CS30 Simulation and Tools:

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Enrico Sundjojo
Arin Reinsch

OREGON STATE UNIVERSITY   DHBW RAVENSBURG

Agenda

- Team overview

- Simulation team structure

- Devops

- Simulation

- Rendering

- Testing

Team Mission

Provide a full simulation and test environment for the autonomous race car to provide necessary testing of the car for competitions

Team History

Team Wins
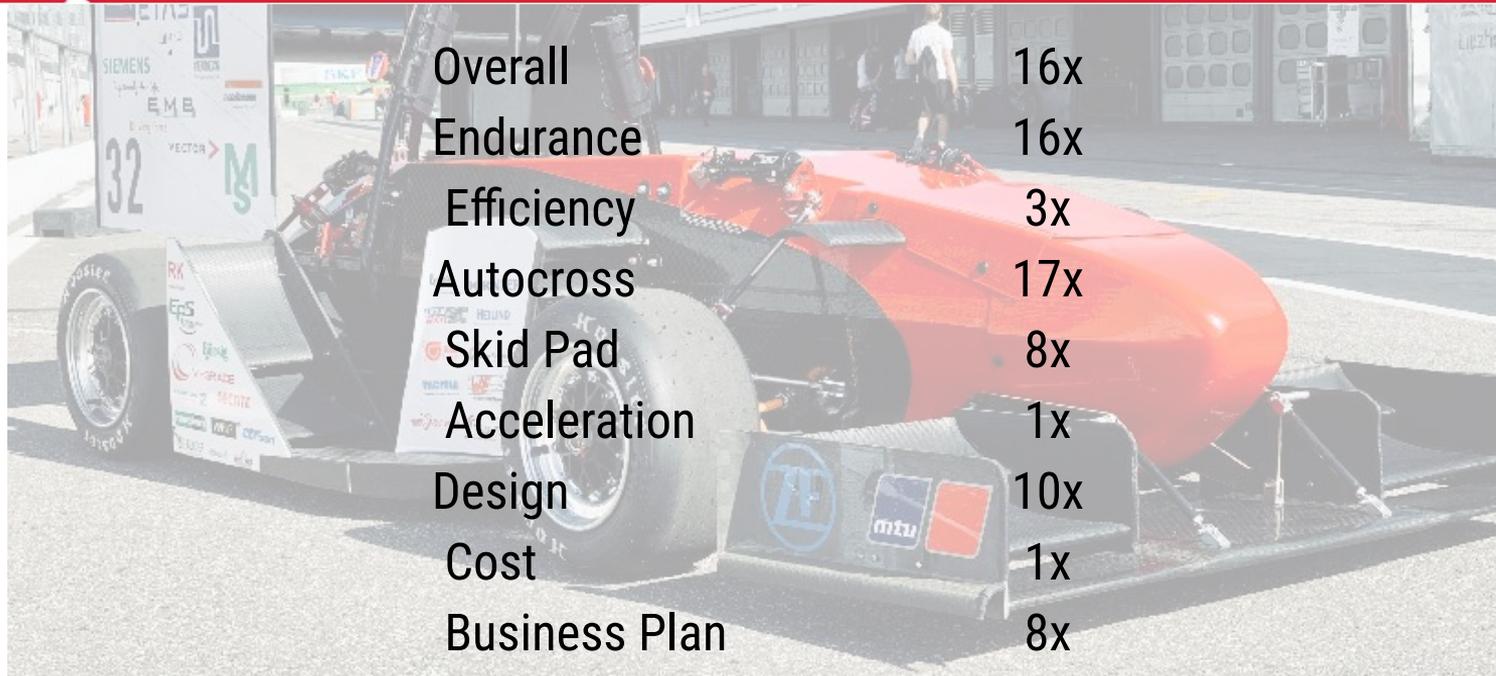
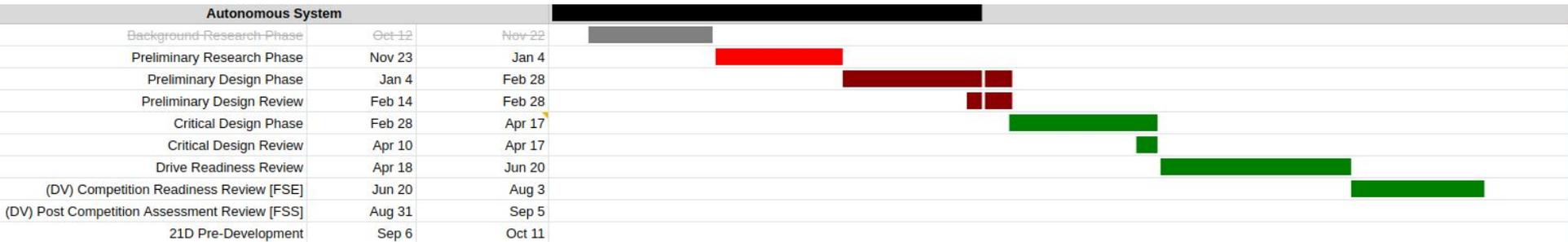|	
Overall	16x
Endurance	16x
Efficiency	3x
Autocross	17x
Skid Pad	8x
Acceleration	1x
Design	10x
Cost	1x
Business Plan	8x

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Team timeline

- Competition is release
- Everything is based around design, testing testing, and more design
- More software still needs writing even after code freeze

Autonomous System			
Background Research Phase	Oct 12	Nov 22	
Preliminary Research Phase	Nov 23	Jan 4	
Preliminary Design Phase	Jan 4	Feb 28	
Preliminary Design Review	Feb 14	Feb 28	
Critical Design Phase	Feb 28	Apr 17	
Critical Design Review	Apr 10	Apr 17	
Drive Readiness Review	Apr 18	Jun 20	
(DV) Competition Readiness Review [FSE]	Jun 20	Aug 3	
(DV) Post Competition Assessment Review [FSS]	Aug 31	Sep 5	
21D Pre-Development	Sep 6	Oct 11	

