intel Software

Node.js* Client & Web Bridge Ready for ROS* 2.0

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Agenda

- Who We Are
- Why Use Node.js & Web in Robotics
- Thinking in “ROS 2.0 + Web”
- What We Have Done for “ROS 2.0 + Web”
- The Design of `rclnodejs` & `ros2-web-bridge`
- List of Features
- Performance Comparison: Node.js, C++ & Python
- Video Demo
- Intel ❤ Robot
- Contacts & Resource Links

Who we are

- Intel Open Source Technology Center (OTC) is home to the core of Intel's open source development efforts.
- We’re from OTC Web Team; we do web technology in client, edge, cloud, IoT, W3C standard, Robotics & etc., to keep web open, secure, rich-featured and performant.

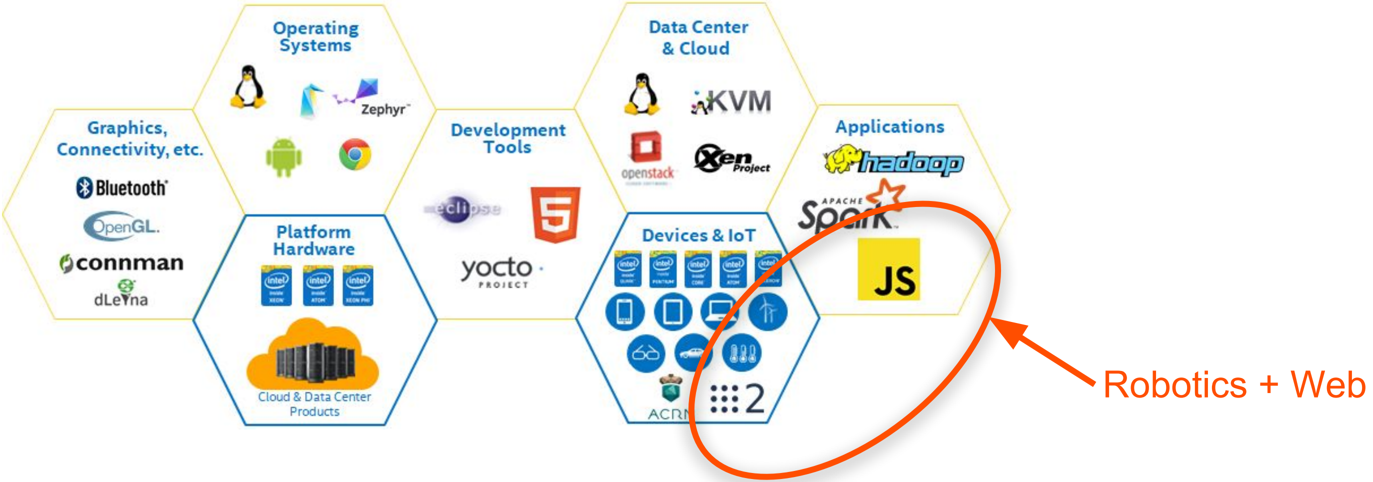
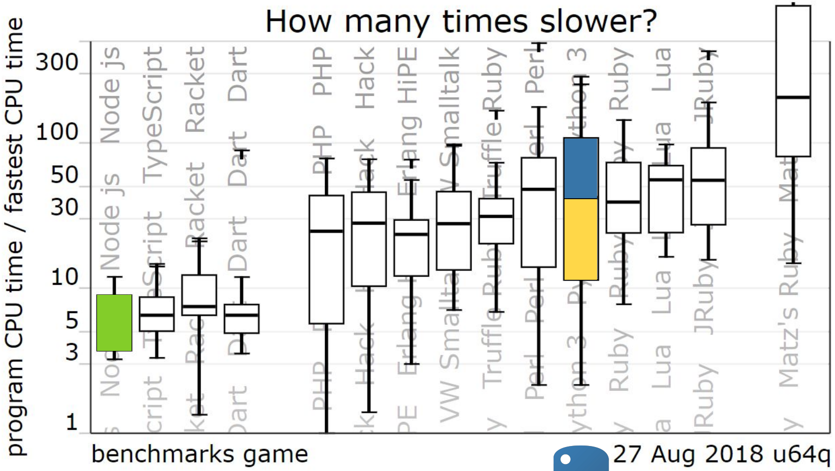


