10 TF release and monitoring

10.1 tf function package

10.1.1 tf is a function package that allows users to track multiple coordinate systems over time. It uses a tree data structure to buffer and maintain the coordinate transformation relationship between multiple coordinate systems according to time, which can help developers at any time., to complete coordinate transformations such as points and vectors between coordinate systems.

10.1.2 Use steps

1. monitor tf transformation

Receive and cache all coordinate system transformation data published in the system, and query the required coordinate transformation relationship from it.

2. broadcast tf transformation

Broadcasts the coordinate transformation relationship between coordinate systems to the system. There may be multiple broadcasts of tf transforms of different parts in the system. Each broadcast can directly insert the coordinate transformation relationship into the tf tree without synchronization.

10.2 Programming implementation of tf coordinate system broadcasting and monitoring**

10.2.1 Create and compile function packages

```
cd ~/catkin_ws/src
catkin_create_pkg learning_tf rospy roscpp turtlesim tf
cd ..
catkin_make
```

10.2.2 how to implement a tf broadcaster

1. define tf broadcaster(TransformBroadcaster);
2. initialize tf data, create coordinate transformation value;
3. publish coordinate transformation(sendTransform);

10.2.3 How to implement a tf listener

1. define TF listener(TransformListener);
2. find coordinate transformation(waitForTransform, lookupTransform)

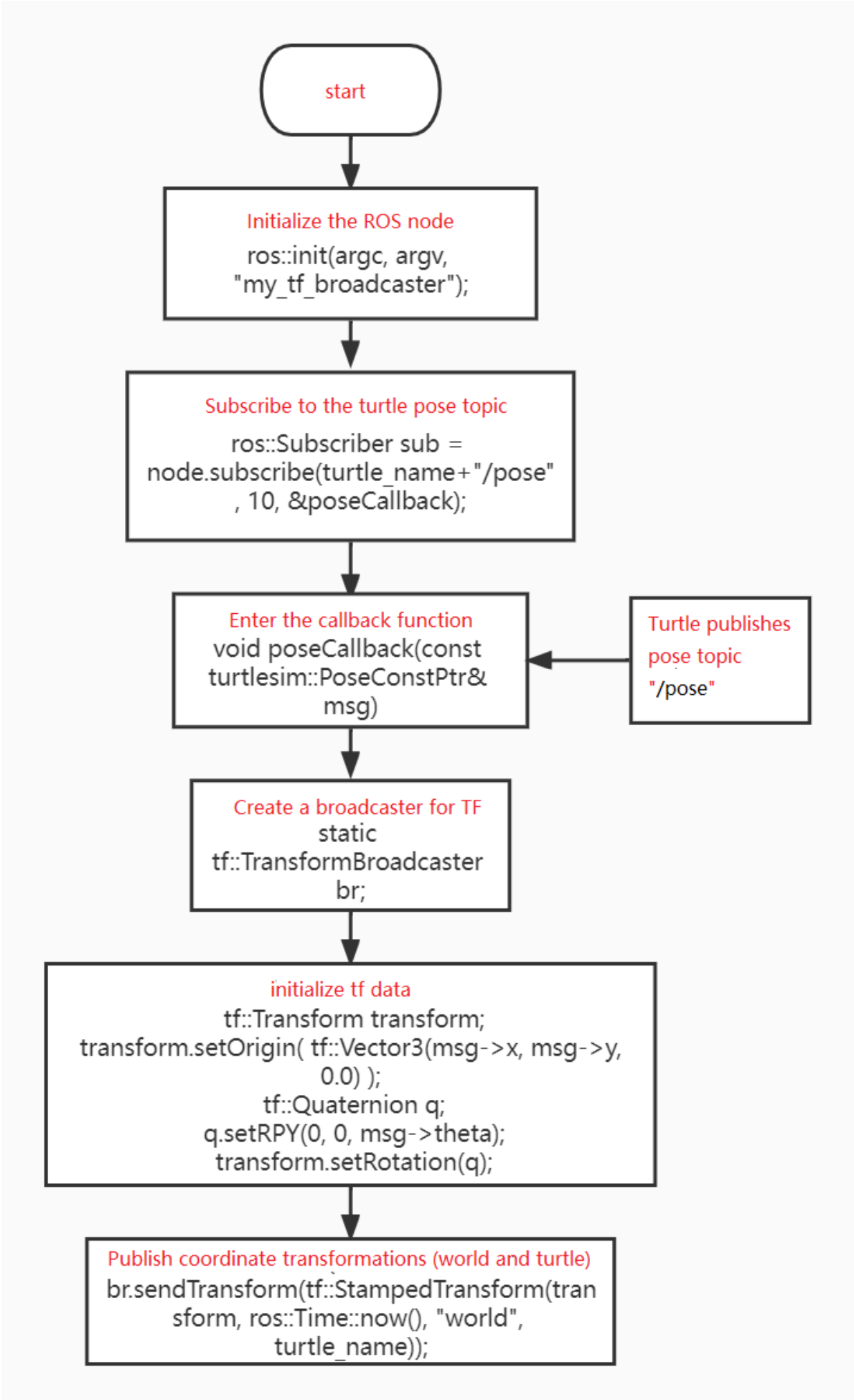
10.2.4 C++ language implements tf broadcaster

