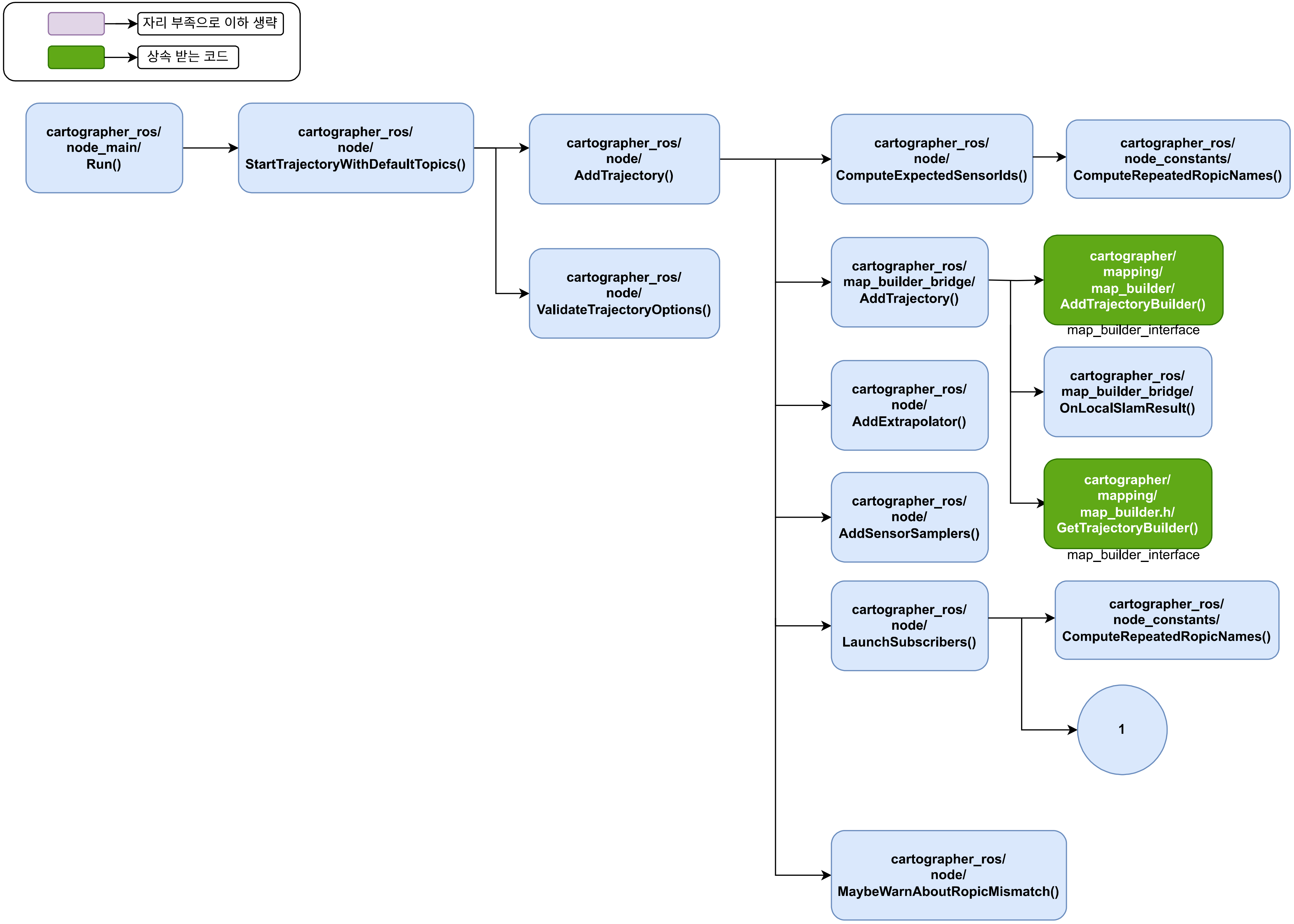
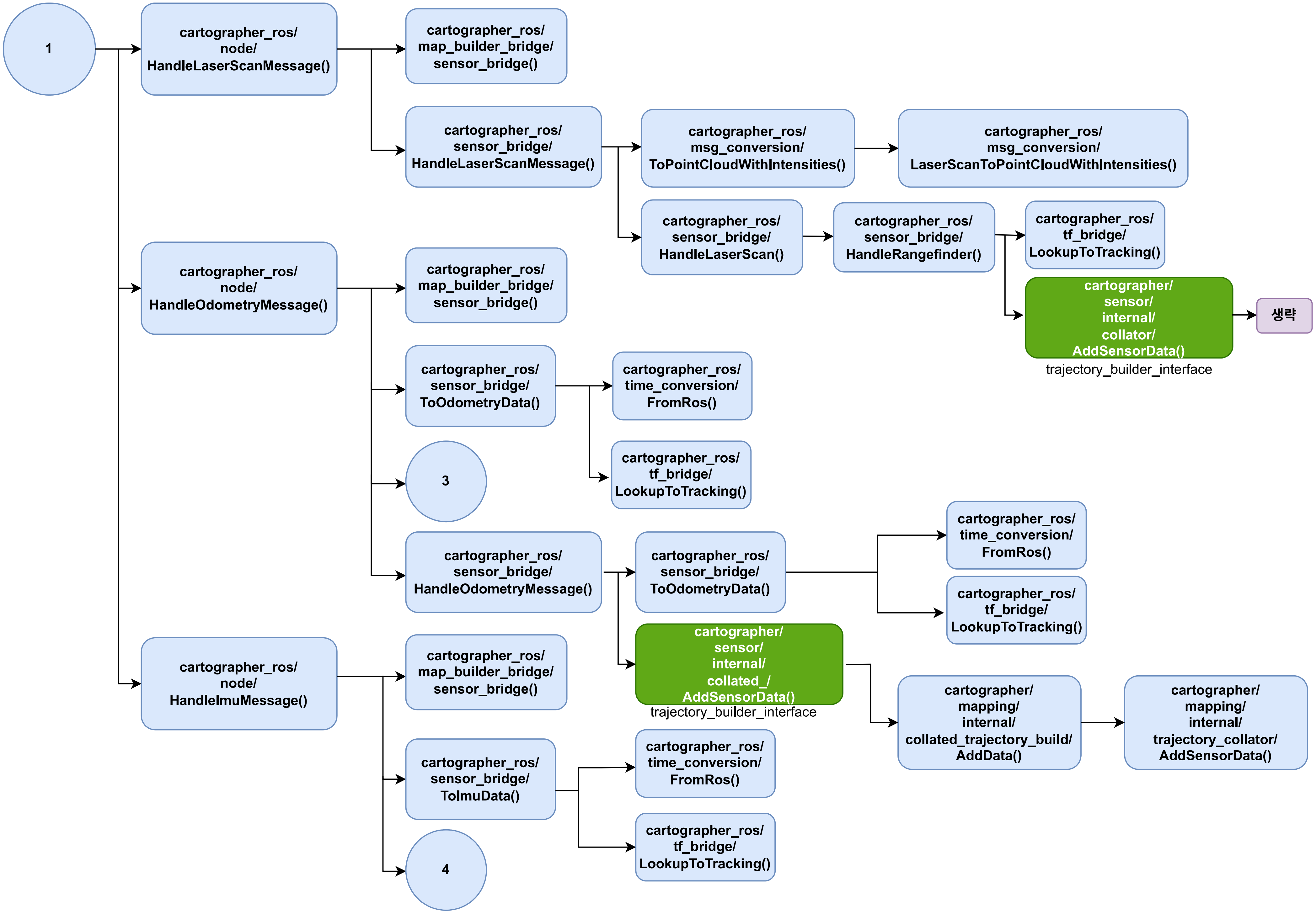
