EMC 2013
C++ and ROS

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Where innovation starts

September 11, 2013

C++

- We will use C++ as programming language
- One of the two core ROS languages
  - Packages roscpp and roslib
- C++ is object-oriented C
  - “C with Classes”
  - Encapsulate data and functionality within objects
- Many tutorials available, *e.g.*:
  - http://www.cplusplus.com/doc/tutorial
  - MIT’s Introduction to C++

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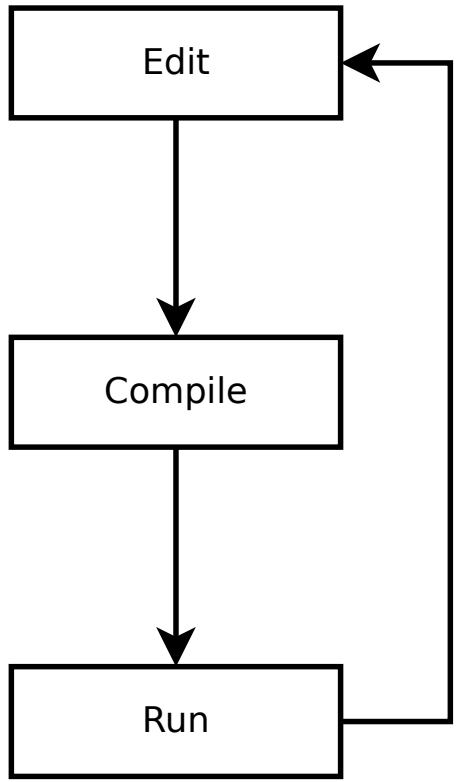

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- main() must return an error code
  - 0 means no errors

Expressions and Variables

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- Outcome: 3^2 = 9

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if (CONDITION) {
    // only happens if CONDITION is true
} else {
    // only happens if CONDITION is false
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  - Step-by-step instructions
  - re-use of code
  - Advanced control flow

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  - Cumbersome to pass around
  - Not very clear we're talking about a point (semantics)

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...? determineNearestPoint() {
    // Some nice code
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- Now we can use Point as data type:

```
Point determineNearestPoint() {
    // Some nice code
    Point p;     // declare variable p of type Point
    p.x = ...    // set x member of p
    p.y = ...    // set y member of p
    return p;
}
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```
void main() {
    Point p = determineNearestPoint();
    std::cout << "x = " << p.x << std::endl;
    std::cout << "y = " << p.y << std::endl;
}
```

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```
// ...
Line l;
l.p1.x = 3.0;
l.p1.y = 4.5;
l.p2.x = 6.0;
l.p2.y = 10.3;

Point q = l.p2;

