REACTIVE WEB INTERFACES WITH POLYMER AND ROS

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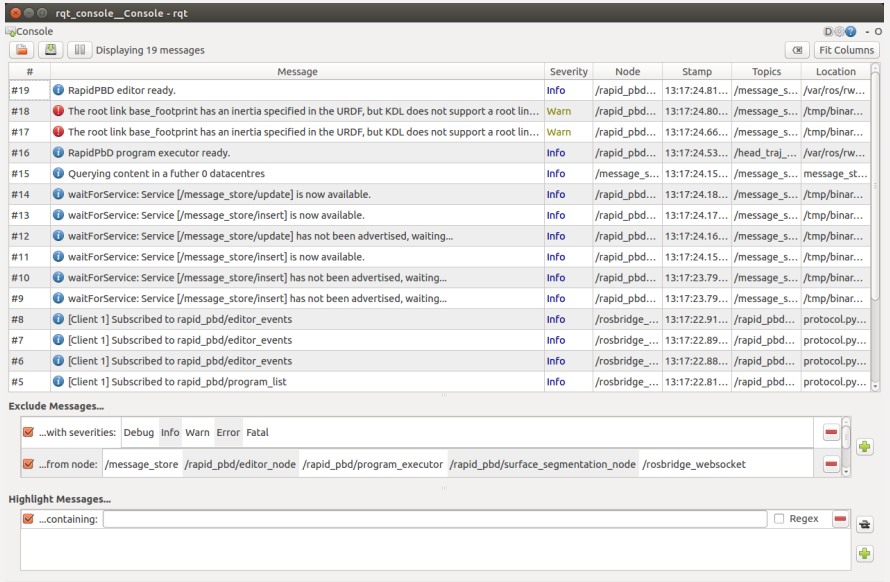
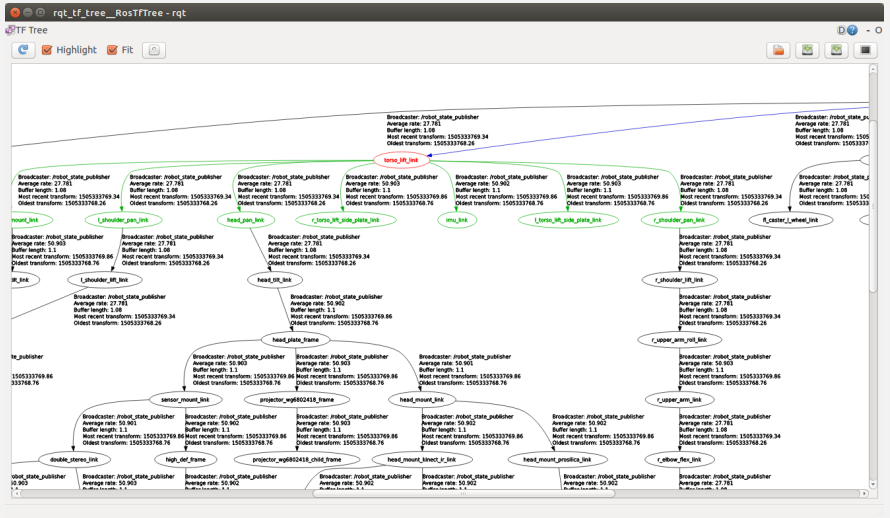
Paul G. Allen School, University of Washington