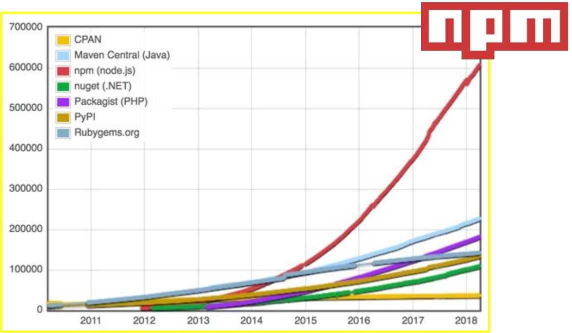
Figure: What Intel OTC does

Why Use Node.js & Web in Robotics

- High-performance (JIT), faster than Python
  - Do more on same robot control board
- Strong ecosystem/community
  - The most popular language on Github*
  - Largest package system in the world
- Easy deployment & debugging
- Naturally for web interface



Benchmark Link

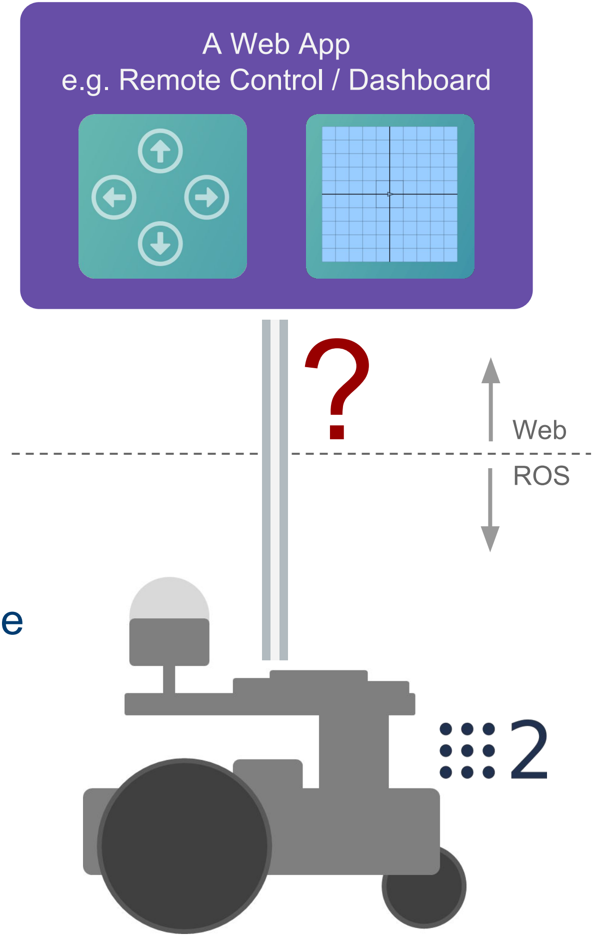


NPM* is the largest package system in the world (>600k)

Thinking in “ROS 2.0 + Web”

- Web is best choice for remote control & dashboard
  - e.g. status inspection, supervised motion control, posture visualization, video streaming & etc.
  - Available anywhere, easy to embed, tons of resources & etc.
- How to bring ROS into the web?
  - RWT* can bring ROS 1.0 APIs into a web browser
  - Nothing for ROS 2.0 back in Mid’17, so we did one
  - But is it the best way to expose all ROS API in web? e.g. service
- Another approach: Node.js web server, is flexible & effective
  - ROS API exposed in server; only business logic in web - RaaS
  - Don’t be scared, web server is just a few lines in Node.js
  - Same skill set for both frontend & backend, easy debugging

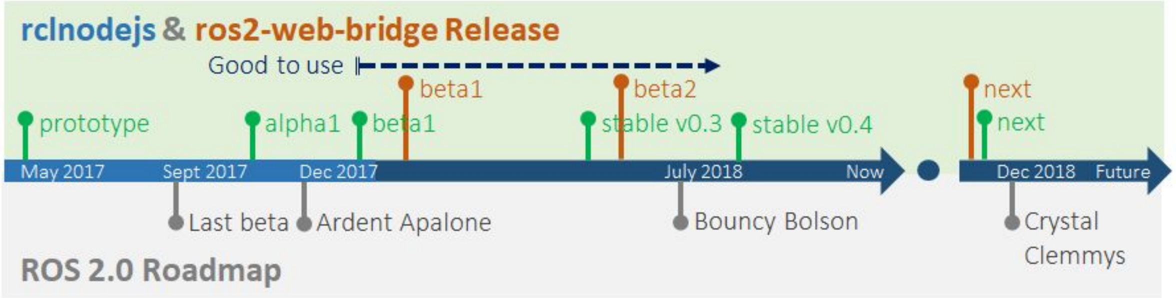
ROS + Web = Better Robot... **But How**?