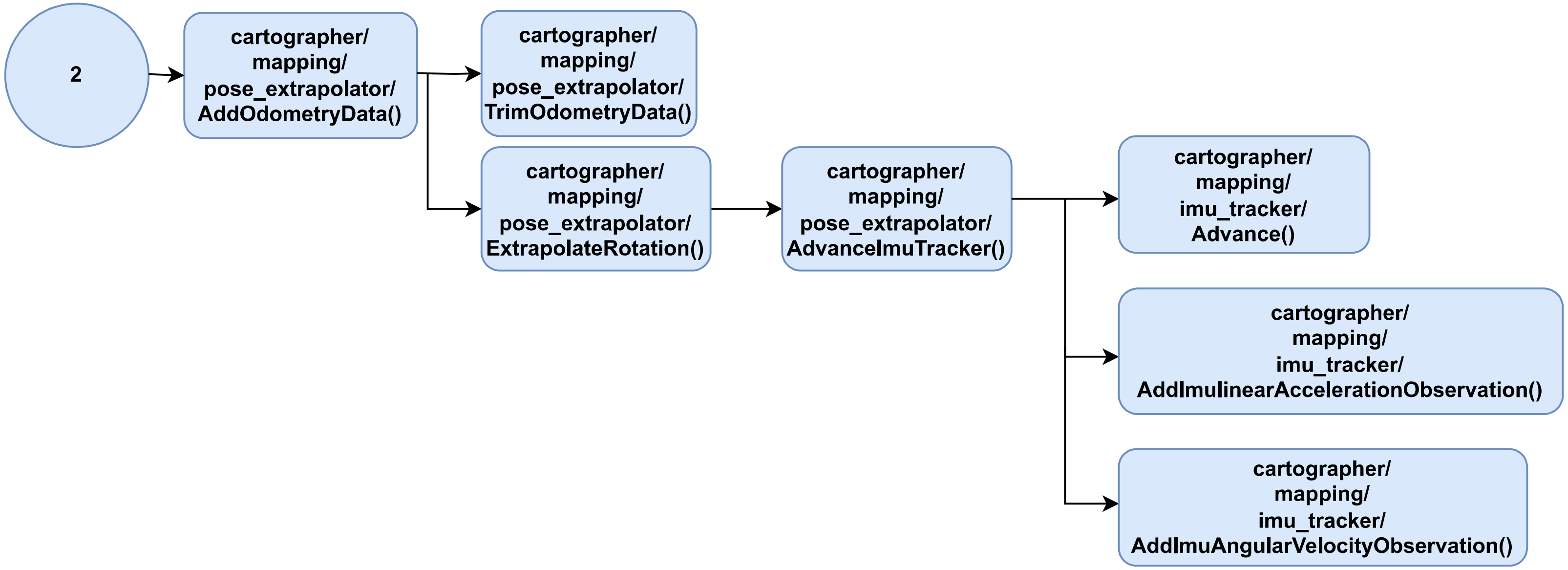
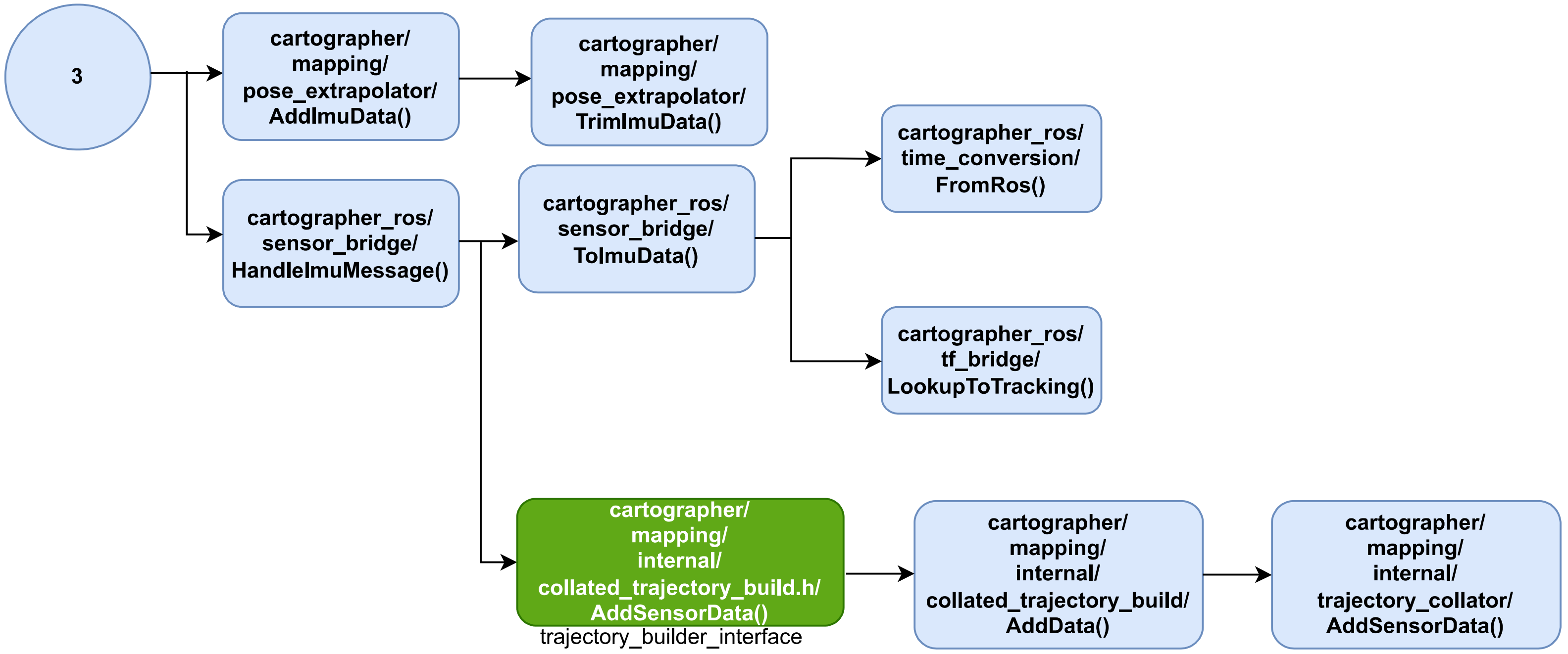