Sim team structure

- Arin - Devops and Rendering

- Ryan - Sim Core

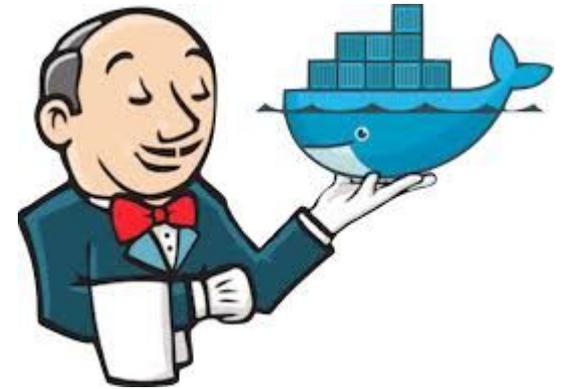- Enrico - Testing

Sim team structure
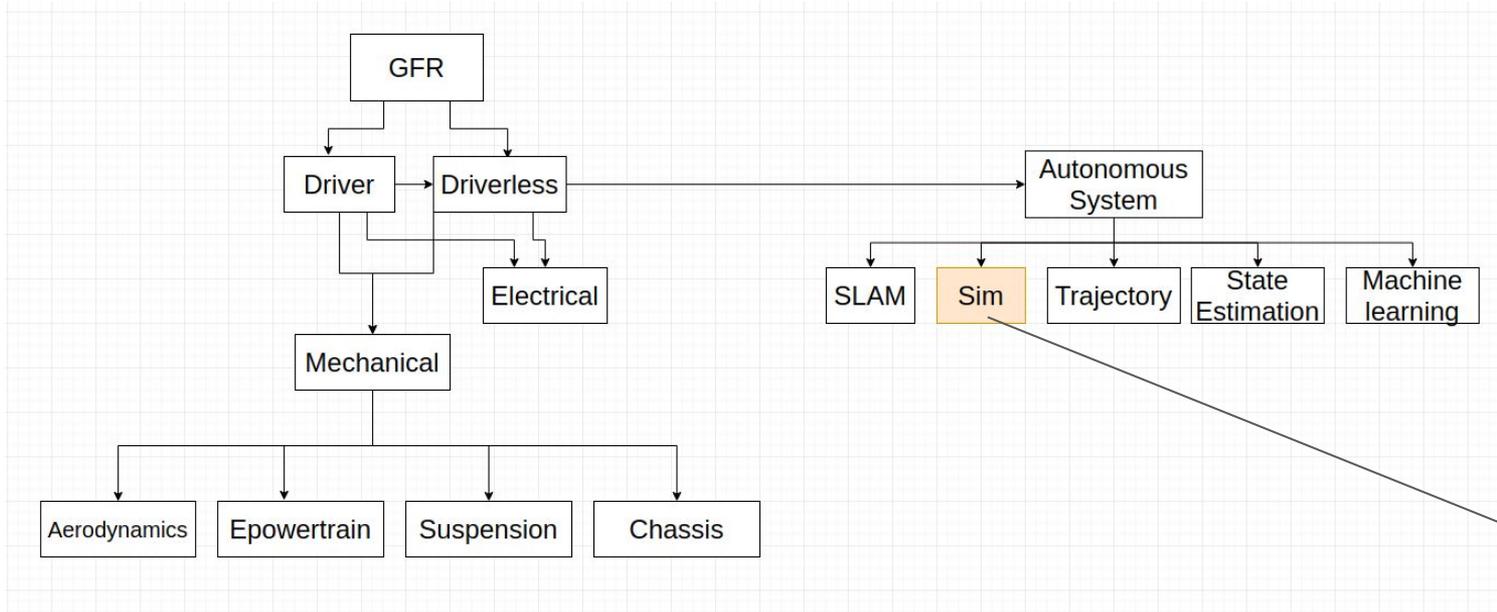
Devops

Goals

- Maintain stable master branch

- Validate new code

- Manage test data

- Track progress

- Streamline deployment

Devops
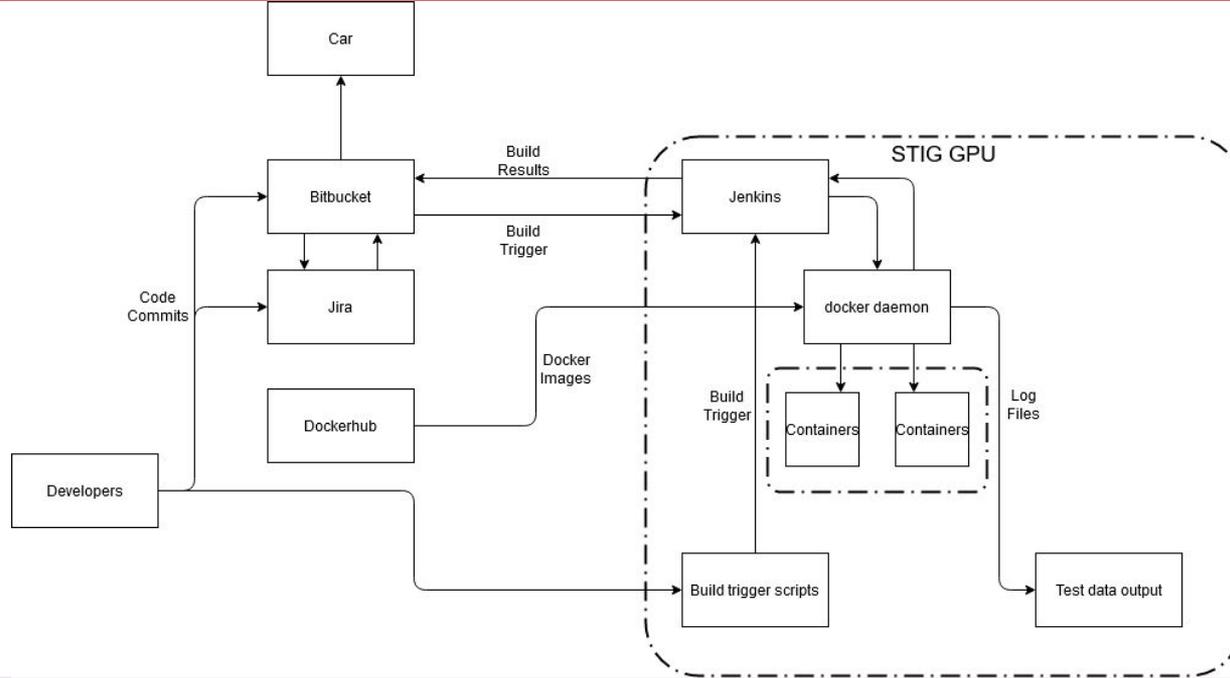
- Docker - virtualize build environments

- Jenkins - manage builds

- Bitbucket - version control

- Jira - manage agile projects

Devops

Devops

Dockerfiles - builds from user trigger

```
1   FROM ubuntu:latest
2   LABEL MAINTAINER "Arin Reinsch" <Arin.Reinsch@global-formula-racing.de>
3
4   ENV ROS_DISTRO melodic
5
6   #Update container
7   RUN apt-get update -qq && apt-get -qq install --no-install-recommends -y apt-utils gnupg wget ca-certificates lsb-release
8   RUN echo 'debconf debconf/frontend select Noninteractive' | debconf-set-selections
9   #Install supporting programs
10  RUN apt-get -y install gnupg1; \
11      apt-get install -y git
12  RUN apt-get install build-essential clang-3.9 git cmake ninja-build python3-requests python-dev tzdata sed curl wget unzip autoconf libtool
13  #Configure ROS environment
14  RUN sh -c 'echo "deb http://packages.ros.org/ros/ubuntu $(lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'
15  RUN apt-key adv --keyserver 'hkp://keyserver.ubuntu.com:80' --recv-key C1CF6E31E6BADE8868B172B4F42ED6FBAB17C654
16  RUN apt-get update
17  RUN apt-get install -y ros-melodic-desktop
18  #Install Unreal
19  RUN update-alternatives --install /usr/bin/clang++ clang++ /usr/lib/llvm-3.9/bin/clang++ 100; \
20      update-alternatives --install /usr/bin/clang clang /usr/lib/llvm-3.9/bin/clang 100
21  RUN git clone --depth=1 -b 4.18 https://github.com/EpicGames/UnrealEngine.git ~/UnrealEngine_4.18; \
22      cd ~/UnrealEngine_4.18; \
23      ./Setup.sh && ./GenerateProjectFiles.sh && make; \
24      cd ~/
25  #Build Carla
26  RUN git clone https://github.com/carla-simulator/carla; \
27      ./Setup.sh
28  #Premission for Jenkins user.
29  RUN echo "%jenkis ALL=NOPASSWD: A::%" >> /etc/sudoers \
30      mkdir /home/jenkins \
31      useradd -u 1001 -d /home/jenkins jenkins \
32      chown -R jenkins:jenkins /home/jenkins \
33      chmod 755 /home/jenkins \
34      usermod -a -G jenkins
35  #Configure shell
36  CMD ["/bin/bash"]
```