1. In the src folder of the function package learning_tf, create a c++ file(the file suffix is .cpp) and name it turtle_tf_broadcaster.cpp
2. copy and paste the program code below into the turtle_tf_broadcaster.cpp file

```
#include <ros/ros.h>
#include <tf/transform_broadcaster.h>
#include <turtlesim/Pose.h>

std::string  turtle_name;

void  poseCallback(const  turtlesim::PoseConstPtr &  msg)
{

    static  tf::TransformBroadcaster  br; // create a broadcaster for tf

    // initialize tf data
    tf::Transform  transform;
    transform.setOrigin(tf::Vector3(msg -> x, msg -> y, 0.0)); //set xyz
coordinates
    tf::Quaternion  q;
    q.setRPY(0, 0, msg -> theta); //Set Euler angle: rotate with x-axis, y-axis,
z-axis
    transform.setRotation(q);

    br.sendTransform(tf::StampedTransform(transform, ros::Time::now() "world",
turtle_name)); // broadcast tf data between world and turtle coordinate system
}

int  main(int  argc, char**  argv)
{
```

```
    ros::init(argc, argv, "turtle_world_tf_broadcaster"); // initialize the ROS
node

    if (argc != 2)
    {
        ROS_ERROR("Missing a parameter as the name of the turtle!");
        return -1;
    }

    turtle_name = argv [ 1 ]; // input argument as turtle name

    // Subscribe to the turtle's pose topic/pose
    ros::NodeHandle node;
    ros::Subscriber sub = node.subscribe(turtle_name + "/pose", 10, &
poseCallback);

        // loop waiting for the callback function
    ros::spin();

    return 0;
};
```

3. program flow chart



4. code analysis

First of all, first subscribe to the /pose pose topic of the little turtle. If there is a topic published, then enter the callback function. In the callback function, the tf broadcaster is first created, and then the tf data is initialized. The value of the data is the data transmitted by the subscription/pose topic. Finally, the transformation of the small turtle to the world coordinates is released through br.sendTransform. Here is the function sendTransform. There are 4 parameters, the first parameter represents the coordinate transformation of type tf::Transform(that is, the tf data initialized before) the second parameter is the timestamp, the third and fourth are the source coordinate system of the transformation and target coordinate system.