자리 부족으로 이하 생략
상속 받는 코드
cartographer_ros/ node_main/ Run()
cartographer_ros/ node/ StartTrajectoryWithDefaultTopics()
cartographer_ros/ node/ AddTrajectory()
cartographer_ros/ node/ ValidateTrajectoryOptions()
cartographer_ros/ node/ ComputeExpectedSensorIds()
cartographer_ros/ node_constants/ ComputeRepeatedRopicNames()
cartographer_ros/ map_builder_bridge/ AddTrajectory()
cartographer/ mapping/ map_builder/ AddTrajectoryBuilder()
map_builder_interface
cartographer_ros/ map_builder_bridge/ OnLocalSlamResult()
cartographer/ mapping/ map_builder.h/ GetTrajectoryBuilder()
map_builder_interface
cartographer_ros/ node/ AddExtrapolator()
cartographer_ros/ node/ AddSensorSamplers()
cartographer_ros/ node/ LaunchSubscribers()
cartographer_ros/ node_constants/ ComputeRepeatedRopicNames()
1
cartographer_ros/ node/ MaybeWarnAboutRopicMismatch()


1
cartographer_ros/ node/ HandleLaserScanMessage()
cartographer_ros/ map_builder_bridge/ sensor_bridge()
cartographer_ros/ sensor_bridge/ HandleLaserScanMessage()
cartographer_ros/ msg_conversion/ ToPointCloudWithIntensities()
cartographer_ros/ msg_conversion/ LaserScanToPointCloudWithIntensities()
cartographer_ros/ sensor_bridge/ HandleLaserScan()
cartographer_ros/ sensor_bridge/ HandleRangefinder()
cartographer_ros/ tf_bridge/ LookupToTracking()
cartographer/ sensor/ internal/ collator/ AddSensorData()
생략
trajectory_builder_interface
cartographer_ros/ node/ HandleOdometryMessage()
cartographer_ros/ map_builder_bridge/ sensor_bridge()
cartographer_ros/ sensor_bridge/ ToOdometryData()
cartographer_ros/ time_conversion/ FromRos()
cartographer_ros/ tf_bridge/ LookupToTracking()
3
cartographer_ros/ sensor_bridge/ HandleOdometryMessage()
cartographer_ros/ sensor_bridge/ ToOdometryData()
cartographer_ros/ time_conversion/ FromRos()
cartographer_ros/ tf_bridge/ LookupToTracking()
cartographer/ sensor/ internal/ collated_/ AddSensorData()
trajectory_builder_interface
cartographer/ mapping/ internal/ collated_trajectory_build/ AddData()
cartographer/ mapping/ internal/ trajectory_collator/ AddSensorData()
cartographer_ros/ node/ HandleImuMessage()
cartographer_ros/ map_builder_bridge/ sensor_bridge()
cartographer_ros/ sensor_bridge/ ToImuData()
cartographer_ros/ time_conversion/ FromRos()
cartographer_ros/ tf_bridge/ LookupToTracking()
4