Devops

Dockerfiles - automated builds from bitbucket
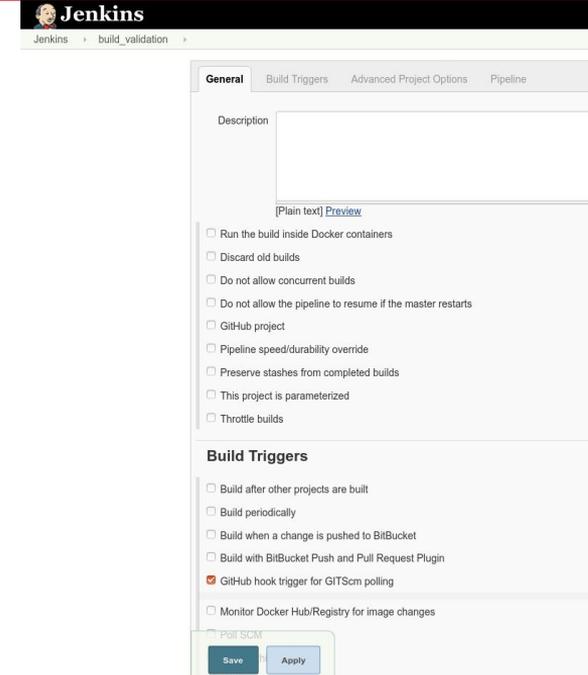
```
1   FROM ubuntu:latest
2   LABEL MAINTAINER "Arin Reinsch" <Arin.Reinsch@global-formula-racing.de>
3
4   ENV ROS_DISTRO melodic
5
6   #Update container
7   RUN apt-get update -qq && apt-get -qq install --no-install-recommends -y apt-utils gnupg wget ca-certificates lsb-release
8   RUN echo 'debconf debconf/frontend select Noninteractive' | debconf-set-selections
9   #Install supporting programs
10  RUN apt-get -y install gnupg1; \
11      apt-get install -y git
12  #Configure ROS environment
13  RUN sh -c 'echo "deb http://packages.ros.org/ros/ubuntu $(lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'
14  RUN apt-key adv --keyserver 'hkp://keyserver.ubuntu.com:80' --recv-key C1CF6E31E6BADE8868B172B4F42ED6FBAB17C654
15  RUN apt update
16  RUN apt install -y ros-melodic-desktop
17
18  #Premission for Jenkins user.
19  RUN echo "%jenkis ALL=NOPASSWD: A::%" >> /etc/sudoers \
20      mkdir /home/jenkins \
21      useradd -u 1001 -d /home/jenkins jenkins \
22      chown -R jenkins:jenkins /home/jenkins \
23      chmod 755 /home/jenkins \
24      usermod -a -G jenkins
25  #Configure shell
26  CMD ["/bin/bash"]
```

Devops

Jenkins configuration

- Github hook with SCM polling

- SSH agent

- Docker agent

- Bitbucket plugin

- Build token trigger plugin

Jenkins builds

- Pull branch into a docker container

- Run inline bash script to build workspace

- Publish results to bitbucket

```
 8        // Before start the build set as INPROGRESS
 9        scmVars =  checkout scm
10        this.COMMIT_HASH = scmVars.GIT_COMMIT
11        //this.notifyBitbucket('INPROGRESS')
12      }
13    }
14  }
15  stage('Agent') {
16      agent {
17          docker {
18              image 'gfr20_ros'
19              args '-u root:sudo'
20          }
21      }
22      steps {
23        script {
24          try {
25              sh '''#!/bin/bash
26              cd /gfr20d_ws
27              ./build.sh
28              '''
29              //Build success
30              currentBuild.result = "SUCCESS"
31          } catch (e) {
32              //If there is an error capture and throw, result is FAILED
33              currentBuild.result = "FAILED"
34              throw e
35          } finally {
36              //Send final status to bitbucket
37              //this.notifyBitbucket(currentBuild.result)
```

Devops

Jenkins builds - remote trigger script

```bash
 1  #!/bin/bash
 2  GREP_RETURN_CODE=0
 3  BUILD_URL='http://gfr_admin:1142a49026d811b57df8cd4b68244f06f0@localhost:8080/'
 4  #API token needs to be generated from jenkins (can only be seen once)
 5  APITOKEN='1142a49026d811b57df8cd4b68244f06f0'
 6  #Use wget to get servers crumb
 7  CRUMB=$(wget -q --auth-no-challenge --user ████████████████--output-document - 'localhost:8080/crumbIssuer/api/xml?xpath=concat(//crumbRequestField,":",//crumb)')
 8  #Trigger jenkins job with post format http://user:APITOKEN@serveraddress:port/job/jobname
 9  curl -X POST $BUILD_URL/job/gfr_main_build/build?token=gfr20d -H "$CRUMB"
10  #Status Message
11  echo -e "Build has Triggred\n"
12  #Wait for bulid to finish
13  while [ $GREP_RETURN_CODE -eq 0 ]; do
14      echo -e "Building job with jenkins\n"
15      sleep 10
16      curl --silent $BUILD_URL/lastBuild/api/json | grep result\":null > /dev/null
17      GREP_RETURN_CODE=$?
18  done
19  #Get the ID of the last build
20  BUILD_ID=$(wget -qO- $BUILD_URL/job/gfr_main_build/lastBuild/buildNumber)
21  #Create output file name with the bulid ID
22  FILESTRING=$(echo "./build_results_$BUILD_ID")
23  #Get the console output of the most recent build
24  OUTPUT=$(wget -qO- $BUILD_URL/job/gfr_main_build/lastBuild/consoleText)
25  #Write output to file
26  echo $OUTPUT >> $FILESTRING
27  #Status Message
28  echo -e "Build Complete\nSee output at $FILESTRING\n"
```