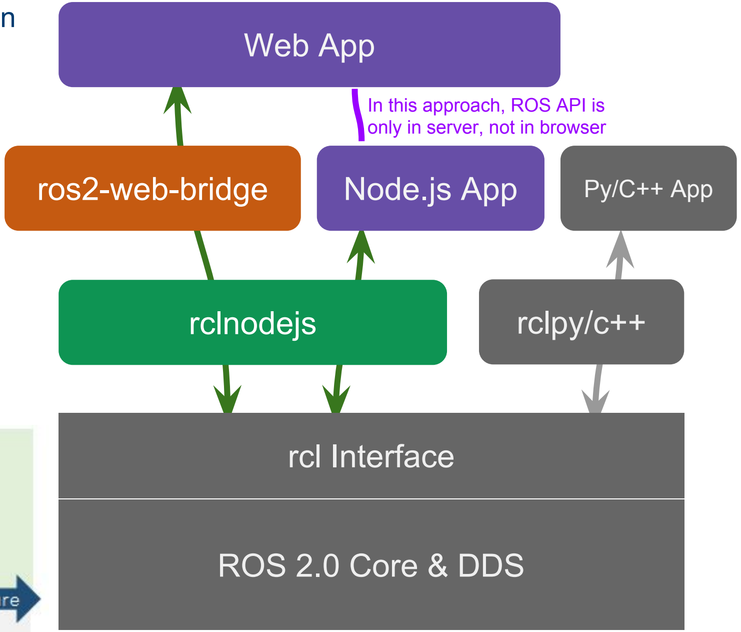


What We Have Done for “ROS 2.0 + Web”

2 packages. Both hosted in GitHub RWT thanks to Jihoon

- rclnodejs (github repo)
  It’s a Node.js client of ROS 2.0. It provides fast, easy & powerful JavaScript API of ROS 2.0
- ros2-web-bridge (github repo)
  Make it possible to call ROS 2.0 API in a web page. It’s compatible with `roslibjs*`





We’ve done the green and orange, and made the purples possible

The Design of rclnodejs (the ROS 2.0 Node.js API)

Principles and philosophy

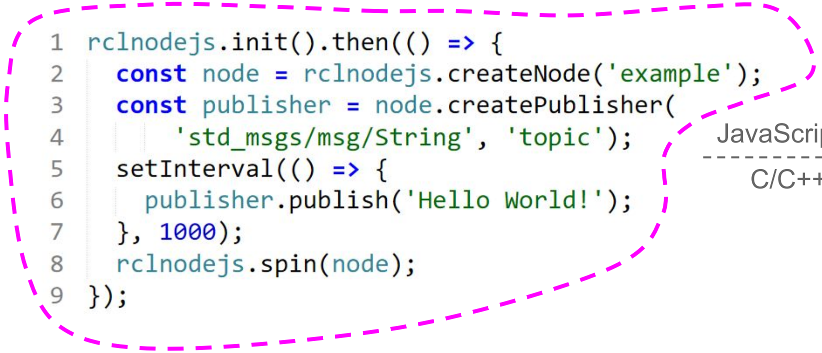
- A thin wrapper to rcl -- same mindset, fast & easier to adapt change
- Event-driven, non-blocking (promise/event) -- advantage of async IO, very simple & efficient
- Able to use new ROS message without recompiling -- everything's on the fly
- User-friendly debugging -- easy to figure out what's wrong
- Embrace ES6* -- most recent cool features of JavaScript language