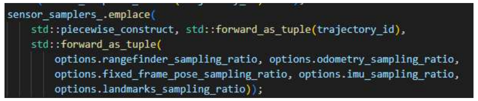

2
cartographer/ mapping/ pose_extrapolator/ AddOdometryData()
cartographer/ mapping/ pose_extrapolator/ TrimOdometryData()
cartographer/ mapping/ pose_extrapolator/ ExtrapolateRotation()
cartographer/ mapping/ pose_extrapolator/ AdvanceImuTracker()
cartographer/ mapping/ imu_tracker/ Advance()
cartographer/ mapping/ imu_tracker/ AddImulinearAccelerationObservation()
cartographer/ mapping/ imu_tracker/ AddImuAngularVelocityObservation()


3
cartographer/ mapping/ pose_extrapolator/ AddImuData()
cartographer/ mapping/ pose_extrapolator/ TrimImuData()
cartographer_ros/ sensor_bridge/ HandleImuMessage()
cartographer_ros/ sensor_bridge/ ToImuData()
cartographer_ros/ time_conversion/ FromRos()
cartographer_ros/ tf_bridge/ LookupToTracking()
cartographer/ mapping/ internal/ collated_trajectory_build.h/ AddSensorData()
trajectory_builder_interface
cartographer/ mapping/ internal/ collated_trajectory_build/ AddData()
cartographer/ mapping/ internal/ trajectory_collator/ AddSensorData()

→ 포인터에 값을 저장하는 경우
→ 포인터로 부터 값을 가져오는 경우

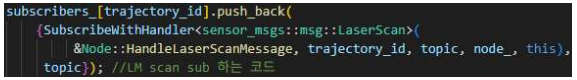
<node.cpp>

cartographer_ros/node/AddSensorSamplers() → sensor_samplers_



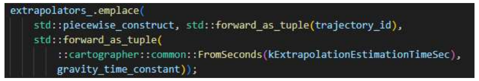
```
sensor_samplers_.emplace(
    std::piecewise_construct, std::forward_as_tuple(trajectory_id),
    std::forward_as_tuple(
        options.rangefinder_sampling_ratio, options.odometry_sampling_ratio,
        options.fixed_frame_pose_sampling_ratio, options.imu_sampling_ratio,
        options.landmarks_sampling_ratio));
```

cartographer_ros/node/LaunchSubscriber() → subscriber_



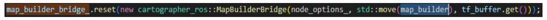
```
subscribers_[trajectory_id].push_back(
    {SubscribeWithHandler<sensor_msgs::msg::LaserScan>(
         &Node::HandleLaserScanMessage, trajectory_id, topic, node_, this),
     topic}); //LM scan sub 하는 코드
```

cartographer_ros/node/AddExtrapolator() → extrapolators_



```
extrapolators_.emplace(
    std::piecewise_construct, std::forward_as_tuple(trajectory_id),
    std::forward_as_tuple(
        ::cartographer::common::FromSeconds(kExtrapolationEstimationTimeSec),
        gravity_time_constant));
```