std::cout << q.x << std::endl;
// ...
```

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int main() {
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    v.push_back(10);     /* Add '10' to the back of the vector */
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    for(unsigned int i = 0; i < v.size(); i++) {
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ROS Concepts

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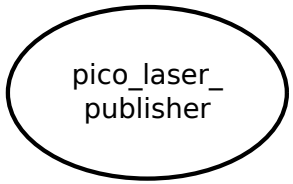
- **Node**: process that performs computation
- **Master**: provides name registration and lookup
- **Messages**: nodes communicate with each other by passing messages
- **Topics**: named buses over which nodes exchange messages

ROS Communication Example



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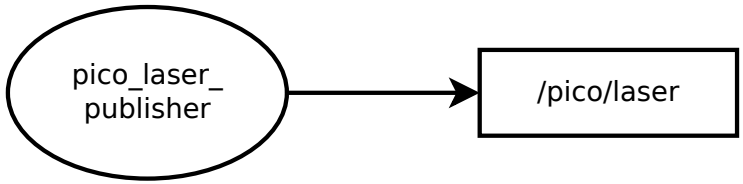

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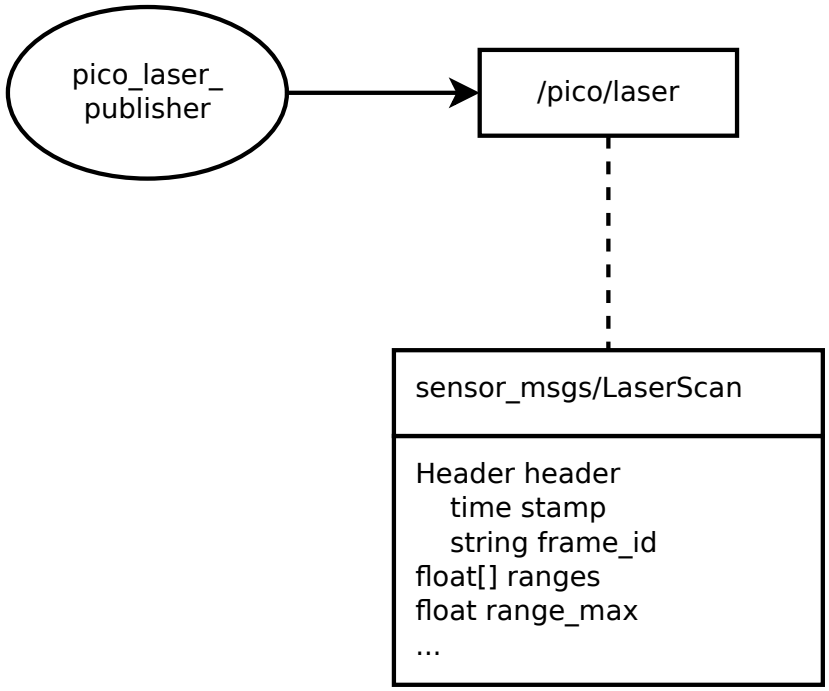

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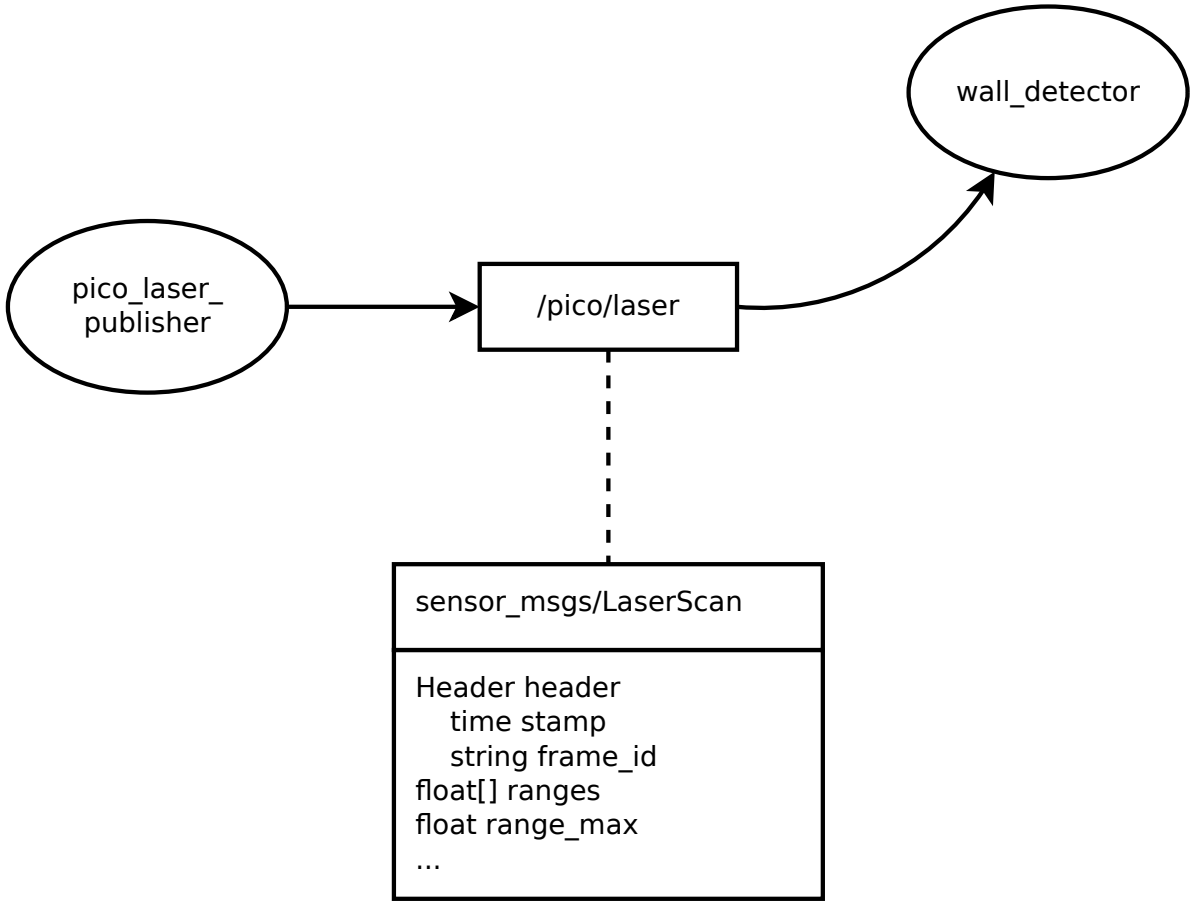

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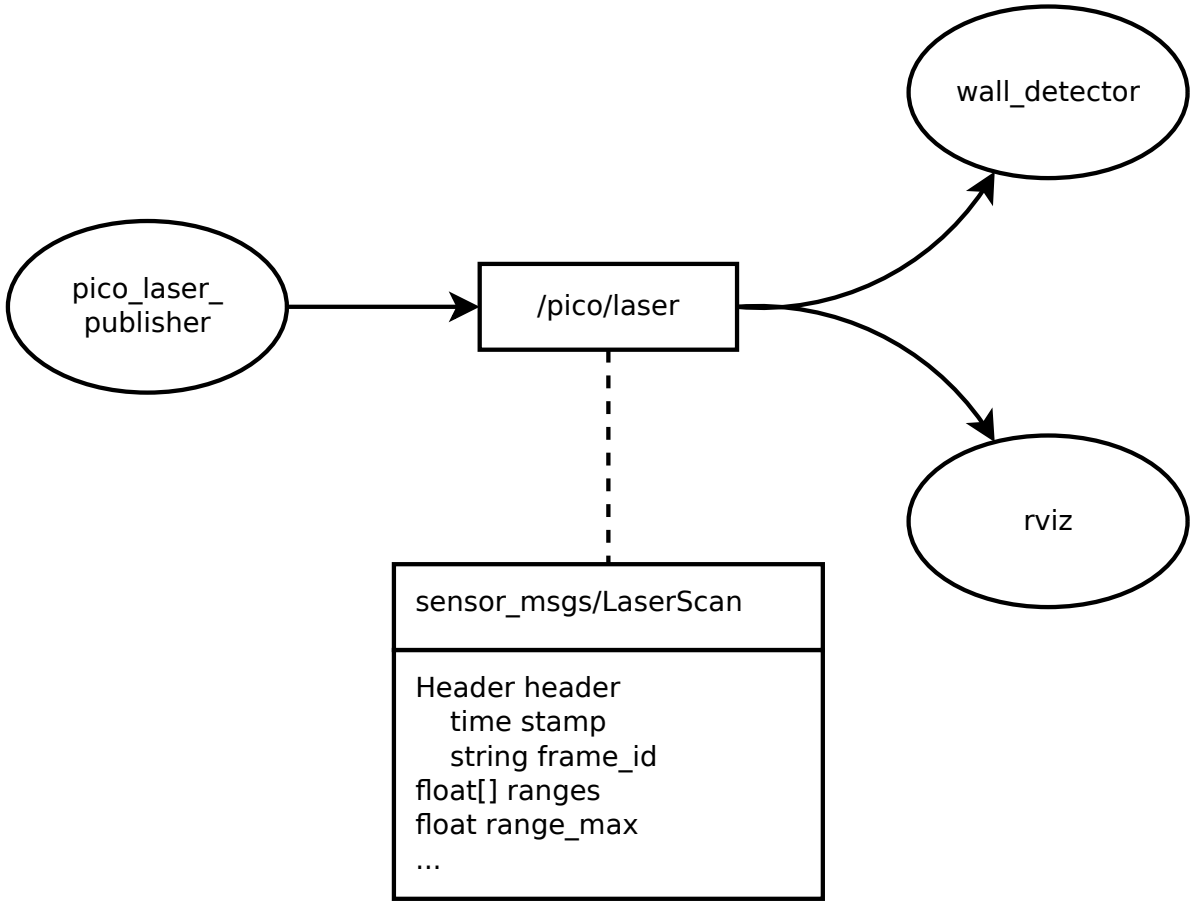
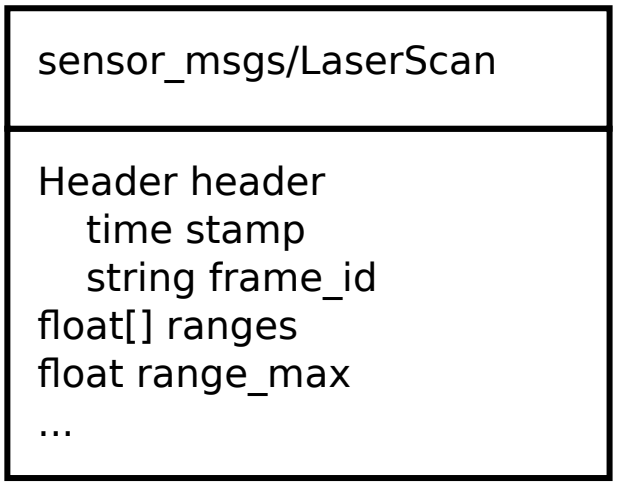


ROS Message Types



ROS Message Types

sensor_msgs/LaserScan

Header header
  time stamp
  string frame_id
float[] ranges
float range_max
...

Is in fact:

```
struct LaserScan {
    Header header;
    float range_max;
    std::vector<float> ranges;
}

struct Header {
    std::string frame_id;
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}

struct Time {
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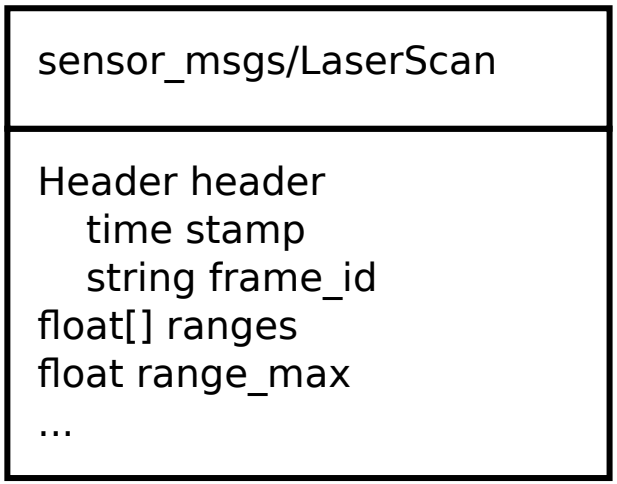

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ros::NodeHandle n;
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ros::spin();
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```
ros::spin();
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- This function is called every time the node receives a message:

```
void callbackFunction(sensor_msgs::LaserScan scan) {
    // do something
    std::cout << scan.header.stamp << std::endl;
}
```

ROS C++ Example


```
#include <ros/ros.h>                    // include ROS
#include <sensor_msgs/LaserScan.h>      // include LaserScan
                                        // message type

void callback(sensor_msgs::LaserScan scan) {
    // do something
    std::cout << scan.header.stamp << std::endl;
}

int main(int argc, char** argv) {  // ignore argc and argv
    ros::init(argc, char** argv, "example");  // register node
                                              // to master
    ros::NodeHandle n;
    ros::Subscriber sub = n.subscribe("/pico/laser",
                                      1, callback);

    ros::spin();     // Keep receiving messages
    return 0;
}
```

ROS C++ Example

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- The callback function gets the ROS message as input argument:

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void callback(sensor_msgs::LaserScan scan) {
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- Remember:

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void callback(sensor_msgs::LaserScan scan) {

    for(unsigned int i = 0; i < scan.ranges.size(); i++) {
        if (scan.ranges[i] < 0.3) {
            std::cout << "HELP!" << std::end;
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- Try to get this example running
  - Together with the jazz_example package, it's a good start for your project

Recap

- C++ Data Types
- Structs
- C++ Standard Library
  - std::vector
  - std::string
  - std::map
- ROS Message as C++ struct
- ROS C++ Subscriber Example