Livox Mid-40 and APX-15 - High precision mapping

This post notes my analysis and understanding about how a Livox Mid-40 lidar and an APX-15 GNSS-INS module are used in a high precision mapping project demonstrated by Livox.

#lidar #gnss #ins #mapping

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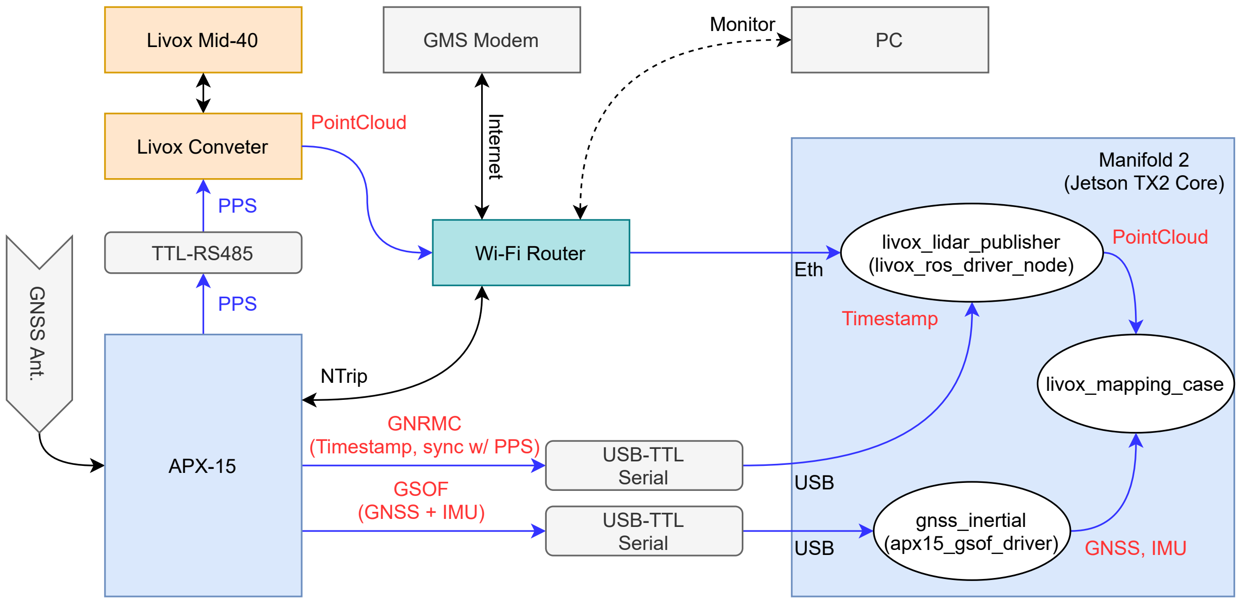
The official guide and source code is hosted in livox_high_precision_mapping

1. Overview

This project aims to stick geographical information into a point cloud. The data from GNSS and INS module is used to calculate high precision position of every point captured from the Lidar. The sample project uses a Livox Mid-40 lidar and an APX-15 GNSS-INS module.

The system block diagram looks like below:



Livox mapping using APX-15

- The APX-15 module sends PPS pulse to Livox, and sends GPS timestamp in GNRMC messages to the Manifold 2 computer which forwards timestamp to Livox through an Ethernet connection
- The APX-15 module sends Trimble's GSOF messages which contains GNSS location data and IMU information to the Manifold 2
- The Livox Mid-40, gets PPS and GNRMC timestamp then sends point cloud message to the Manifold 2 on the Ethernet connection
- The Manifold2 processes GNSS, IMU and pointcloud together to create a geo-referenced pointcloud.

I do not have an APX-15 module here, as it is very expensive. I will build a similar system with a cheaper GNSS and IMU module. So, this post contains my analysis about the software only.