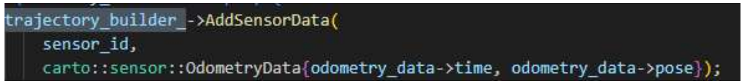
cartographer_ros/node/Node() → map_builder_bridge_



```
map_builder_bridge_.reset(new cartographer_ros::MapBuilderBridge(node_options_, std::move(map_builder), tf_buffer.get()));
```

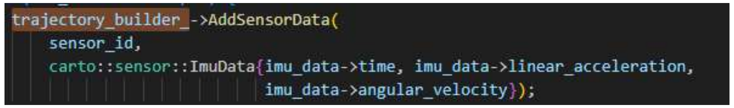
<sensor_bridge.cpp>

cartographer_ros/sensor_bridge/HandleOdometryMessage() → imu_tracker_



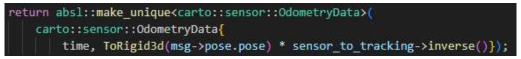
```
trajectory_builder_->AddSensorData(
    sensor_id,
    carto::sensor::OdometryData{odometry_data->time, odometry_data->pose});
```

cartographer_ros/sensor_bridge/HandleImuMessage() → trajectory_builder_



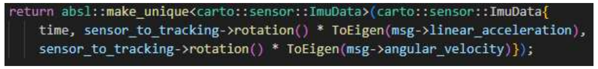
```
trajectory_builder_->AddSensorData(
    sensor_id,
    carto::sensor::ImuData{imu_data->time, imu_data->linear_acceleration,
                           imu_data->angular_velocity});
```

cartographer_ros/sensor_bridge/ToOdometryData() → extrapolators_



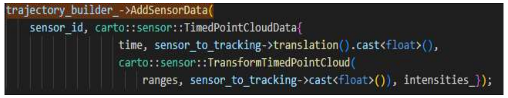
```
return absl::make_unique<carto::sensor::OdometryData>(
    carto::sensor::OdometryData{
        time, ToRigid3d(msg->pose.pose) * sensor_to_tracking->inverse()});
```

cartographer_ros/sensor_bridge/ToImuData() → extrapolators_



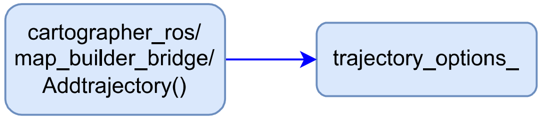
```
return absl::make_unique<carto::sensor::ImuData>(carto::sensor::ImuData{
    time, sensor_to_tracking->rotation() * ToEigen(msg->linear_acceleration),
    sensor_to_tracking->rotation() * ToEigen(msg->angular_velocity)});
```

cartographer_ros/sensor_bridge/HandleRangefinder() → trajectory_builder_

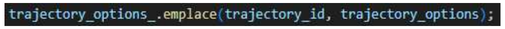


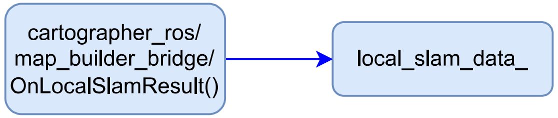
```
trajectory_builder_->AddSensorData(
    sensor_id, carto::sensor::TimedPointCloudData{
                   time, sensor_to_tracking->translation().cast<float>(),
                   carto::sensor::TransformTimedPointCloud(
                       ranges, sensor_to_tracking->cast<float>()), intensities_});
```

<map_builder_bridge.cpp>

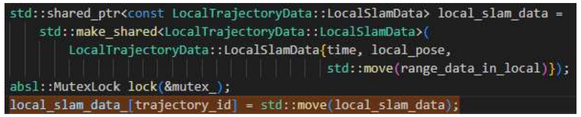

cartographer_ros/
map_builder_bridge/
Addtrajectory()

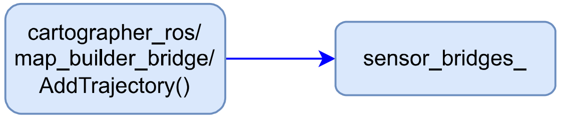
trajectory_options_


```cpp
trajectory_options_.emplace(trajectory_id, trajectory_options);
```

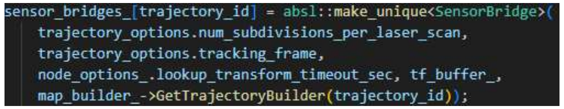

cartographer_ros/
map_builder_bridge/
OnLocalSlamResult()