Legend

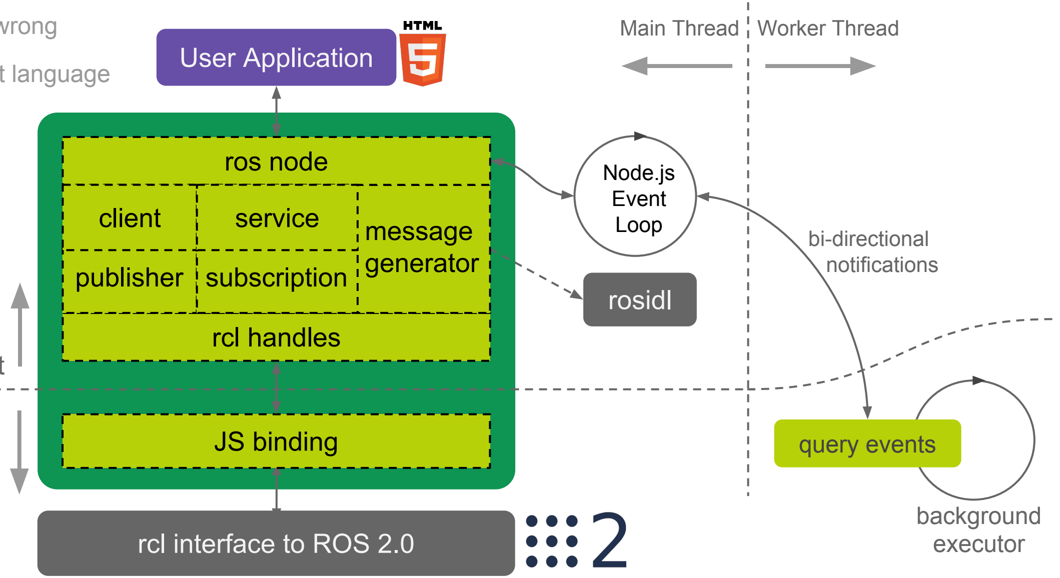
⬛ ROS 2

🟩 rclnodejs

As a result, user can write ROS app easily & effectively.



```
rclnodejs.init().then(() => {
  const node = rclnodejs.createNode('example');
  const publisher = node.createPublisher(
      'std_msgs/msg/String', 'topic');
  setInterval(() => {
    publisher.publish('Hello World!');
  }, 1000);
  rclnodejs.spin(node);
});
```

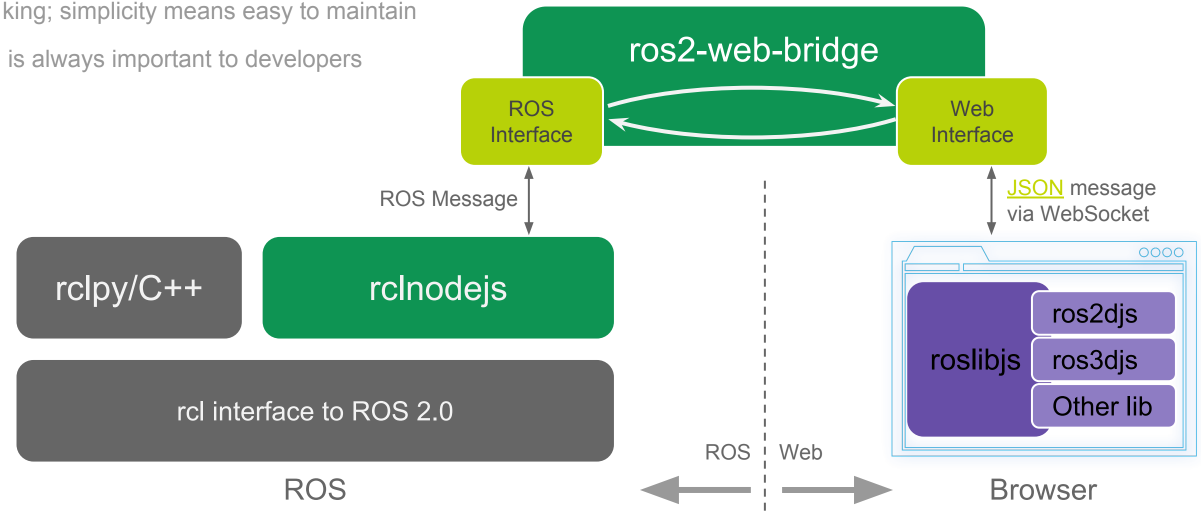


ros2-web-bridge Design (Bring ROS in Browser)

Principles and philosophy

- Meet user’s expectation, be compatible with ROS 1.0 bridge (rosbridge_suite)
    - Protocol compatible with the existing protocol of JSON messages (ROS 1.0)
    - Existing Web Tools can be directly used, e.g. 2D/3D visualization
- Keep it fast and simple -- speed is the king; simplicity means easy to maintain
- User-friendly debugging -- debugging is always important to developers

As a result, RWT ROS 1.0 components are transparently compatible with ROS 2.0



List of Features

rclnodejs

- ROS node -- create/destroy ROS nodes
- Publisher/Subscription -- send/receive ROS message
- Client/Service -- write client/service of ROS request
- QoS support -- configure network QoS policy
- Timer -- periodical notification/callback
- Time/Time Source -- different type of clocks
- Actionlib w/ RethinkRobotics* -- preemptable task management
- Message Gen (idl) -- dynamic generation on the fly
- Validation utilities -- check if it meets rules
- Logging -- easier debugging

ros2-web-bridge

- Publisher/Subscription -- send/receive msg in browser
- Client/Service -- write client/service of ROS request in browser
- Status message support -- figure out what's going on