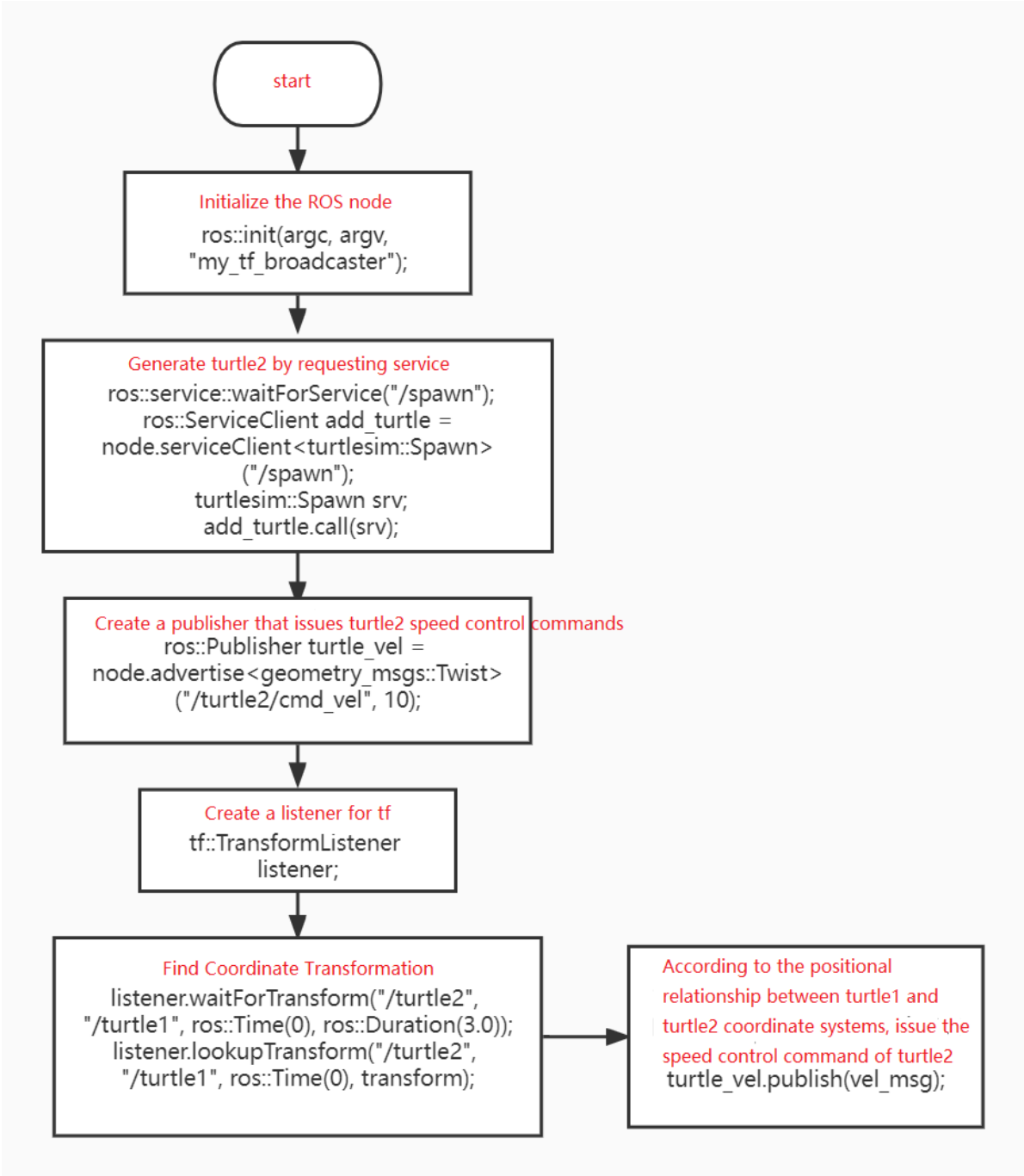
10.2.4 C++ language implements tf listener