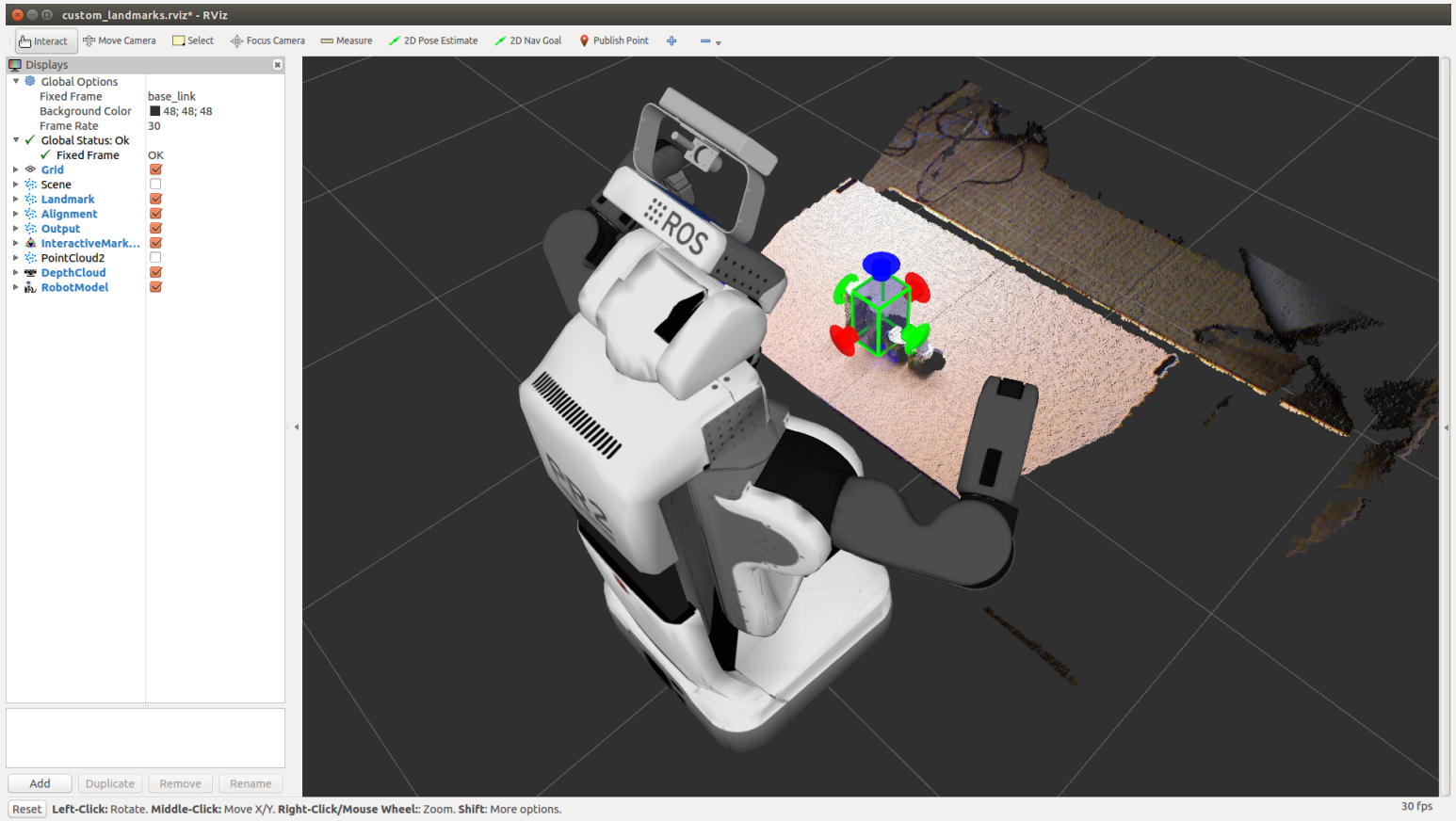
September 21-22, 2017

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