Devops

- SSH key management

- Docker out of Docker

- Publishing build results to bitbucket

Devops

- Parameter passing with user triggered builds

- Integrate testing framework

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Simulator

Overview

- Provide detailed simulation

- Accurate data
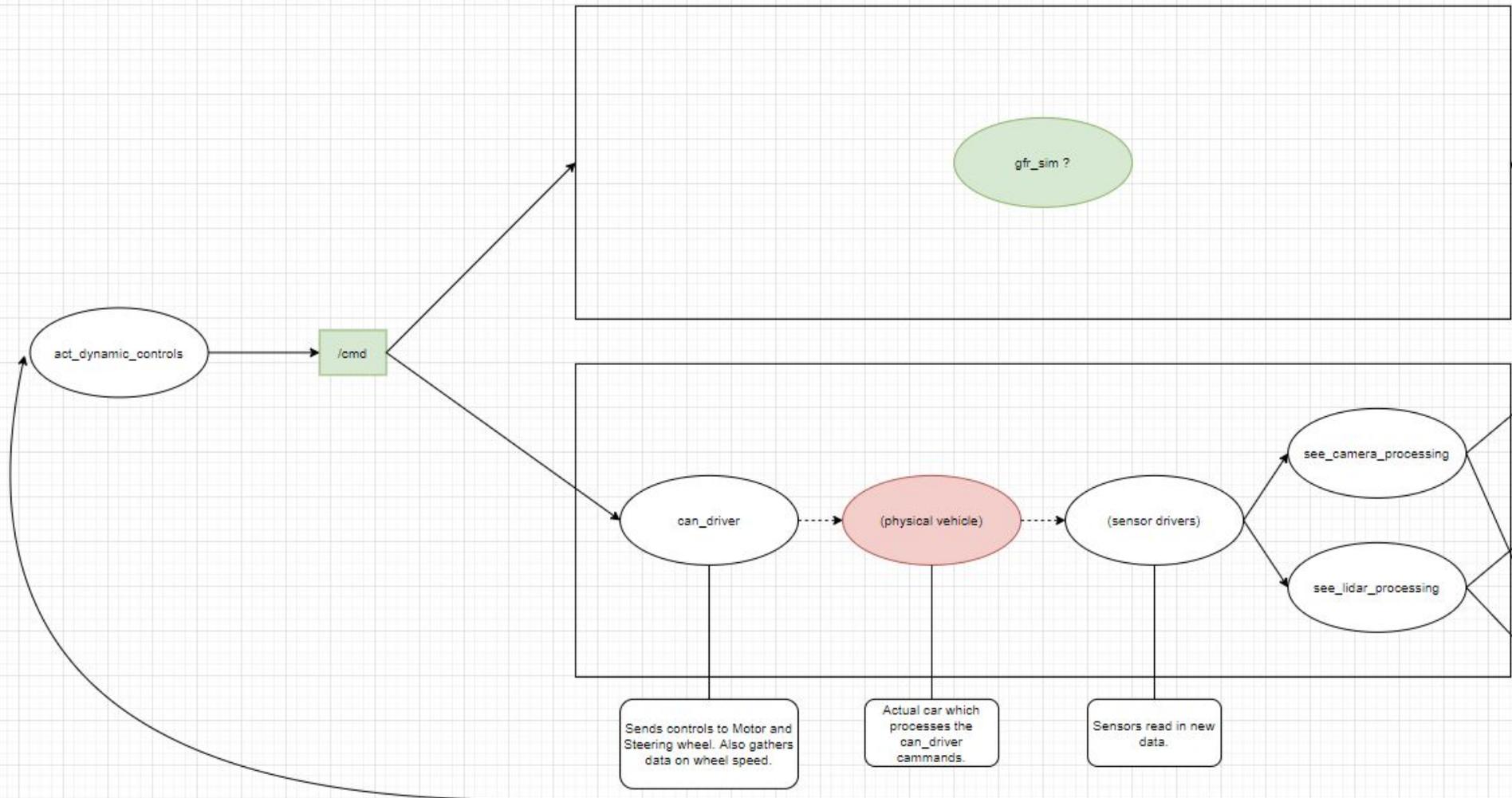
- Easy to test

- Easy to modify

Simulator

Goals

- Automate testing

    - Test new code before it gets merged to master

- Visualize different parameters

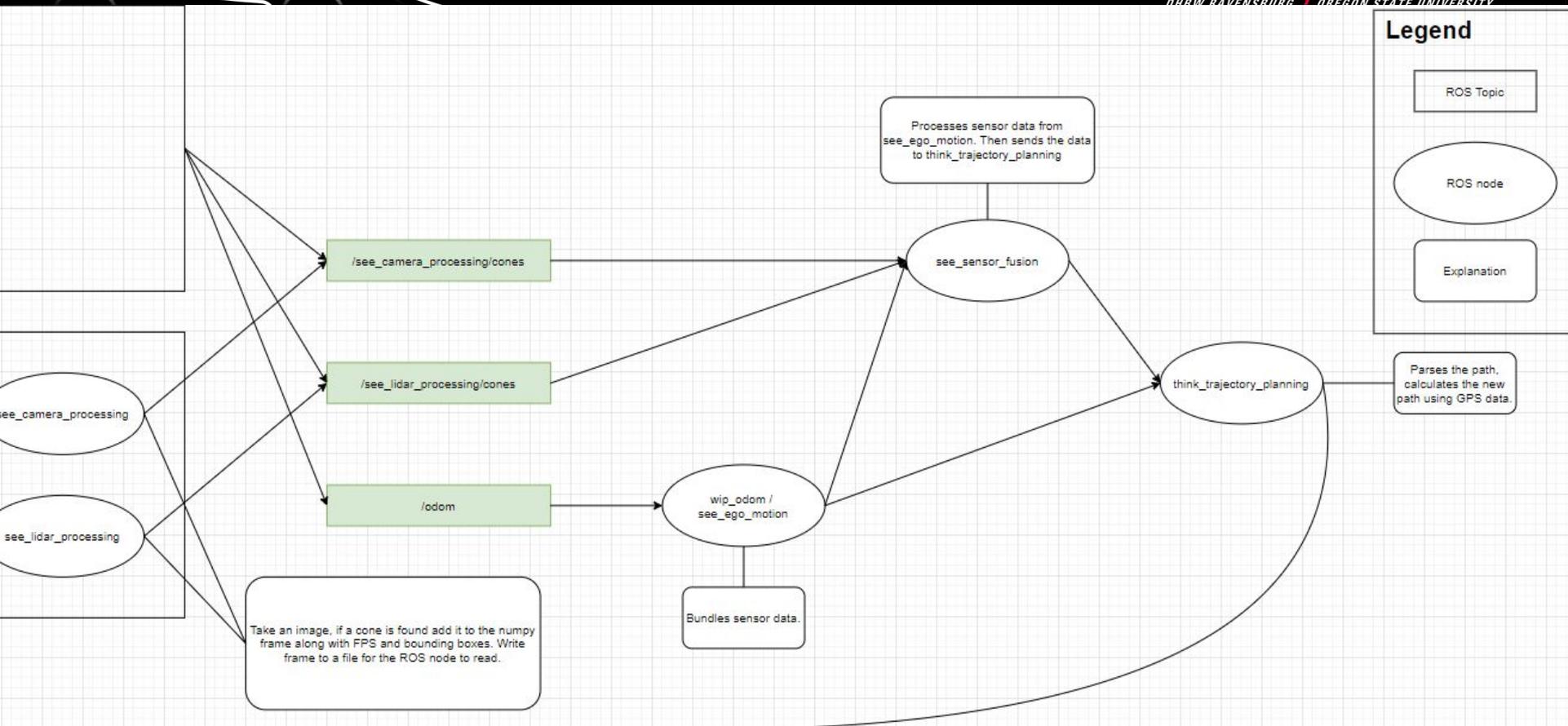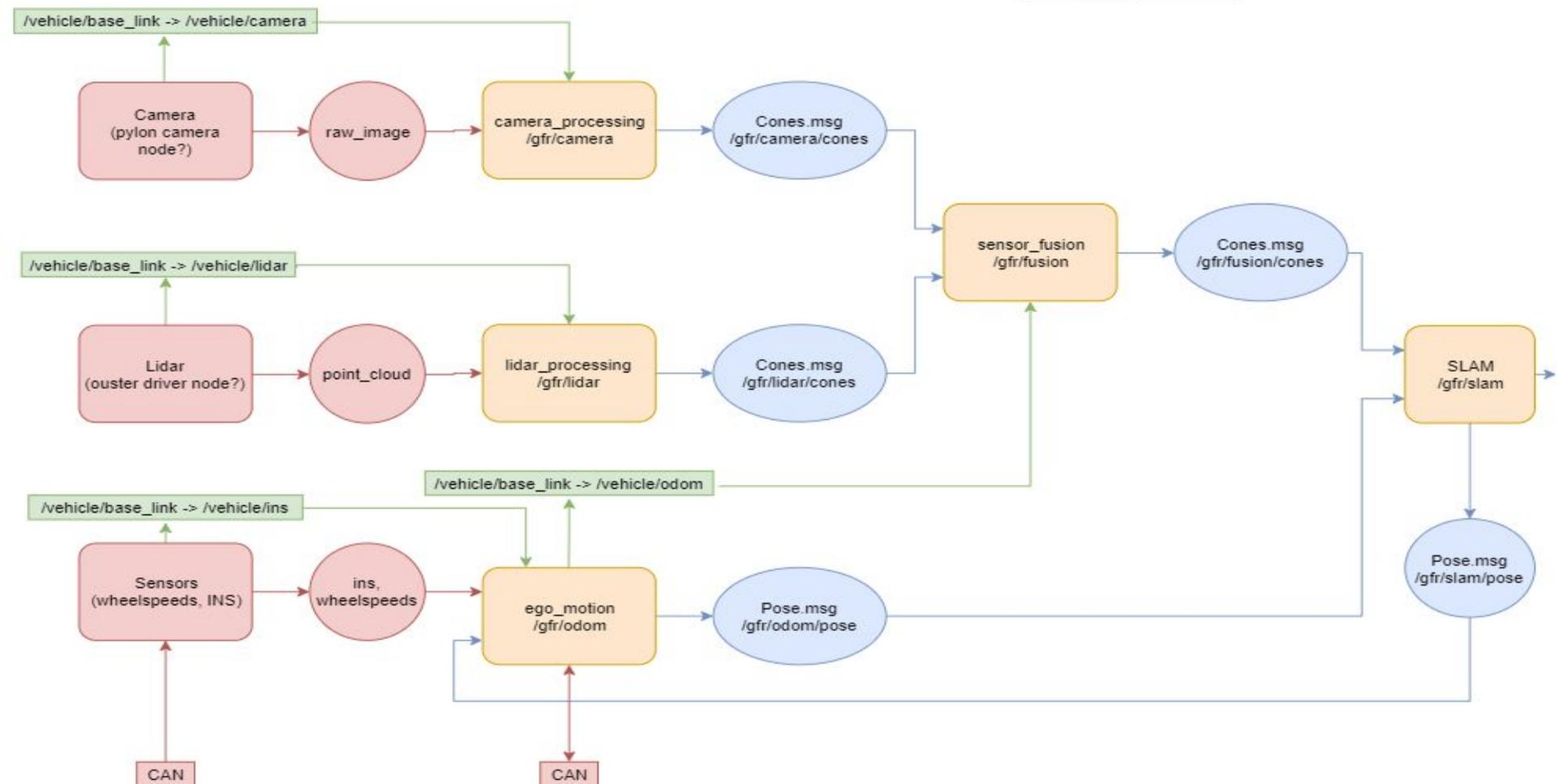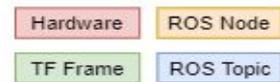- Make the whole process much easier
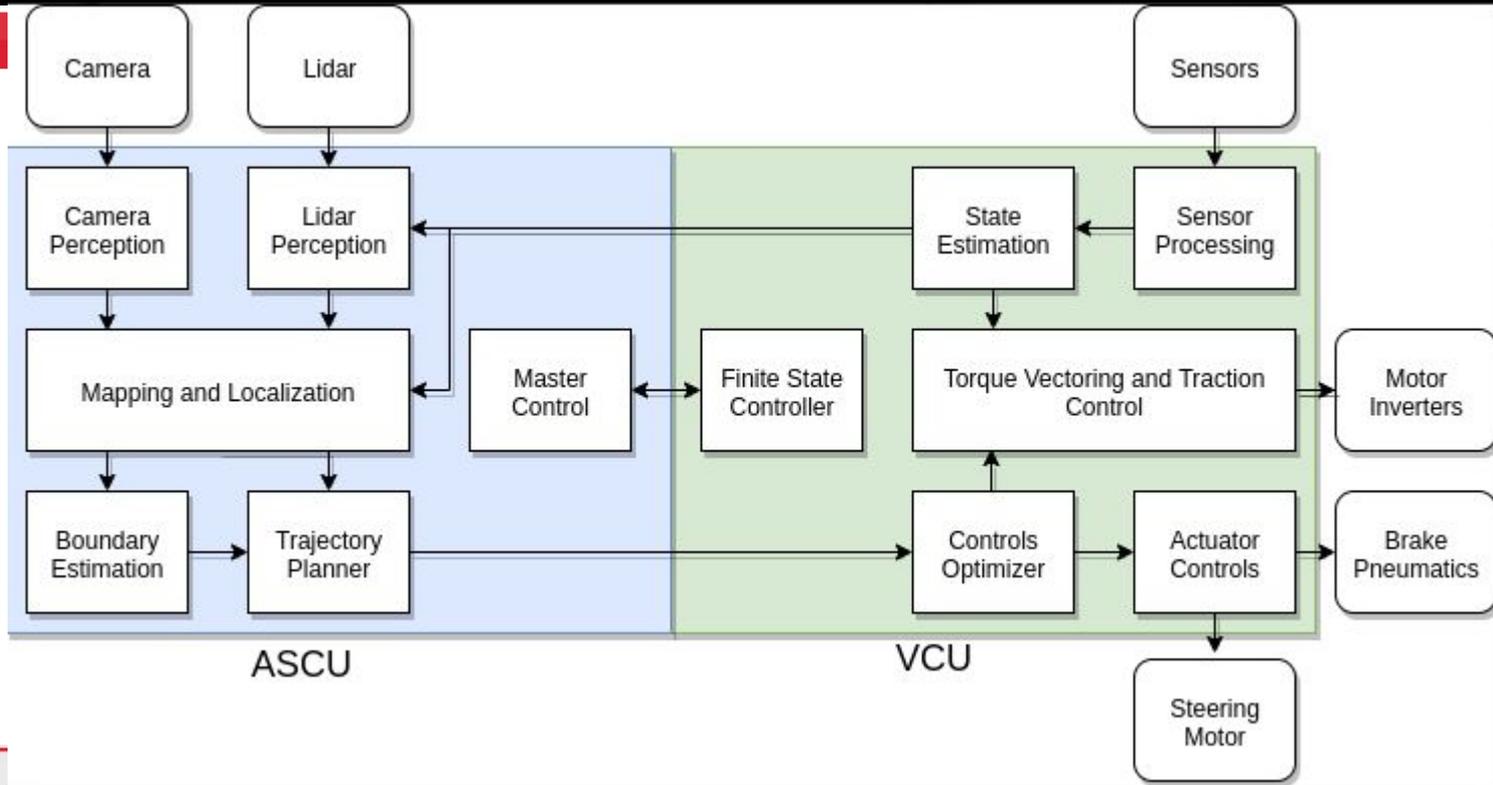
See