1. In the src folder of the function package learning_tf, create a c++ file(the file suffix is .cpp) and name it turtle_tf_listener.cpp
2. copy and paste the program code below into the turtle_tf_listener.cpp file

```
/**
 * This routine monitors tf data, and calculates and issues the speed command of
turtle2
   turtle2->turtle1 = world->turtle*world->turtle2
 */

#include <ros/ros.h>
#include <tf/transform_listener.h>
#include <geometry_msgs/Twist.h>
#include <turtlesim/Spawn.h>

int  main(int  argc, char**  argv)
{

    ros::init(argc, argv, "turtle1_turtle2_listener"); // initialize the ROS
node


    ros::NodeHandle  node; // create node handle

    // Request service to generate turtle2
    ros::service::waitForService("/spawn");
    ros::ServiceClient  add_turtle  =  node.serviceClient < turtlesim::Spawn >
("/spawn");
    turtlesim::Spawn  srv;
    add_turtle.call(srv);

    // Create a publisher that issues turtle2 speed control commands
    ros::Publisher  vel  =  node.advertise < geometry_msgs::Twist >
("/turtle2/cmd_vel", 10);

    tf::TransformListener  listener; // Create a listener for tf

    ros::Rate  rate(10.0);

    while (node.ok())
    {
        // Get tf data between turtle1 and turtle2 coordinate systems
        tf::StampedTransform  transform;
```

```
        try
        {
            listener.waitForTransform("/turtle2", "/turtle1", ros::Time(0)
 ros::Duration(3.0));
            listener.lookupTransform("/turtle2", "/turtle1", ros::Time(0)
 transform);
        }
        catch (tf::TransformException  & ex)
        {
            ROS_ERROR("%s", ex.what());
            ros::Duration(1.0). sleep();
            continue;
        }

        // According to the positional relationship between turtle1 and turtle2
coordinate systems, through mathematical formulas, the angular velocity and
linear velocity are obtained, and the speed control command of turtle2 is issued

        geometry_msgs::Twist  turtle2_vel_msg;

        turtle2_vel_msg.angular.z  =  6.0  *  atan2(transform.getOrigin(). y()
                                        transform.getOrigin(). x());
        turtle2_vel_msg.linear.x  =  0.8  *  sqrt(pow(transform.getOrigin(). x()
 2)  +
                                       pow(transform.getOrigin(). y()  2));
        vel.publish(turtle2_vel_msg);

        rate.sleep();
    }
    return  0;
};
```

3. program flow chart



4. code analysis

First, generate another small turtle turtle2 through a service call, and then create a turtle2 speed control publisher; then create a listener to monitor and find the left transformation of turtle1 and tuetle2, which involves two functions waitForTransform and lookupTransform

waitForTransform(target_frame, source_frame, time, timeout): The two frames represent the target coordinate system and the source coordinate system respectively, time represents the time to wait for the transformation between the two coordinate systems, because the coordinate transformation is a blocking program, so you need to set the timeout, indicating overtime time.

lookupTransform(target_frame,source_frame,time,transform): Given the source coordinate system(source_frame) and the target coordinate system(target_frame) get the coordinate transformation(transform) of the specified time(time) between the two coordinate systems.

After lookupTransform, we get the result of the coordinate transformation, transform, and then get the values of x and y through transform.getOrigin().y() transform.getOrigin().x() and then get the angular velocity angular.z and line through mathematical operations Speed linear.x, finally released, let turtle2 do the movement.

10.2.5 Modify CMakelist.txt and compile

1. modify and modify CMakelist.txt

Modify the CMakelist.txt under the function package and add the following content

```
add_executable(turtle_tf_listener src/turtle_tf_listener.cpp)
target_link_libraries(turtle_tf_listener ${catkin_LIBRARIES})

add_executable(turtle_tf_broadcaster src/turtle_tf_broadcaster.cpp)
target_link_libraries(turtle_tf_broadcaster ${catkin_LIBRARIES})
```

2. compile

```
cd ~/catkin_ws
catkin_make
source devel/setup.bash #Environment      variables need to be configured,
otherwise the system cannot find the running program
```

10.2.6 Demonstration of startup and running effects

1. start

```
roscore
rosrun  turtlesim  turtlesim_node
rosrun  learning_tf  turtle_tf_broadcaster  __name := turtle1_tf_broadcaster
/turtle1
rosrun  learning_tf  turtle_tf_broadcaster  __name := turtle2_tf_broadcaster
/turtle2
rosrun  learning_tf  turtle_tf_listener
rosrun  turtlesim turtle_teleop_key  #Open   the turtle keyboard control program
to control the turtle movement
```

