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Performance Optimization Analysis of Robotic Operating System ROS Communication

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Abstract: ROS is the actual standard operating system in robotics field. It uses TCP / IP based communication mode to realize the loose-coupling connection between the points of modules.

Keywords: ROS communication, distributed, shared memory

1. Introduction

ROS is the actual standard operating system in robotics field. It uses TCP / IP based communication mode to realize the loose-coupling connection between the points of modules.

2. Advantages and Disadvantages of ROS

2.1. Advantages of ROS

ROS has a high degree of industry recognition, and its framework has been used by the robotics industry for a long time. It currently has more than 3,000 libraries that support rapid application development. ROS adopts the message mechanism and divides the whole system into several modules, each module is responsible for receiving, processing and publishing its own message. When modules need to be linked, the framework allows for the rapid integration of the modules together. ROS is the most widely used framework in the academic world and is very convenient for validating the latest robotic algorithms.

2.2. Disadvantages of ROS

ROS lacks a standard method for building a multi-robot system, is not available or functional on non-Linux operating systems, lacks real-time design, requires a good network environment to ensure data integrity, and lacks data encryption and security protection.

3. ROS communication and performance optimization

3.1. Mechanism for ROS communications

The essence of ROS communication is P2P with a center. The sending node (Publisher) registers the message to Master, while the receiving node registers to the same Topic. After registration, if the sending nodes need to send data, they send it to a local Publish queue, receive it as a node. The receiving node takes the data from the Subscribe queue, and then calls the callback function after backstreaming. Inevitably, this process requires two copies of data, one at the sending node and the other at a receiving node.

Given that robots have more sensors, copying greatly affects the performance of the system if a single sensor message has multiple consumers. For example, the single camera' s ROS drive node will send data to multiple ROS nodes. These feature nodes include obstacle detection, location, GUI tools, etc...

3.2. ROS Communications Optimization

The actual Sends Node (Publisher) and Receive Nodes (Subscriber) often share memory in the same robot. It is clear that the transmitting node and the receiving node share the memory. As early as 15 years ago, the Linux-2.4 kernel achieved the shared memory through the Memory Mapping Unit (MMU).

Shared memory can effectively satisfy a pair or more transmission scenarios. When a single camera ROS drive node needs to send data to multiple ROS-nodes, the cameras only need to set up shared memory and write data. The bottleneck problem of the transmission performance of large amount of data is solved..

3.3. Optimal analysis of ROS communications

Baidu' s Apollo system uses the shared memory technology to improve ROS communications and publishes data on performance improvements

(1) Shared memory throughput doubles as socket in one-to-one transfers, and the bandwidth advantage of shared memory transfers widens even further in a pair of multiple

transfers.

(2) Shared memory transmission delay saves half, to the strong real time system' s auto-driving vehicle greatly assists.

(3) Shared memory CPU resource occupancy reduced by 30 %, to some extent improve the ability of the algorithm.

However, the essence of this performance enhancement is to improve performance at the cost of distribution.
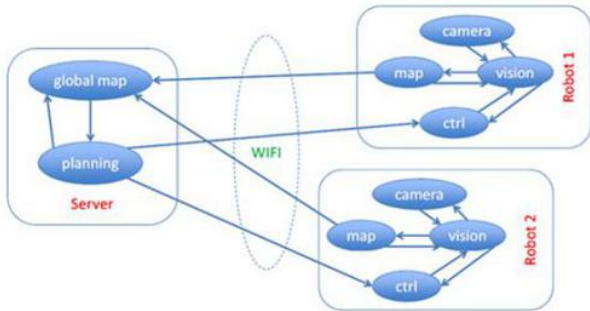

Figure 1. Distributed robot navigation

In Fig. 1 Distributed Robotic Navigation System, it is assumed that there are two robots in the system named Robot1 and Robot 2 respectively, which are equipped with cameras, running the ROS and vision (assuming VSLAM).

It is clear that communication within robot1 and rob ot2 can be optimized by sharing memory. If there is a need to share information between the server and the robots (rob 1, rob 2), or between them, communication can not be done through shared memory because the servers and robots run in different hardware systems.

4. Summary

This paper firstly introduces the advantages and disadvantages of ROS, then detailedly discusses the mechanism, optimization and analysis of the optimization. The communication performance optimization of ROS is not perfect yet, and needs constant exploration and effort..

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