Simulator

Tools

- CARLA - core simulation environment

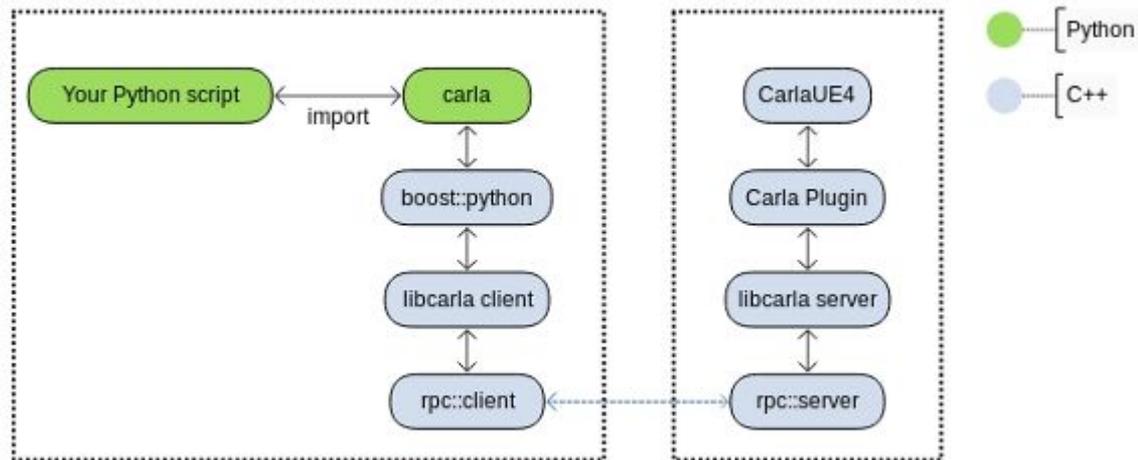- Rviz - allows to visualize data after simulation

- ROS - development environment

Put pics of rviz

Simulator

Simulator

Lidar attributes

Blueprint attribute	Type	Default	Description
channels	int	32	Number of lasers
range	float	10.0	Maximum measurement distance in meters (<=0.9.6: is in centimeters)
points_per_second	int	56000	Points generated by all lasers per second
rotation_frequency	float	10.0	Lidar rotation frequency
upper_fov	float	10.0	Angle in degrees of the upper most laser
lower_fov	float	-30.0	Angle in degrees of the lower most laser
sensor_tick	float	0.0	Seconds between sensor captures (ticks)

Output attributes

```python
# Find the blueprint of the sensor.
blueprint = world.get_blueprint_library().find('sensor.camera.rgb')
# Modify the attributes of the blueprint to set image resolution and field of view.
blueprint.set_attribute('image_size_x', '1920')
blueprint.set_attribute('image_size_y', '1080')
blueprint.set_attribute('fov', '110')
# Set the time in seconds between sensor captures
blueprint.set_attribute('sensor_tick', '1.0')
# Provide the position of the sensor relative to the vehicle.
transform = carla.Transform(carla.Location(x=0.8, z=1.7))
# Tell the world to spawn the sensor, don't forget to attach it to your vehicle actor.
sensor = world.spawn_actor(blueprint, transform, attach_to=my_vehicle)
# Subscribe to the sensor stream by providing a callback function, this function is
# called each time a new image is generated by the sensor.
sensor.listen(lambda data: do_something(data))
```