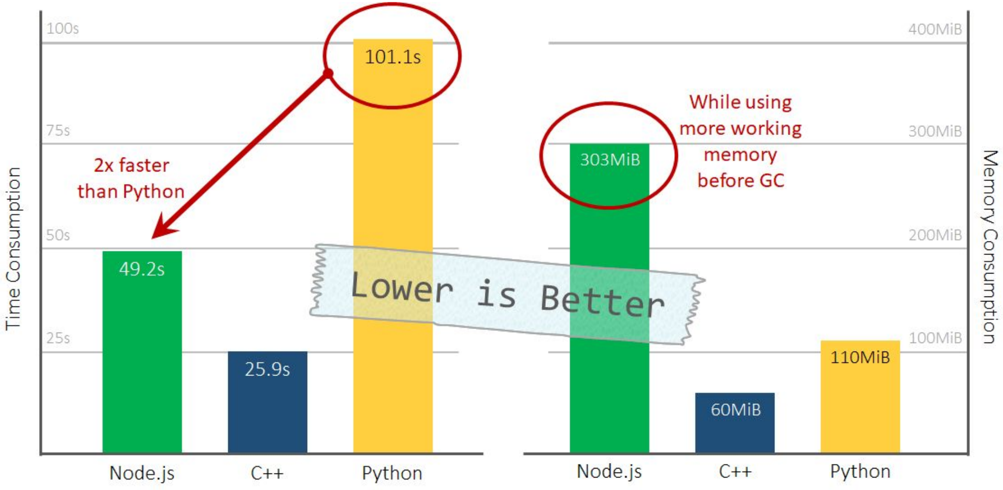
Performance Comparison: Node.js, C++ & Python

Test case: to publish a ROS message, measure the time and memory consumption

- When runcount increases, the trends tend to stabilize
- Same trends were also observed on other types of tests
- Both trends match the common sense

Conclusion: Node.js is times faster than Python, but consumes more memory in runtime.

* Don’t forget to run Python with -O



i5-4250 Haswell/4G RAM/Ubuntu 16.04

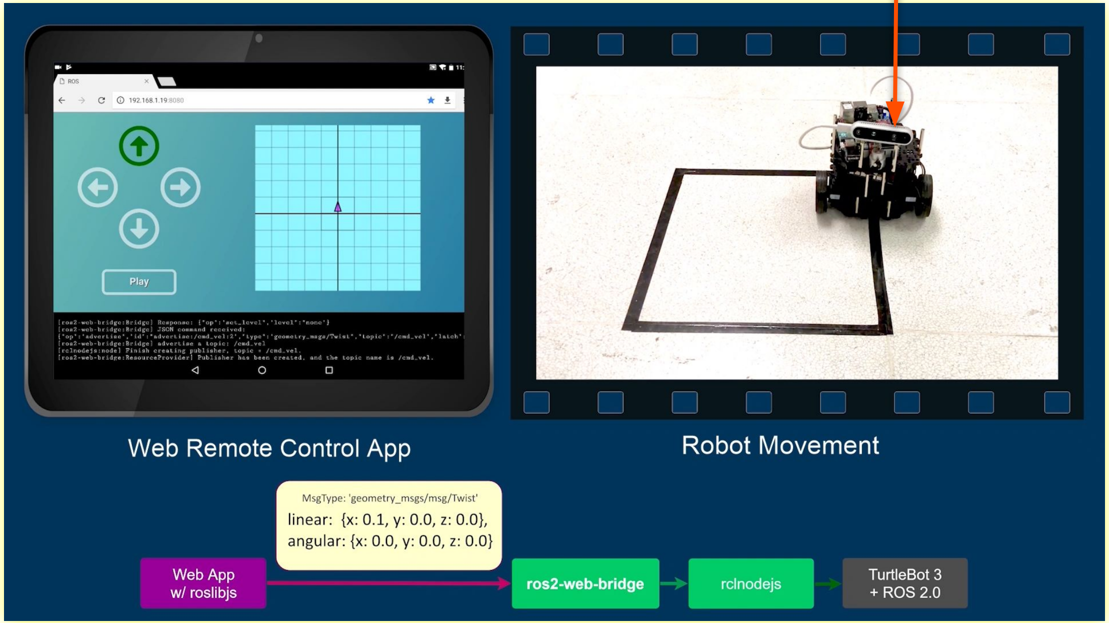
Video Demo (URL)

- Turtlebot* 3 + ROS 2.0
  - Intel® RealSense™ camera
  - Up Board* with Intel Atom®
- A web app as remote control
  - roslibjs + ros2-web-bridge
  - Easy to build powerful UI
  - Running everywhere
- Source code: github
- ROS 2.0 Message Type:
  `geometry_msgs/msg/Twist`

Intel® RealSense™ Depth Camera D415
A compact camera designed to bring depth sensing to more devices:

- Depth FOV: 69.4x42.5x77
- Active IR stereo rolling shutter
- Up to 90 FPS RGB
- Range 0.3-10M+
- Includes ROS 2.0 Wrapper

For more info, please visit https://realsense.intel.com



```
[ros2-web-bridge:Bridge] Response: {"op":'set_level','level':"none'}
[ros2-web-bridge:Bridge] JSON command received:
{"op":'advertise','id':"advertise:/cmd_vel:2','type':'geometry_msgs/Twist","topic":"/cmd_vel','latch':
[ros2-web-bridge:Bridge] advertise a topic: /cmd_vel
[rclnodejs:node] Finish creating publisher, topic = /cmd_vel.
[ros2-web-bridge:ResourceProvider] Publisher has been created, and the topic name is /cmd_vel.
```

Web Remote Control App

Robot Movement

MsgType: 'geometry_msgs/msg/Twist'
linear: {x: 0.1, y: 0.0, z: 0.0},
angular: {x: 0.0, y: 0.0, z: 0.0}

Web App w/ roslibjs → ros2-web-bridge → rclnodejs → TurtleBot 3 + ROS 2.0

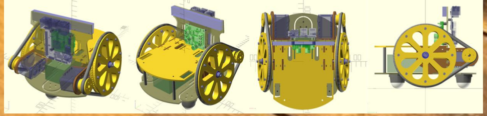
Intel ❤ Robot (Intel's Contribution to Robotics)

- AI/ML/CV Software for ROS 2.0
  - ○ Object detection/segmentation/tracking/velocity estimation & etc.
  - ○ A ROS service to support Intel® OpenVINO™ - the Open Visual Inference & Neural Network Optimization Toolkit.
  - ○ A bridge to connect ROS 2.0 & OpenCV*.
- Movidius^{TM} NCS: dedicated AI hardware by Intel®
  - ○ A ROS service/publisher for object classification and detection
  - ○ Support multiple CNN models of Caffe* and Tensorflow*
- RealSense^{TM} depth camera: perceive the world in 3D
  - ○ Up to 10 meter range, up to 90 fps
  - ○ Realtime 1080p RGB video + 720p depth video
  - ○ Integrated publisher to ROS 2.0, visualized by ROS rviz*
- Better Manipulation with Better ROS MoveIt*
  - ○ Hand-eye calibration
  - ○ Grasp planner (with accelerated grasp detection)
- Redesign of ROS 2.0 Navigation

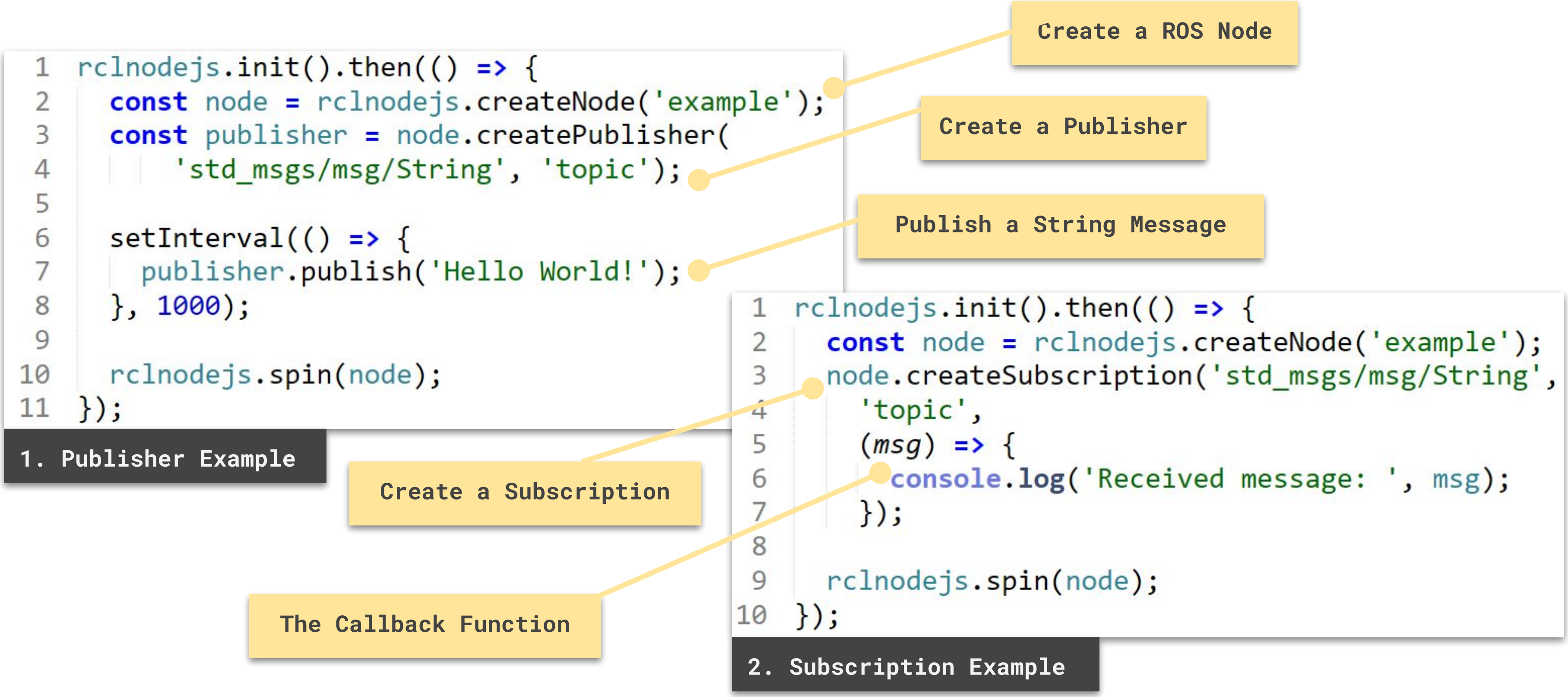
Intel® SAWR robot, both software & hardware are opensource. Simple, inexpensive, built on desktop Ubuntu + ROS, for teaching & learning.