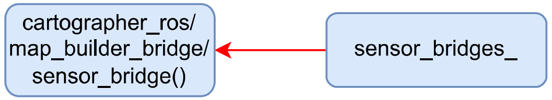
local_slam_data_


```cpp
std::shared_ptr<const LocalTrajectoryData::LocalSlamData> local_slam_data =
    std::make_shared<LocalTrajectoryData::LocalSlamData>(
        LocalTrajectoryData::LocalSlamData{time, local_pose,
                                           std::move(range_data_in_local)});
absl::MutexLock lock(&mutex_);
local_slam_data_[trajectory_id] = std::move(local_slam_data);
```

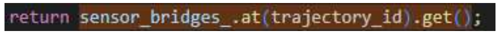

cartographer_ros/
map_builder_bridge/
AddTrajectory()

sensor_bridges_

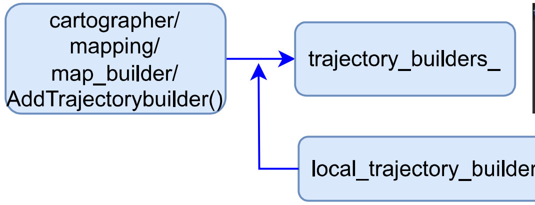

```cpp
sensor_bridges_[trajectory_id] = absl::make_unique<SensorBridge>(
    trajectory_options.num_subdivisions_per_laser_scan,
    trajectory_options.tracking_frame,
    node_options_.lookup_transform_timeout_sec, tf_buffer_,
    map_builder_->GetTrajectoryBuilder(trajectory_id));
```


cartographer_ros/
map_builder_bridge/
sensor_bridge()

sensor_bridges_

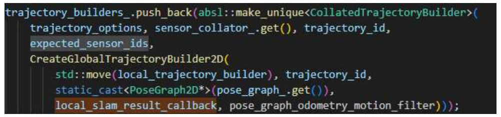

```cpp
return sensor_bridges_.at(trajectory_id).get();
```

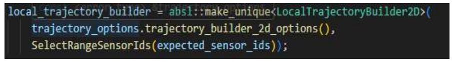
<map_builder.cc, .h>

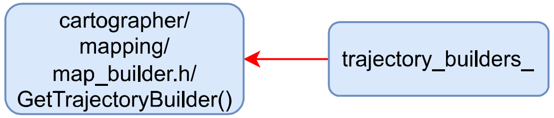

cartographer/
mapping/
map_builder/
AddTrajectorybuilder()

trajectory_builders_

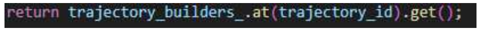
local_trajectory_builder

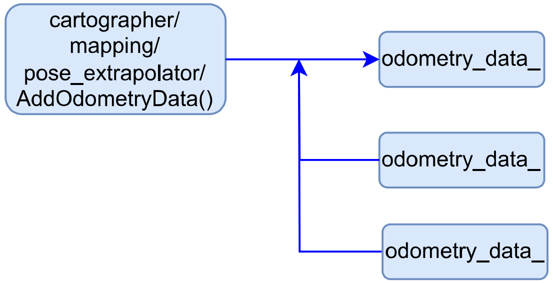

```cpp
trajectory_builders_.push_back(absl::make_unique<CollatedTrajectoryBuilder>(
    trajectory_options, sensor_collator_.get(), trajectory_id,
    expected_sensor_ids,
    CreateGlobalTrajectoryBuilder2D(
        std::move(local_trajectory_builder), trajectory_id,
        static_cast<PoseGraph2D*>(pose_graph_.get()),
        local_slam_result_callback, pose_graph_odometry_motion_filter)));
```


```cpp
local_trajectory_builder = absl::make_unique<LocalTrajectoryBuilder2D>(
    trajectory_options.trajectory_builder_2d_options(),
    SelectRangeSensorIds(expected_sensor_ids));
```


cartographer/
mapping/
map_builder.h/
GetTrajectoryBuilder()

trajectory_builders_

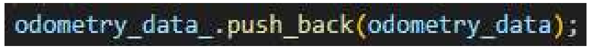

```cpp
return trajectory_builders_.at(trajectory_id).get();
```

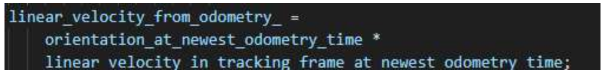

cartographer/
mapping/
pose_extrapolator/
AddOdometryData()

