
ROS Topics
Subscriber
Vehicle 1 sensors
actuation
camera
Vehicle 2 sensors
LIDAR
actuation
camera


ROS Nodes
Sematic Segmentation
Vehicle controller 1
Vehicle controller 2
Sematic Segmentation
3D Map
ROS Topics
\semantic_seg_1
\semantic_seg_2
\3d_map_2
camera
actuation
camera
LIDAR
actuation

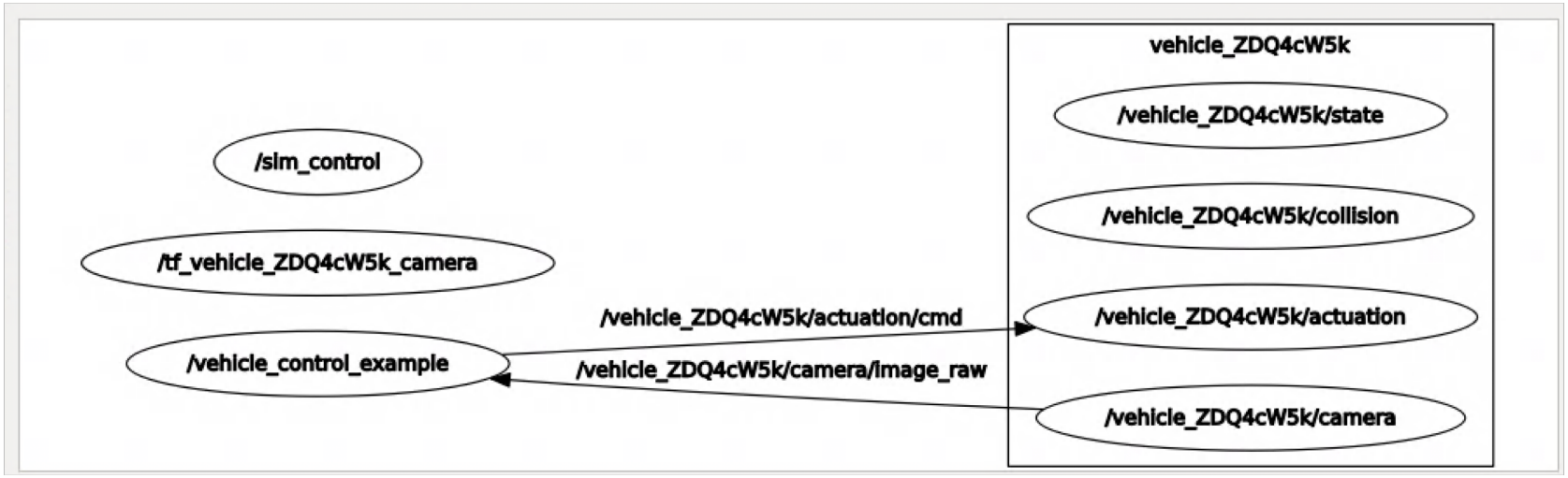
Publisher/Subscriber?

- Let's look at some MP0 node
- A car initially moving with 4.5 m/s has to autonomously stop near a stop sign


ROS NODES
vehicle_control_example.py
ROS TOPICS
vehicle_id\image_raw
vehicle_id\state
vehicle_id\actuation\cmd

Demonstration

Visualizing topics and nodes (rqt_graph)



Roslaunch

- Important for large projects with multiple nodes
- In form a .xml file

Writing Scripts in RightHook

- Mount Docker
  nvidia-docker run --env="DISPLAY" -e "KEY=API KEY" -e "PORTAL_URL=https://illini.righthook.io" -v /tmp/.X11-unix:/tmp/.X11-unix:rw -v /usr/lib/x86_64-linux-gnu/libXv.so.1:/usr/lib/x86_64-linux-gnu/libXv.so.1 --ulimit nofile=65535:65535 rh_sim/minimaps:c000140725e017ab00810eea6ab55e1cc9310182

- Ros network setup
  export ROS_MASTER_URI=http://172.17.0.2:11311
  export ROS_IP=172.17.0.1
  export ROS_HOSTNAME=172.17.0.1

Running scripts

- Git clone the repository https://gitlab.engr.illinois.edu/GolfCar/mp-release.git
- Go into the cloned repository
- catkin_make
- ./setup.sh
- ./run.sh
- source devel/setup.bash
- roslaunch mp0 run_mp.launch

Writing scripts in RightHook

- Running a particular scenario
  curl http://172.17.0.2:8080/connected_launch -X POST -d "42»

- Run the Simulator
  rosrun rh_msgs advance_step_loop.py

  OR

  roslaunch mp0 run_mp.launch

rosbag

- Rosbag is a set of tools for recording from and playing back to ROS topics.
- By calling the rosbag API, we can record different types of ROS messages
- rosbag record <topic_name>