OS1-64

64 channels

512, 1024, or 2048

120 m

33.2º (±16.6º)

0.53º

±1.5 - 10 cm

1,310,720

10 or 20 Hz

Simulator

Current standing

- Maps made and processed

- Validating simulation

- Integration in progress

- Packaging everything together

- Build script

Terminal 1: ryan@Hyde: ~/Documents/carla-source/carla

Static/Buildings/Farm_Houseadd/M_farmHouse_v3.uasset
Static/Buildings/Farm_Houseadd/M_farmHouse_v3_d.uasset
Static/Buildings/Farm_Houseadd/M_farmHouse_v3_h.uasset
Static/Buildings/Farm_Houseadd/M_farmHouse_v3_n.uasset
Static/Buildings/Farm_Houseadd/M_farmHouse_v3_orm.uasset
Static/Buildings/Farm_MidHouse/
Static/Buildings/Farm_MidHouse/M_FarmBigHouse.uasset
Static/Buildings/Farm_MidHouse/T_FarmBigHouse_d.uasset
Static/Buildings/Farm_MidHouse/T_FarmBigHouse_h.uasset
Static/Buildings/Farm_MidHouse/T_FarmBigHouse_n.uasset
Static/Buildings/Farm_MidHouse/T_FarmBigHouse_orm.uasset
Static/Buildings/Farm_SmallHouse/
Static/Buildings/Farm_SmallHouse/M_farmHouse_v1.uasset
Static/Buildings/Farm_SmallHouse/M_farmHouse_v1_d.uasset
Static/Buildings/Farm_SmallHouse/M_farmHouse_v1_h.uasset
Static/Buildings/Farm_SmallHouse/M_farmHouse_v1_n.uasset
Static/Buildings/Farm_SmallHouse/M_farmHouse_v1_orm.uasset
Static/Buildings/Garage01/
Static/Buildings/Garage01/MI_Garage01_1.uasset
Static/Buildings/Garage01/T_Garage01_1_d.uasset
Static/Buildings/Garage01/T_Garage01_1_n.uasset
Static/Buildings/Garage01/T_Garage01_1_orm.uasset
Static/Buildings/GasStation01/
Static/Buildings/GasStation01/M_GasStation01CarWash.uasset
Static/Buildings/GasStation01/M_GasStation01Column.uasset
Static/Buildings/GasStation01/M_GasStation01Cover.uasset
Static/Buildings/GasStation01/M_GasStation01Dispenser.uasset
Static/Buildings/GasStation01/M_GasStation01Office.uasset
Static/Buildings/GasStation01/M_GasStation01SideWalk.uasset
Static/Buildings/GasStation01/M_GasStation01SideWalk_d.uasset
Static/Buildings/GasStation01/M_GasStation01SignBoard.uasset
Static/Buildings/GasStation01/M_GasStation01Store.uasset
Static/Buildings/GasStation01/M_GasStation01StoreCover.uasset
Static/Buildings/GasStation01/M_GasStation01WashMaq.uasset
Static/Buildings/GasStation01/T_GasStation101WashMaq_orm.uasset
Static/Buildings/GasStation01/T_GasStation01CarWash_d.uasset
Static/Buildings/GasStation01/T_GasStation01CarWash_n.uasset
Static/Buildings/GasStation01/T_GasStation01CarWash_orm.uasset
Static/Buildings/GasStation01/T_GasStation01Column_d.uasset
Static/Buildings/GasStation01/T_GasStation01Column_n.uasset
Static/Buildings/GasStation01/T_GasStation01Column_orm.uasset

Terminal 2: ryan@Hyde: ~/UnrealEngine_4.22/Engine/Binaries/Linux

ialAO, compiling.
[2020.02.24-19.04.33:987][0]LogMaterial: Display: Missing cached shader map for material Metal
lic, compiling.
[2020.02.24-19.04.34:016][0]LogMaterial: Display: Missing cached shader map for material Opaci
ty, compiling.
[2020.02.24-19.04.34:361][0]LogMaterial: Display: Missing cached shader map for material Rough
ness, compiling.
[2020.02.24-19.04.34:388][0]LogMaterial: Display: Missing cached shader map for material Scene
Color, compiling.
[2020.02.24-19.04.34:410][0]LogMaterial: Display: Missing cached shader map for material Scene
Depth, compiling.
[2020.02.24-19.04.34:442][0]LogMaterial: Display: Missing cached shader map for material Separ
ateTranslucencyRGB, compiling.
[2020.02.24-19.04.34:452][0]LogMaterial: Display: Missing cached shader map for material Separ
ateTranslucencyA, compiling.
[2020.02.24-19.04.34:462][0]LogMaterial: Display: Missing cached shader map for material Specu
                                   play: Missing cached shader map for material Subsu
                                   play: Missing cached shader map for material World
                                   play: Missing cached shader map for material Ambie
                                   play: Missing cached shader map for material Custo
                                   play: Missing cached shader map for material Scene
[2020.02.24-19.04.34:691][0]LogMaterial: Display: Missing cached shader map for material Veloc
ity, compiling.
[2020.02.24-19.04.34:717][0]LogMaterial: Display: Missing cached shader map for material PreTo
nemapHDRColor, compiling.
[2020.02.24-19.04.34:760][0]LogMaterial: Display: Missing cached shader map for material PostT
onemapHDRColor, compiling.
[2020.02.24-19.04.37:700][0]LogTcpMessaging: Initializing TcpMessaging bridge
[2020.02.24-19.04.37:825][0]LogUdpMessaging: Initializing bridge on interface 0.0.0.0:0 to mul
ticast group 230.0.0.1:6666.
[2020.02.24-19.04.42:203][0]LogAndroidPermission: UAndroidPermissionCallbackProxy::GetInstance
[2020.02.24-19.04.51:786][0]SourceControl: Source control is disabled
[2020.02.24-19.04.51:823][0]SourceControl: Source control is disabled
[2020.02.24-19.04.52:221][0]SourceControl: Source control is disabled
[2020.02.24-19.04.53:827][0]SourceControl: Source control is disabled

Splash dialog:

UNREAL EDITOR

Unreal Editor 4.22.3
Copyright © 1998-2019 Epic Games, Inc. All rights reserved.

Initializing... 72%

Unreal Engine 4 Crash Reporter

An Unreal process has crashed: UE4-

We are very sorry that this crash occurred. Our goal is to prevent crashes like this from occurring in the future. Please help us track down and fix this crash by providing detailed information about what you were doing so that we may reproduce the crash and fix it quickly. You can also log a Bug Report with us using the Bug Submission Form and work directly with support staff to report this issue.

Thanks for your help in improving the Unreal Engine.

Please provide detailed information about what you were doing when the crash occurred.