2. effect display

3. program description

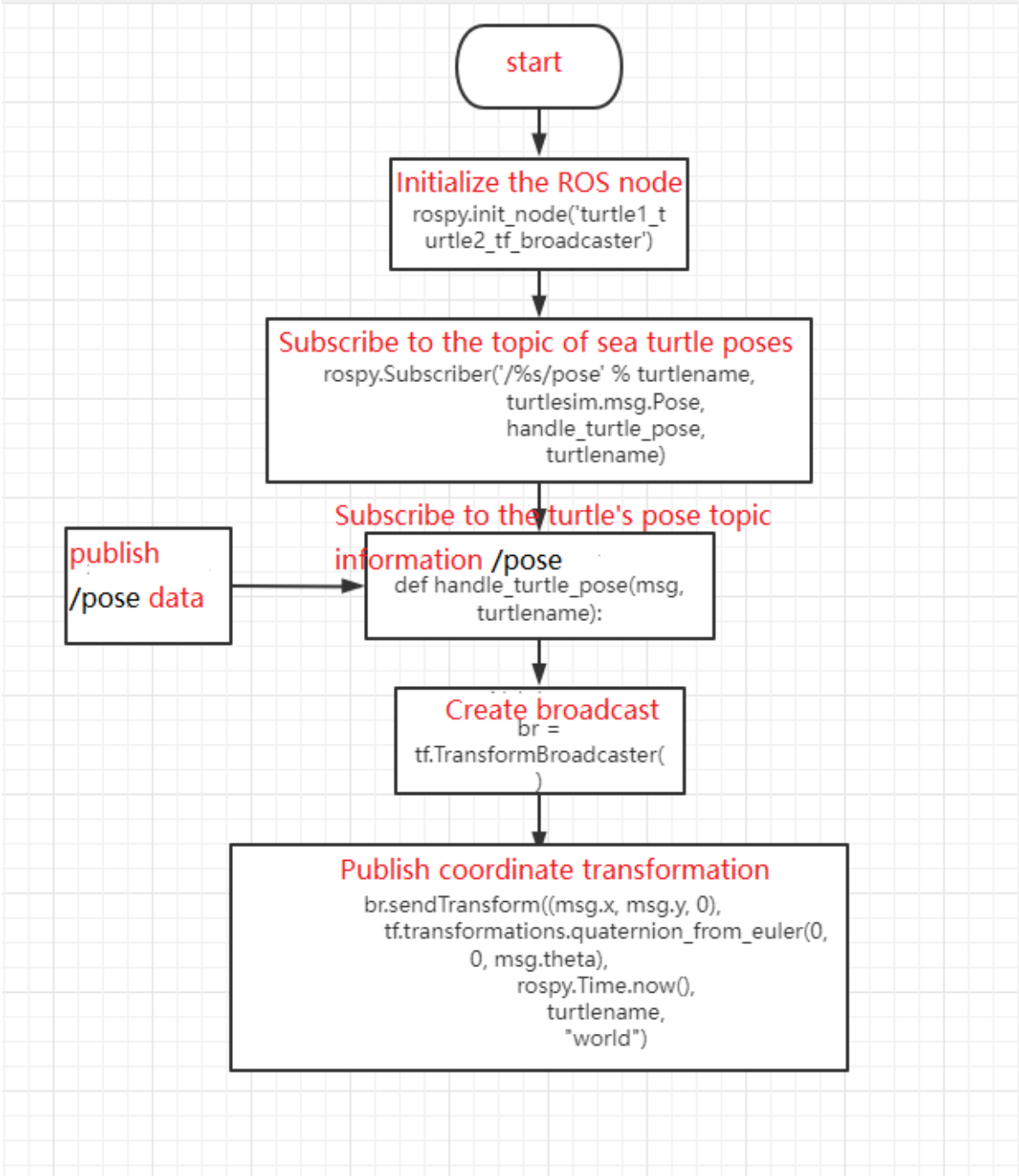
After starting roscore, open the small turtle node, and a small turtle will appear in the terminal; then we publish two tf transformations, turtle1->world, turtle2->world, because to know the change between turtle2 and turtle1, then You need to know the transformation between them and the world; then, open the tf listener program, you will find that the terminal has generated another small turtle, turtle2, and turtle2 will move to turtle1; then, we open the keyboard control, by pressing the arrow keys to control the movement of turtle1, and then turtle2 will chase turtle1 to move.