- Opensource chassis or Turtlebot 3
- SLAM capability
- Intel$^{(R)}$ RealSense^{TM} depth camera

SAWR = Simple Autonomous Wheeled Robot



Code Example: Publisher/Subscription



```
rclnodejs.init().then(() => {
  const node = rclnodejs.createNode('example');
  const publisher = node.createPublisher(
      'std_msgs/msg/String', 'topic');

  setInterval(() => {
    publisher.publish('Hello World!');
  }, 1000);

  rclnodejs.spin(node);
});
```

1. Publisher Example

```
rclnodejs.init().then(() => {
  const node = rclnodejs.createNode('example');
  node.createSubscription('std_msgs/msg/String',
    'topic',
    (msg) => {
      console.log('Received message: ', msg);
    });

  rclnodejs.spin(node);
});
```

2. Subscription Example

Create a ROS Node

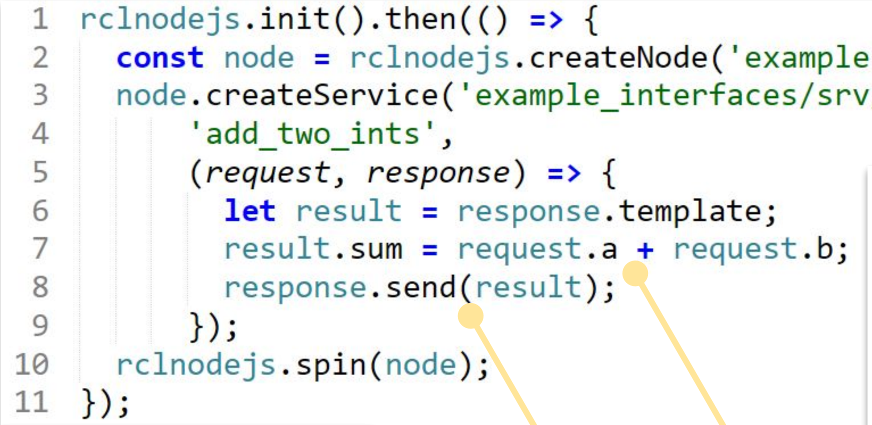
Create a Publisher

Publish a String Message

Create a Subscription

The Callback Function

Code Example: Service/Client



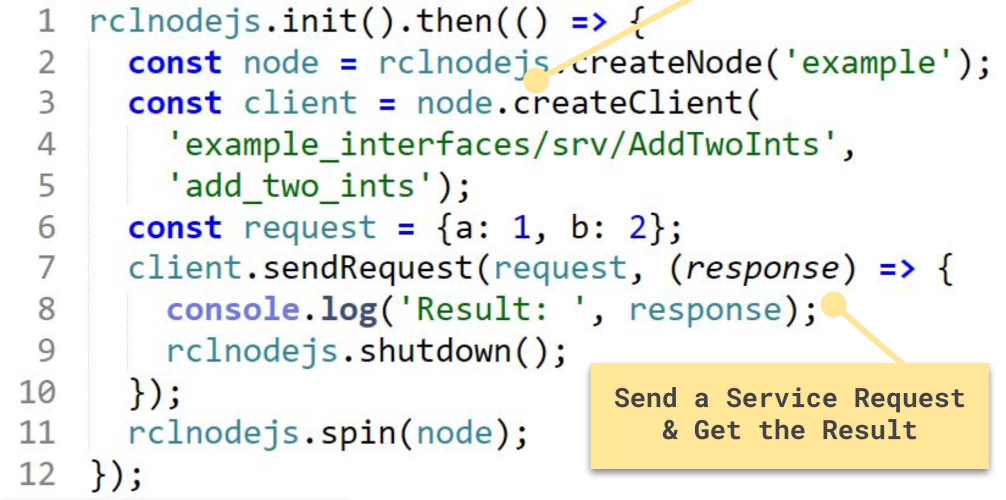
```
rclnodejs.init().then(() => {
  const node = rclnodejs.createNode('example');
  node.createService('example_interfaces/srv/AddTwoInts',
      'add_two_ints',
      (request, response) => {
        let result = response.template;
        result.sum = request.a + request.b;
        response.send(result);
      });
  rclnodejs.spin(node);
});
```

3. Service Example

Create a Service

Get Requested Data

Send Result to Client