Crash reports comprise diagnostics files (click here to view directory) and the following summary information:

Assertion failed: InSize == (~0ULL) || InSize + Offset <= Size [File:/home/ryan/UnrealEngine_4.22/Engine/Source/Runtime/VulkanRHI/Private

libUE4Editor-Core.so!FGenericPlatformMisc::RaiseException(unsigned int) [/home/ryan/UnrealEngine_4.22/Engine/Source/Runtime/Core/Pri
libUE4Editor-Core.so!FUnixErrorOutputDevice::Serialize(char16_t const*, ELogVerbosity::Type, FName const&) [/home/ryan/UnrealEngine_4.2
libUE4Editor-Core.so!FOutputDevice::LogfImpl(char16_t const*, ...) [/home/ryan/UnrealEngine_4.22/Engine/Source/Runtime/Core/Private/Mi
libUE4Editor-Core.so!AssertFailedImplV(char const*, char const*, int, char16_t const*, __va_list_tag*) [/home/ryan/UnrealEngine_4.22/Engine/
libUE4Editor-Core.so!FDebug::CheckVerifyFailedImpl(char const*, char const*, int, char16_t const*, ...) [/home/ryan/UnrealEngine_4.22/Engine
libUE4Editor-VulkanRHI.so!VulkanRHI::FDeviceMemoryAllocation::Map(unsigned long, unsigned long) [/home/ryan/UnrealEngine_4.22/Engine/
libUE4Editor-VulkanRHI.so!VulkanRHI::FOldResourceHeap::AllocateResource(VulkanRHI::FOldResourceHeap::EType, unsigned int, unsigned in
libUE4Editor-VulkanRHI.so!VulkanRHI::FResourceHeapManager::AllocateBufferMemory(VkMemoryRequirements const&, unsigned int, char c
libUE4Editor-VulkanRHI.so!VulkanRHI::FStagingManager::AcquireBuffer(unsigned int, unsigned int, bool) [/home/ryan/UnrealEngine_4.22/Engi
libUE4Editor-VulkanRHI.so!FVulkanDynamicRHI::RHILockTexture2D(FRHITexture2D*, unsigned int, EResourceLockMode, unsigned int&, bool) |
libUE4Editor-SlateRHIRenderer.so!FSlateTextureAtlasRHI::UpdateTexture_RenderThread(FSlateTextureData*) [/home/ryan/UnrealEngine_4.2

☑ Include log files with submission. I understand that logs contain some personal information such as my system and user name.

☑ I agree to be contacted by Epic Games via email if additional information about this crash would help fix it.

Close Without Sending   Send and Close   Send and Restart

Simulator

Problems

```
[2020.02.24-19.09.50:267][  0]LogVulkanRHI: Display: 10: Flags 0xe Heap 1  HostVisible HostCoher
ent HostCached
[2020.02.24-19.09.50:285][  0]LogVulkanRHI: Warning: Failed to allocate Device Memory, Requested
=32768.00Kb MemTypeIndex=10
Assertion failed: InSize == (~0ULL) || InSize + Offset <= Size [File:/home/ryan/UnrealEngine_4.2
2/Engine/Source/Runtime/VulkanRHI/Private/VulkanMemory.cpp] [Line: 387]

[2020.02.24-19.09.50:576][  0]LogCore: Error: appError called: Assertion failed: InSize == (~0UL
L) || InSize + Offset <= Size [File:/home/ryan/UnrealEngine_4.22/Engine/Source/Runtime/VulkanRHI
/Private/VulkanMemory.cpp] [Line: 387]



Signal 11 caught.
Malloc Size=65538 LargeMemoryPoolOffset=65554
```

Rendering

- Provide 3D assets and meshes to the simulator

- Create test tracks
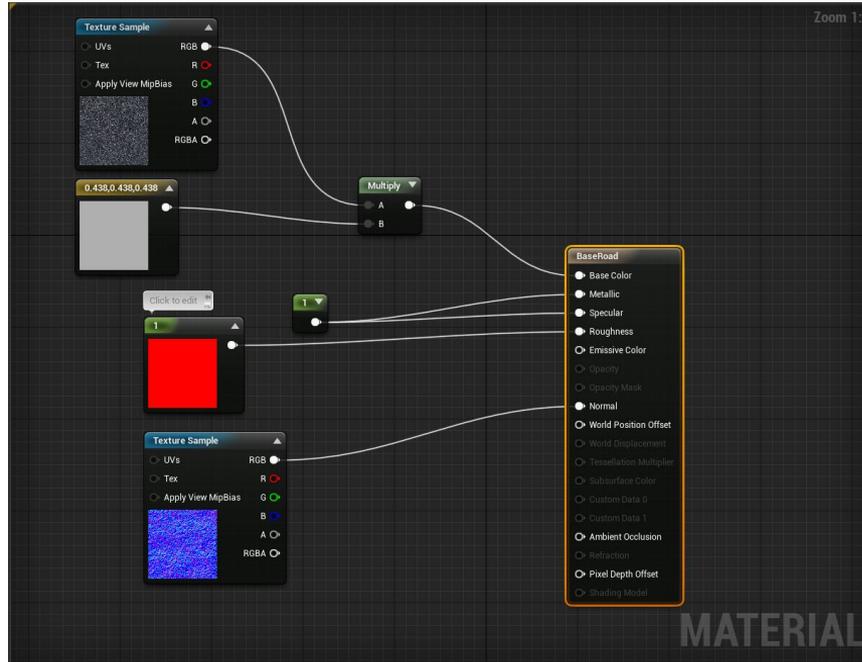

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Rendering

- CLARA map generator - Create base map

- Unreal Engine 4 - Edit and configure 3D Assets

- Sketchup Pro - Convert 3D mesh types

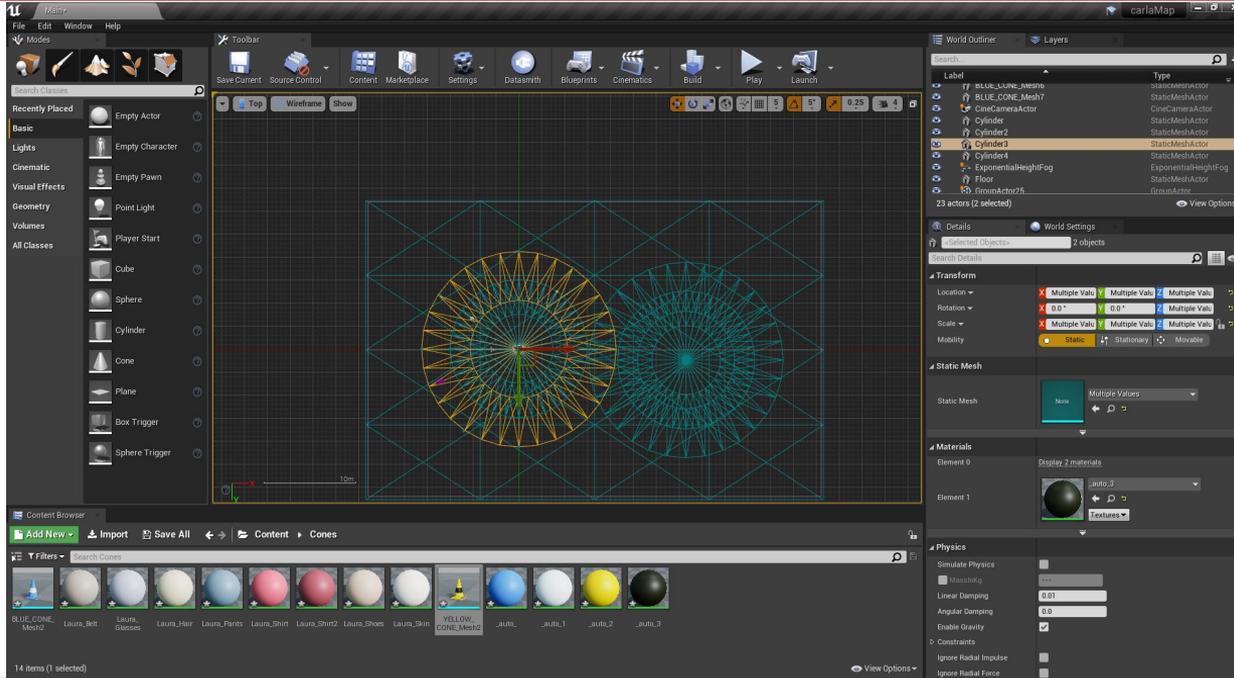OREGON STATE UNIVERSITY   DHBW RAVENSBURG