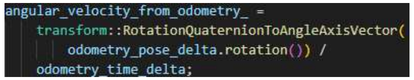
odometry_data_

odometry_data_

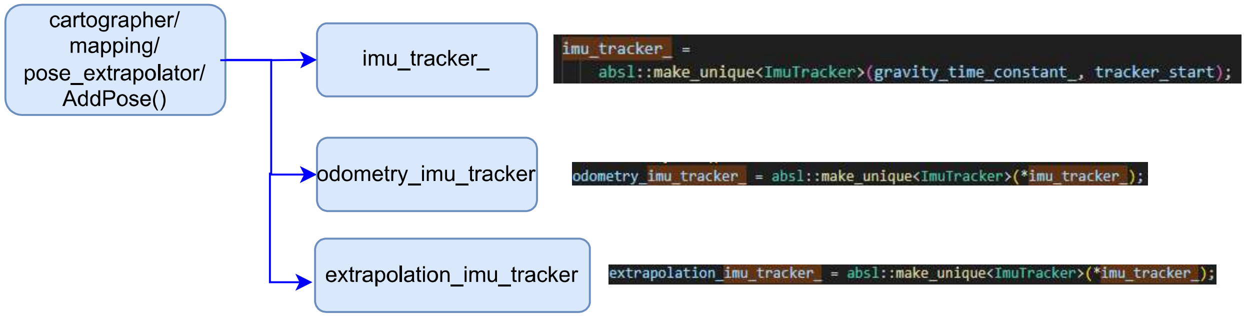
odometry_data_


```cpp
odometry_data_.push_back(odometry_data);
```


```cpp
linear_velocity_from_odometry_ =
    orientation_at_newest_odometry_time *
    linear_velocity_in_tracking_frame_at_newest_odometry_time;
```


```cpp
angular_velocity_from_odometry_ =
    transform::RotationQuaternionToAngleAxisVector(
        odometry_pose_delta.rotation()) /
    odometry_time_delta;
```