10.2.7 Python language implements tf broadcaster

1. In the function package learning_tf, create a folder script, switch to this directory, and create a new .py file named turtle_tf_broadcaster.py
2. copy and paste the program code below into the turtle_tf_broadcaster.py file

```
# !/usr/bin/env python
# -*- coding: utf-8 -*-

import  roslib
roslib.load_manifest('learning_tf')
import  rospy

import  tf
import  turtlesim.msg

 def handle_turtle_pose(msg, turtlename):
    br = tf.TransformBroadcaster() #define a tf broadcast
    # Broadcast tf transformation between world and input named turtle
    br.sendTransform((msg.x, msg.y, 0)
                     tf.transformations.quaternion_from_euler(0, 0, msg.theta)
                     rospy.Time.now()
                     turtlename,
                     "world")

if  __name__  ==  '__main__' :

    rospy.init_node('turtle1_turtle2_tf_broadcaster') ros node

    turtlename = rospy.get_param('~turtle') the turtle's name from the parameter
server
    #Subscribe/pose topic data, which is turtle's pose information
    rospy.Subscriber('/%s/pose'  %  turtlename,
                     turtlesim.msg.Pose,
                     handle_turtle_pose,
                     turtlename)
    rospy.spin()
```

3. program flow chart



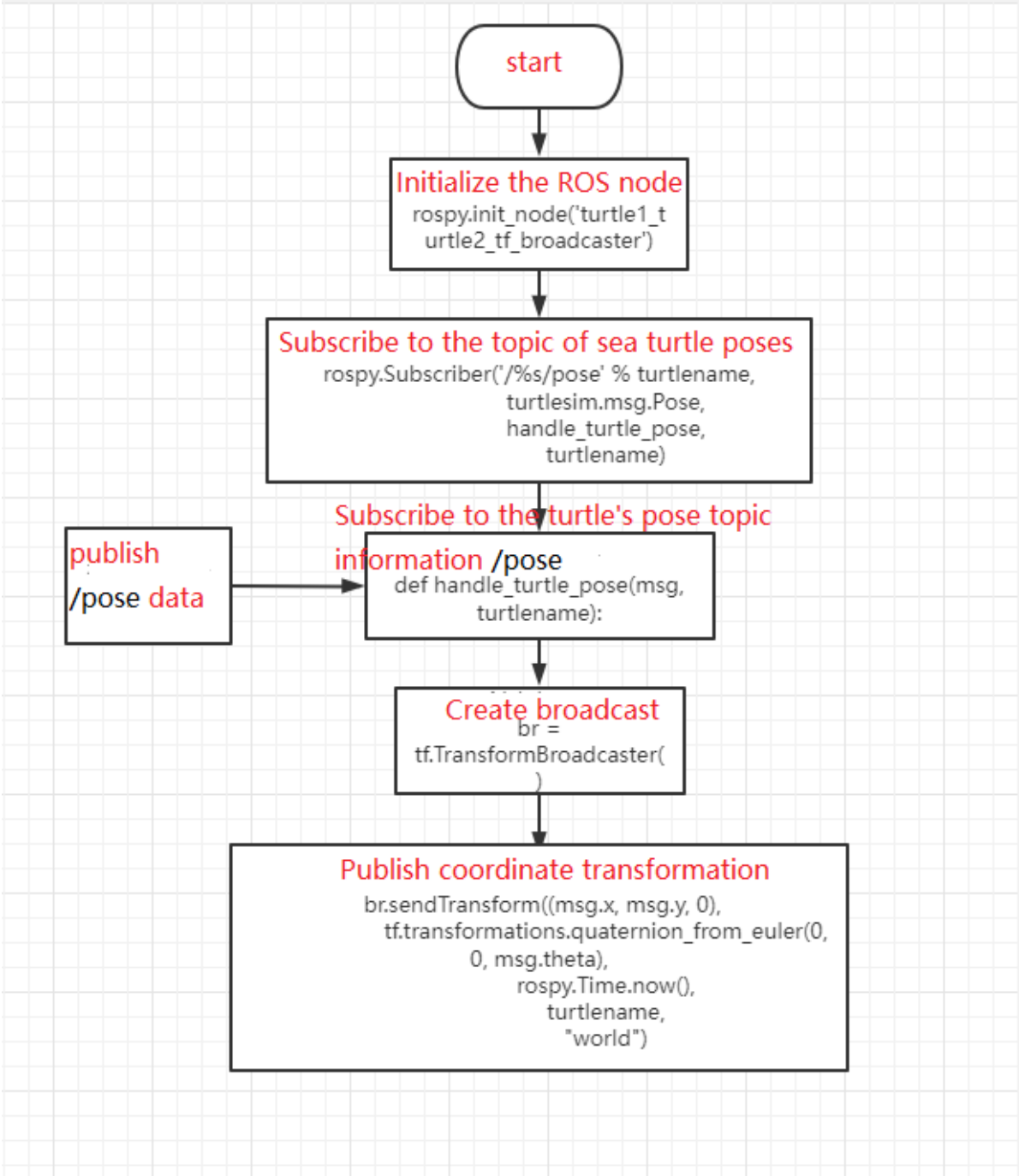
10.2.8 Python language implements tf listener