2. Mapping package

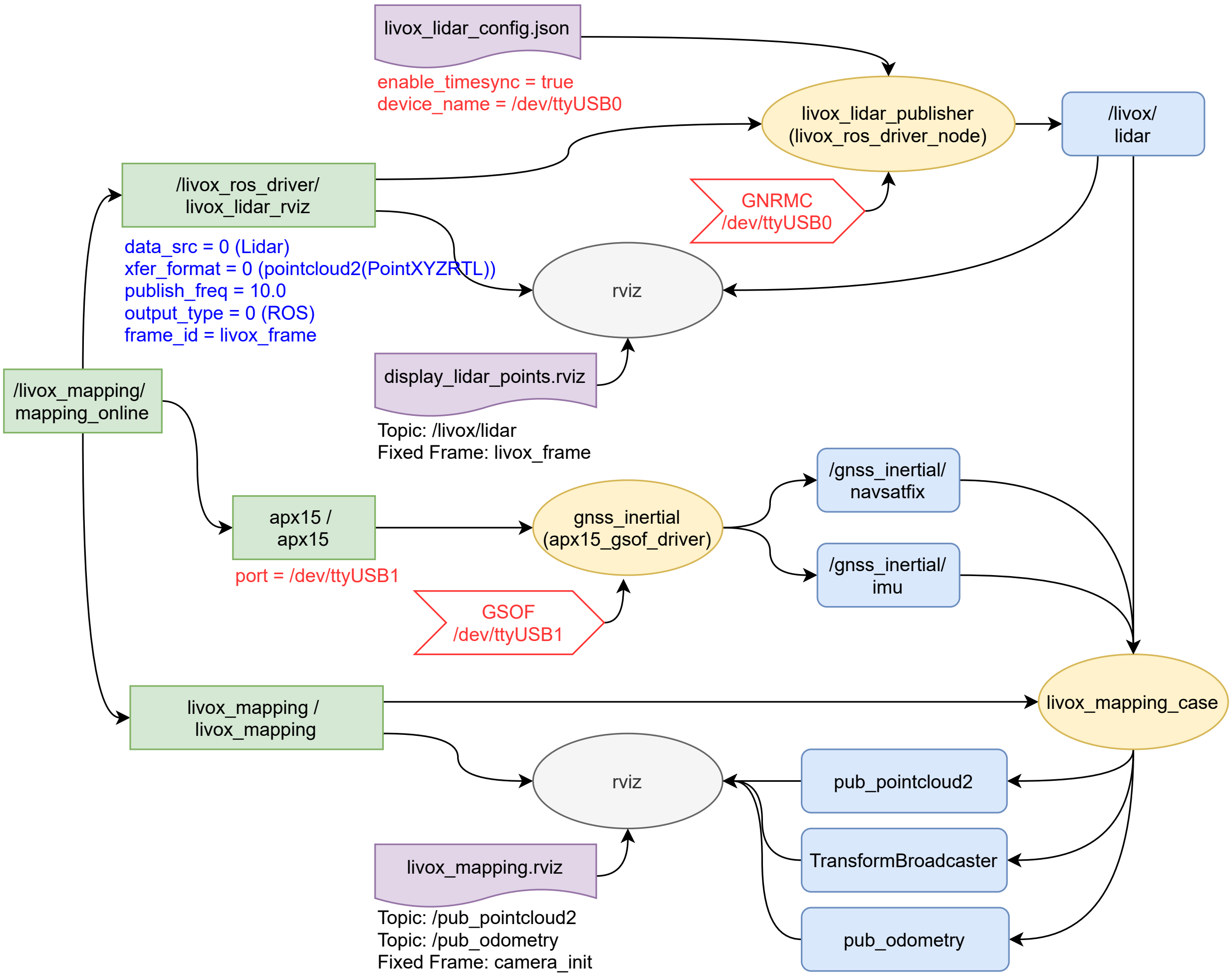
Install Livox SDK and livox_ros_driver firstly. Then download can compile the livox_high_precision_mapping package:

```
cd ws_livox/src && \
git clone https://github.com/Livox-SDK/livox_high_precision_mapping.git && \
cd ws_livox && \
catkin_make && \
source ./devel/setup.sh
```

Directly run the `mapping_online.launch` file to generate point cloud data in the pointcloud2 format that combines the IMU pose and GNSS position:

```
roslaunch livox_mapping mapping_online.launch
```

The calls and data flow are described in the below diagram:



Lidar Mapping system calls and data flow

Note the user configuration points:

- Turn on Timestamp Synchronization and set GNRMC input device in `livox_lidar_config.json` file
- Set GSOF input device in `apx15.launch` file