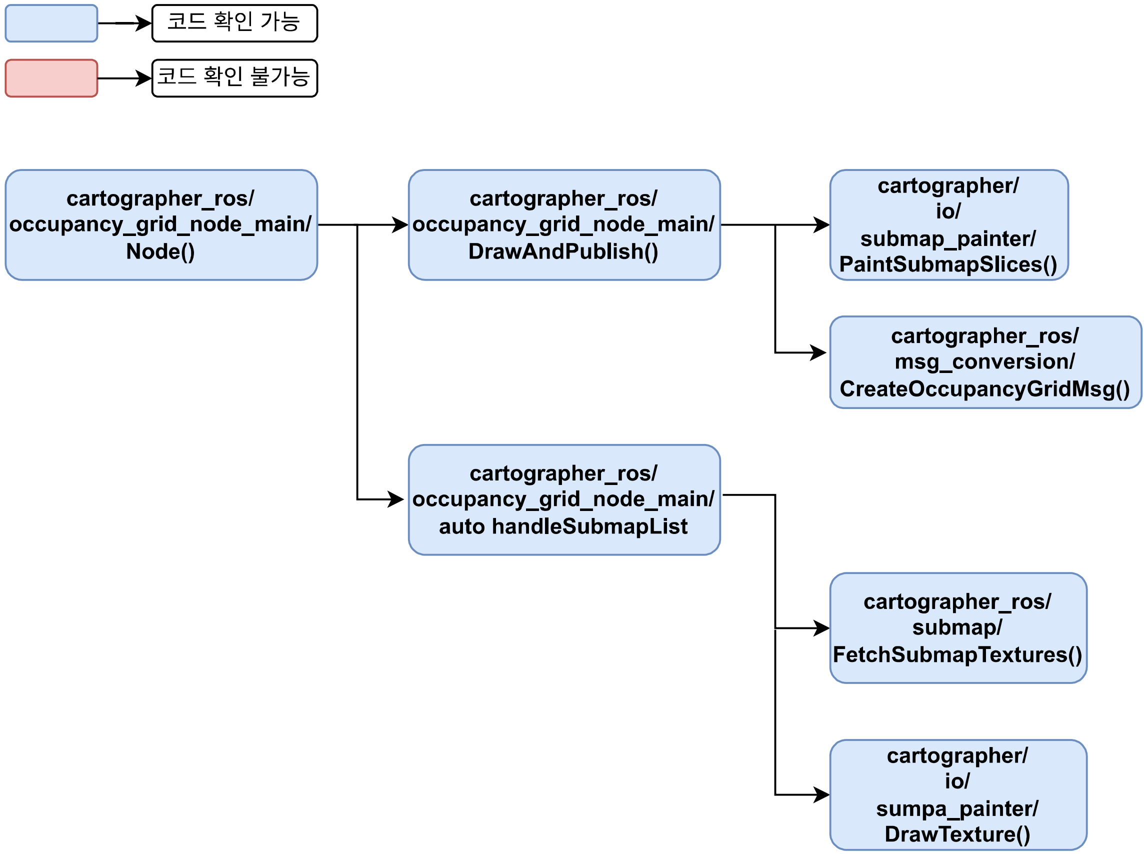
<pose_extrapolator.cc>

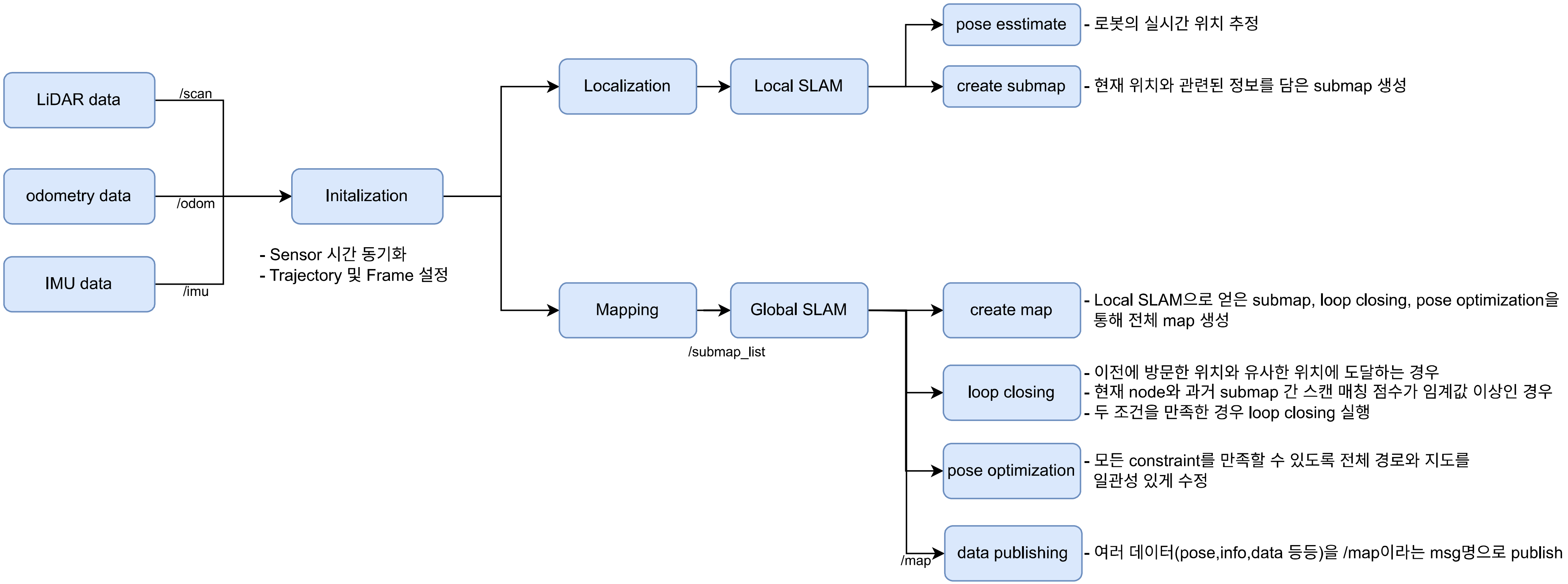

cartographer/
mapping/
pose_extrapolator/
AddPose()
imu_tracker_
odometry_imu_tracker
extrapolation_imu_tracker

```
imu_tracker_ =
    absl::make_unique<ImuTracker>(gravity_time_constant_, tracker_start);
```

```
odometry_imu_tracker_ = absl::make_unique<ImuTracker>(*imu_tracker_);
```

```
extrapolation_imu_tracker_ = absl::make_unique<ImuTracker>(*imu_tracker_);
```


코드 확인 가능
코드 확인 불가능
cartographer_ros/ occupancy_grid_node_main/ Node()
cartographer_ros/ occupancy_grid_node_main/ DrawAndPublish()
cartographer/ io/ submap_painter/ PaintSubmapSlices()
cartographer_ros/ msg_conversion/ CreateOccupancyGridMsg()
cartographer_ros/ occupancy_grid_node_main/ auto handleSubmapList
cartographer_ros/ submap/ FetchSubmapTextures()
cartographer/ io/ sumpa_painter/ DrawTexture()


LiDAR data
/scan
odometry data
/odom
IMU data
/imu
Initalization
Localization
Local SLAM
pose esstimate
create submap
Mapping
Global SLAM
/submap_list
create map
loop closing
pose optimization
data publishing
/map

- Sensor 시간 동기화
- Trajectory 및 Frame 설정

- 로봇의 실시간 위치 추정

- 현재 위치와 관련된 정보를 담은 submap 생성

- Local SLAM으로 얻은 submap, loop closing, pose optimization을 통해 전체 map 생성

- 이전에 방문한 위치와 유사한 위치에 도달하는 경우
- 현재 node와 과거 submap 간 스캔 매칭 점수가 임계값 이상인 경우
- 두 조건을 만족한 경우 loop closing 실행

- 모든 constraint를 만족할 수 있도록 전체 경로와 지도를 일관성 있게 수정

- 여러 데이터(pose,info,data 등등)을 /map이라는 msg명으로 publish