1. In the script folder of the function package learning_tf, create a python file(the file suffix is .py) and name it turtle_tf_listener.py
2. copy and paste the program code below into the turtle_tf_listener.py file

```
# !/usr/bin/env python
# -*- coding: utf-8 -*-

import  rospy
import  math
import  tf
import  geometry_msgs.msg
import  turtlesim.srv

if  __name__  ==  '__main__' :
    rospy.init_node ' #Initialize(turtle_tf_listener') ros node
```

```
    listener = tf.TransformListener() #Initialize a listener

    rospy.wait_for_service('spawn')
    #Call the service to spawn another turtle turtle2
    spawner  =  rospy.ServiceProxy('spawn', turtlesim.srv.Spawn)
    spawner(8, 6, 0, 'turtle2')
    #declare a publisher to publish the speed of turtle2
    turtle_vel  =  rospy.Publisher('turtle2/cmd_vel', geometry_msgs.msg.Twist,
queue_size = 1)

    rate  =  rospy.Rate(10.0)
    while  not  rospy.is_shutdown():
        try :
            #Find tf changes between turtle2 and turtle1
           (trans, rot) =  listener.lookupTransform('/turtle2', '/turtle1',
rospy.Time(0))
        except (tf.LookupException, tf.ConnectivityException,
tf.ExtrapolationException):
            continue
        #Through mathematical calculation, calculate the linear velocity and
angular velocity, and then publish it
        angular  =  6.0  *  math.atan2(trans [ 1 ], trans [ 0 ])
        linear  =  0.8  *  math.sqrt(trans [ 0 ]  **  2  +  trans [ 1 ]  **  2)
        cmd  =  geometry_msgs.msg.Twist()
        cmd.linear.x  =  linear
        cmd.angular.z  =  angular
        turtle_vel.publish(cmd)
        rate.sleep()
```

3. program flow chart



10.2.9 Display of startup and running effects

1. write a launch file

In the function package directory, create a new folder launch, switch to launch, create a new launch file, name it start_tf_demo_py.launch, and copy the following content into it,

```
< launch >

    <!-- Turtle Node-->
    < node  pkg = "turtlesim"  type = "turtlesim_node"  name = "sim" />
    <!--Broadcast turtle1->world-->
    < node  name = "turtle1_tf_broadcaster"  pkg = "learning_tf"  type =
"turtle_tf_broadcaster.py"  respawn = "false"  output = "screen"  >
      < param  name = "turtle"  type = "string"  value = "turtle1"  />
    </ node >
    <!--broadcast turtle2->world-->
```

```
    < node  name = "turtle2_tf_broadcaster"  pkg = "learning_tf"  type =
"turtle_tf_broadcaster.py"  respawn = "false"  output = "screen"  >
      < param  name = "turtle"  type = "string"  value = "turtle2"  />
    </ node >
    <!--Monitor-->
    < node  pkg = "learning_tf"  type = "turtle_tf_listener.py"  name =
"listener"  />
    <!--Turtle keyboard control node-->
    < node  pkg = "turtlesim"  type = "turtle_teleop_key"  name = "teleop"
output = "screen" />
</ launch >
```

2. start

```
roslaunch learning_tf start_tf_demo_py.launch
```

After the program runs, click the mouse on the window to run launch, press the arrow keys, turtle2 will move with turtle1.

3. the operation result is as follows