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

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](https://github.com/rclnodejs))
  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](https://github.com/ros2-web-bridge))
  Make it possible to call ROS 2.0 API in a web page. It's compatible with [roslibjs](https)*

In this approach, ROS API is only in server, not in browser.

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**rclnodejs & ros2-web-bridge Release**

- **Good to use**
  - prototype
  - alpha1
  - beta1
  - beta2
  - stable v0.3
  - stable v0.4

- **Next**
  - next

**ROS 2.0 Roadmap**

- Last beta: Ardent Apalone
- Bouncy Boisun
- Crystal Clemmys

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

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

```javascript
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
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`

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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
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™ NCS**: dedicated AI hardware by Intel®
  - A ROS service/publisher for object classification and detection
  - Support multiple CNN models of Caffe* and Tensorflow*

- **RealSense™ 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**

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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™ depth camera

SAWR = Simple Autonomous Wheeled Robot
Code Example: Publisher/Subscription

1. Publisher Example

```javascript
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);
});
```

Create a ROS Node

Create a Publisher

Publish a String Message

2. Subscription Example

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

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

Create a Subscription

The Callback Function
Code Example: Service/Client

3. Service Example

```javascript
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);
});
```

Create a Service

Get Requested Data

Send Result to Client

4. Client Example

```javascript
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);
});
```

Create a Client

Send a Service Request & Get the Result
Code Example: ROS in Web Browser

```javascript
1. const ros = new ROSLIB.Ros();
2. const twist = {
3.   linear: {x: 0.1, y: 0.0, z: 0.0},
4.   angular: {x: 0.0, y: 0.0, z: 0.0},
5.   };
6. const publisher = new ROSLIB.Topic({
7.   ros: ros,
8.   name: '/cmd_vel',
9.   messageType: 'geometry_msgs/Twist',
10. })
11. publisher.publish(twist);
```

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`. 

5. ROS in Web Browser Example
Contacts & Resource Links

Contacts: Minggang Wang

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Useful links:

- rclnodejs: [github](https://github.com), [npm](https://www.npmjs.com)
- ros2-web-bridge: [github](https://github.com), [npm](https://www.npmjs.com)
- Intel ROS 2.0 projects: [wiki](https://wiki.ros.org) (also 1.0)
- Robot Web Tools: [libs/widgets/systems/etc.](https://github.com)
- 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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