Rendering

Texture Creation

Rendering

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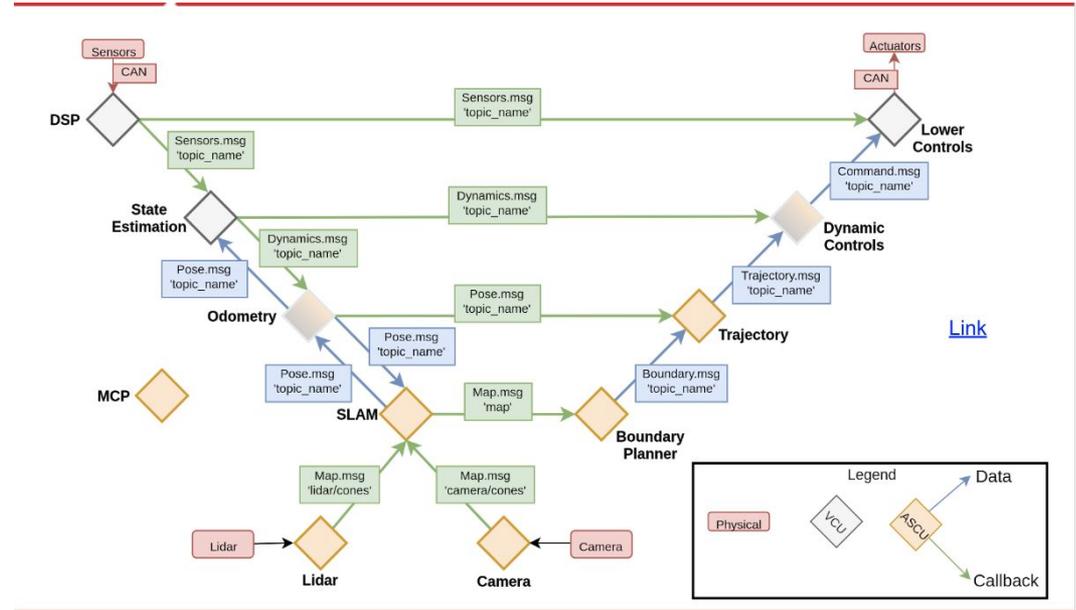
Testing

- Messages are changed to have universal data type and name to fit into the new interface

- Each readings from the simulator will have noise to produce real life accuracy

- Process raw data to be handled into specific messages

Testing

Goals

- Create a message type that are universal

- Convert raw data into specific message types for clarity and ease of access

- Able to show 100% output data with or without noise (ground truth)

- Setting up tracking ID for all data types to boundary estimation

| **Header**	time	time_stamp	Note: Native ROS message type	
	uint32	seq		YES
	string	frame_id		

Testing

- Static and Dynamic data are separated
- While static provide ground truth elements
- Dynamic data processed with added noise built into it

Message Name	Data Type	Data Name	Frequency	Finalized?	Delay	Notes
Pose.msg	std_msgs/Header	header	100Hz			contains time and tf
	geometry_msgs/Vector3	position				
				YES		
	std_msgs/float	yaw				
	std_msgs/float	yaw_stdev				**this all will go into Cones**
	gfr_common/PositionCovariance	position_covariance				
Cones.msg	Header	header	onetime for ground truth			
	gfr_common/Cone[ ]	cones	20Hz for perception	YES		
	gfr_common/Pose	vehicle_pose				
Cone.msg	Header	header	20Hz		Header	**time_stamp**
	geometry_msgs/Vector3	position				**frame_id**
						sequence
	std_msgs/float32	existence_probability		YES		
	gfr_common/PositionCovariance	position_covariance				
	std_msgs/float32[5]	type_probabilities				
	std_msgs/uint8	cone_type				

Node chart
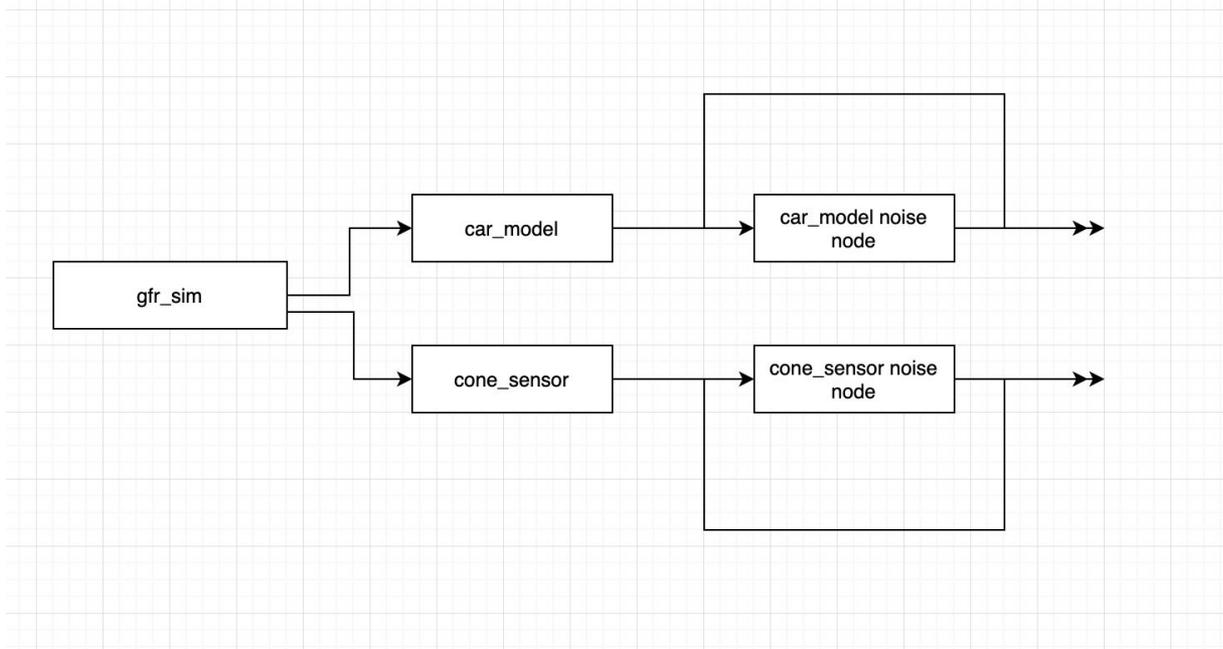
Testing

Overview for noise nodes

- Each node is subscribed to a message type
- Car model and cone sensor are the only dynamic data that require added noise

```cpp
class Car_Noise(){

public:
    Car_Noise(ros::NodeHandle &nh): nh_(nh){
        pub_ground_truth_ = nh.advertise<gfr_sim::State>("/gfr/sim/base_pose_ground_truth", 1);
        pub_car_info_    = nh.advertise<gfr_sim::CarInfo>("/gfr/sim/car_info", 1);
        state_pub        = nh.advertise<gfr_sim::State>("/gfr/sim/car_model_noise", 1);
        //auto state_pub = nh.advertise<gfr_sim::State>("/gfr/sim/car_model_noise", 1);

        sub_f_kin_correction_ = nh.subscribe("/gfr/sim/base_pose_ground_truth", 1, &Car_Noise::noiseCallBack, this);
        //pub_ground_truth_ = nh.advertise<gfr_sim::State>("/gfr/sim/car_model_noise", 1);

    }
private:
    ros::NodeHandle nh;
    ros::Publisher state_pub;
    ros::Subscriber sub_f_kin_correction_;
    void Car_Noise::noiseCallBack(const gfr_sim::State &msg);
    double Car_Noise::getGaussianNoise(double mean, double var);

};


double Car_Noise::getGaussianNoise(double mean, double var) {
    std::normal_distribution<double> distribution(mean, var);
    // construct a trivial random generator engine from a time-based seed:
    long                      seed = std::chrono::system_clock::now().time_since_epoch().count();
    std::default_random_engine      generator(seed);
    return distribution(generator);

}
```

Testing

Current Standings

- New data types are integrated into the new interface

- Car model noise node are basically done

- Cone sensor noise node is in progress

- Setting up tracking ID for each cone to run tests

Team Future

- More validating data and testing

- Improving usability of the simulator

- Reinforce testing interface into SLAM and Boundary Estimation

- Improving CARLA and Continuous Integration Server

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Q&A