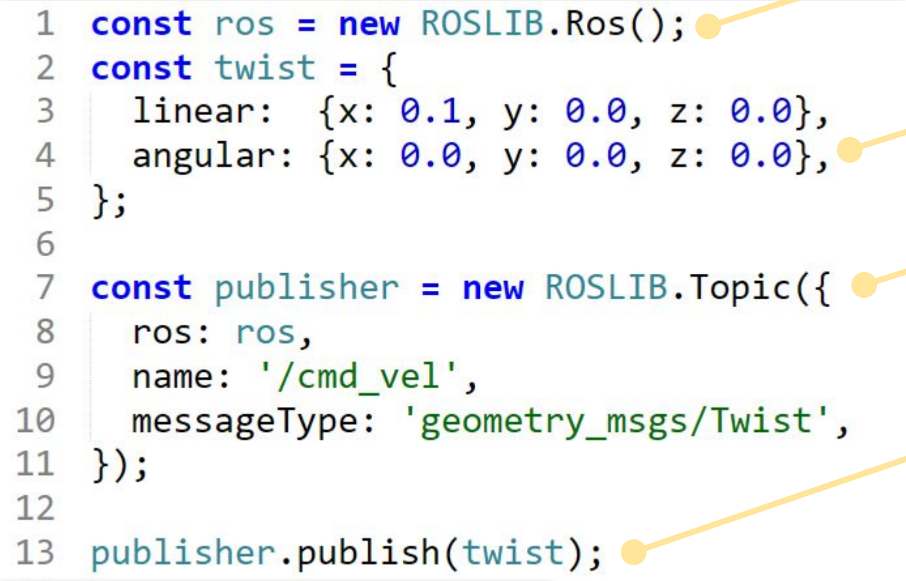
```
rclnodejs.init().then(() => {
  const node = rclnodejs.createNode('example');
  const client = node.createClient(
    'example_interfaces/srv/AddTwoInts',
    'add_two_ints');
  const request = {a: 1, b: 2};
  client.sendRequest(request, (response) => {
    console.log('Result: ', response);
    rclnodejs.shutdown();
  });
  rclnodejs.spin(node);
});
```

4. Client Example

Create a Client

Send a Service Request
& Get the Result

Code Example: ROS in Web Browser



```javascript
const ros = new ROSLIB.Ros();
const twist = {
  linear:  {x: 0.1, y: 0.0, z: 0.0},
  angular: {x: 0.0, y: 0.0, z: 0.0},
};

const publisher = new ROSLIB.Topic({
  ros: ros,
  name: '/cmd_vel',
  messageType: 'geometry_msgs/Twist',
});

publisher.publish(twist);
```

5. ROS in Web Browser Example

A New roslibjs Instance

Define a Twist Message

Create a Publisher in Browser

Publish the Twist Message.

This message will be sent to ROS 2.0 via ros2-web-bridge.

Contacts & Resource Links

Contacts: Minggang Wang

email: minggang.wang@intel.com

Useful links:

- rclnodejs: github, npm
- ros2-web-bridge: github, npm
- Intel ROS 2.0 projects: wiki (also 1.0)
- Robot Web Tools: libs/widgets/systems/etc.
- rosnodejs by RethinkRobotics* for ROS 1.0

The developer/QA team

- Minggang Wang
- Kenny Yuan
- Wanming Lin
- Yi Han
- Zhong Qiu

Questions...

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