3. The APX-15 Node

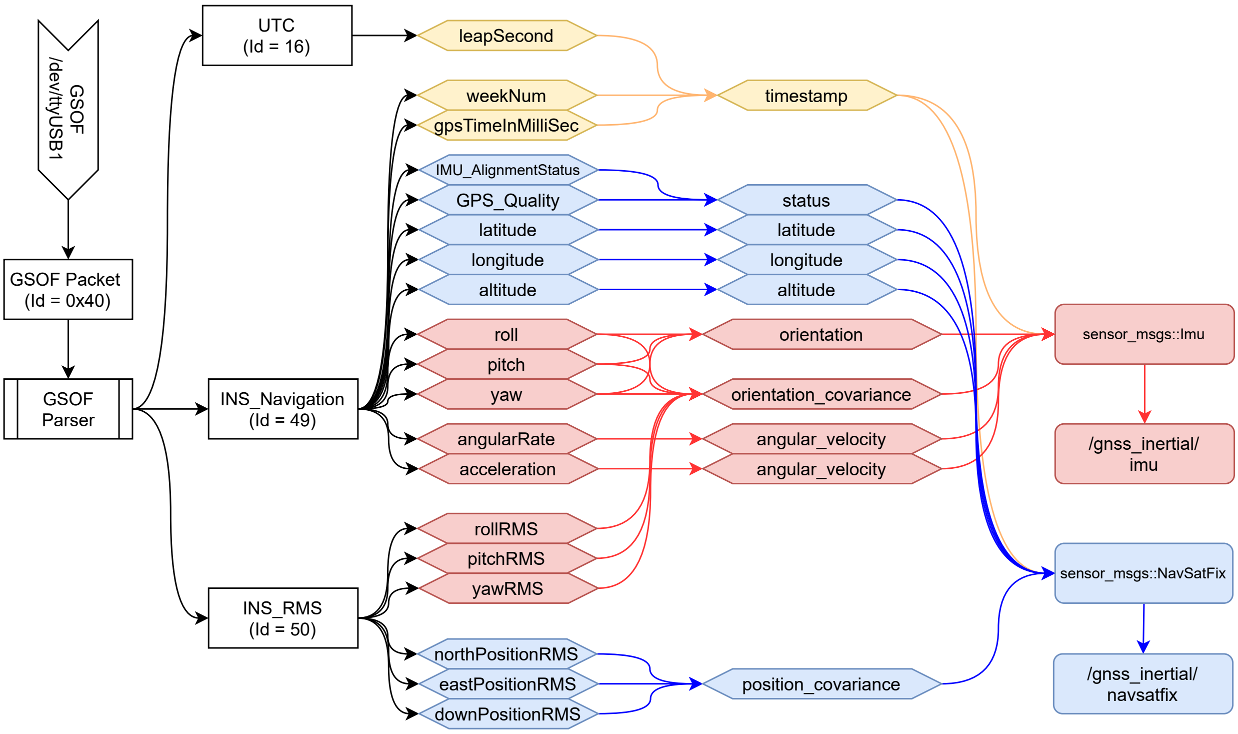
The APX-15 mode reads GSOF messages and extract the GNSS and IMU data from the Report Packet (0x40 — GENOUT).

> GSOF messages are processed data from the APX-15 engine.

There are 3 interesting message types:

- UTC message (ID = 16)
- INS Navigation message (ID = 49)
- INS RMS message (ID = 50)

These extracted information will be used to make `sensor_msgs::NavSatFix` and `sensor_msgs::Imu` messages which are posted to the mapping node.

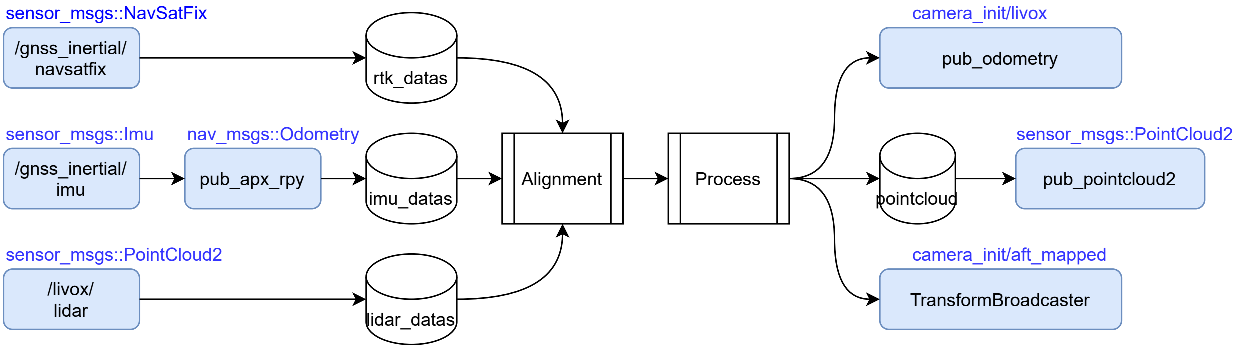


APX-15 data extracting

4. The Mapping node

The mapping node gets the pointcloud from the Lidar ROS driver node, the GNSS and IMU data from the APX-15 node and processes them together:

- Store pointcloud with timestamp
- Store GNSS with timestamp
- Store IMU with timestamp
- Align packets using timestamp
- Apply IMU to GNSS point, and stick geographical information to pointcloud



Process data