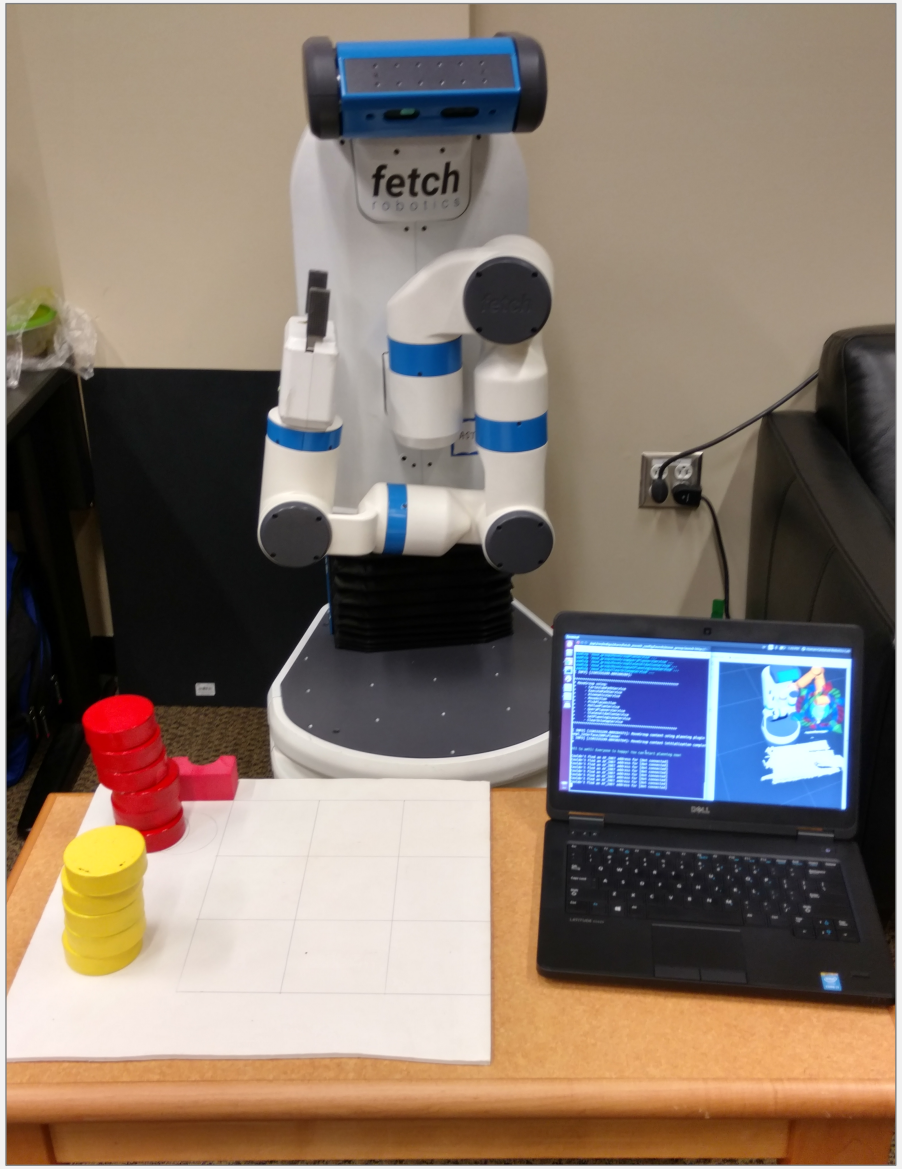
GREAT INTERFACES, DIFFICULT SETUP



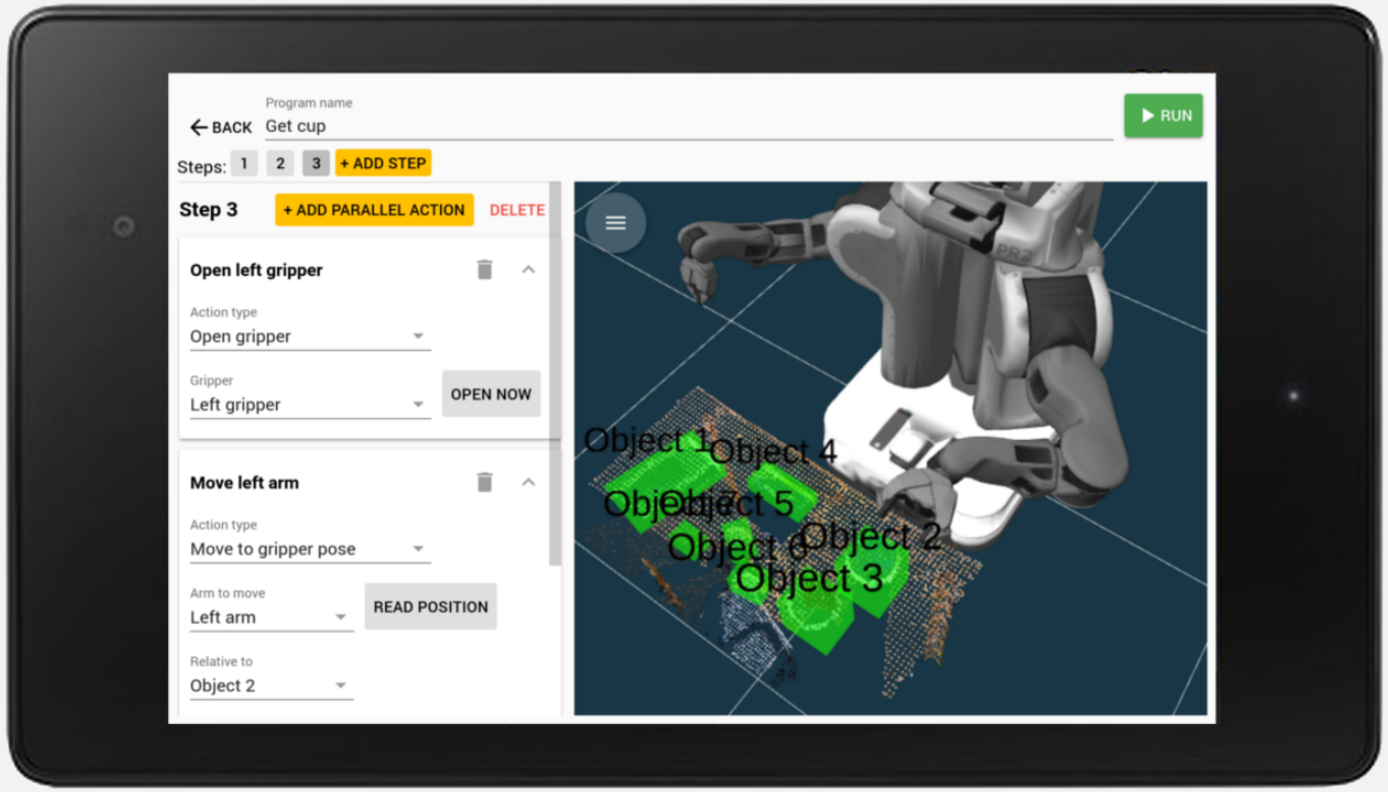




TETHERED TO COMPUTERS

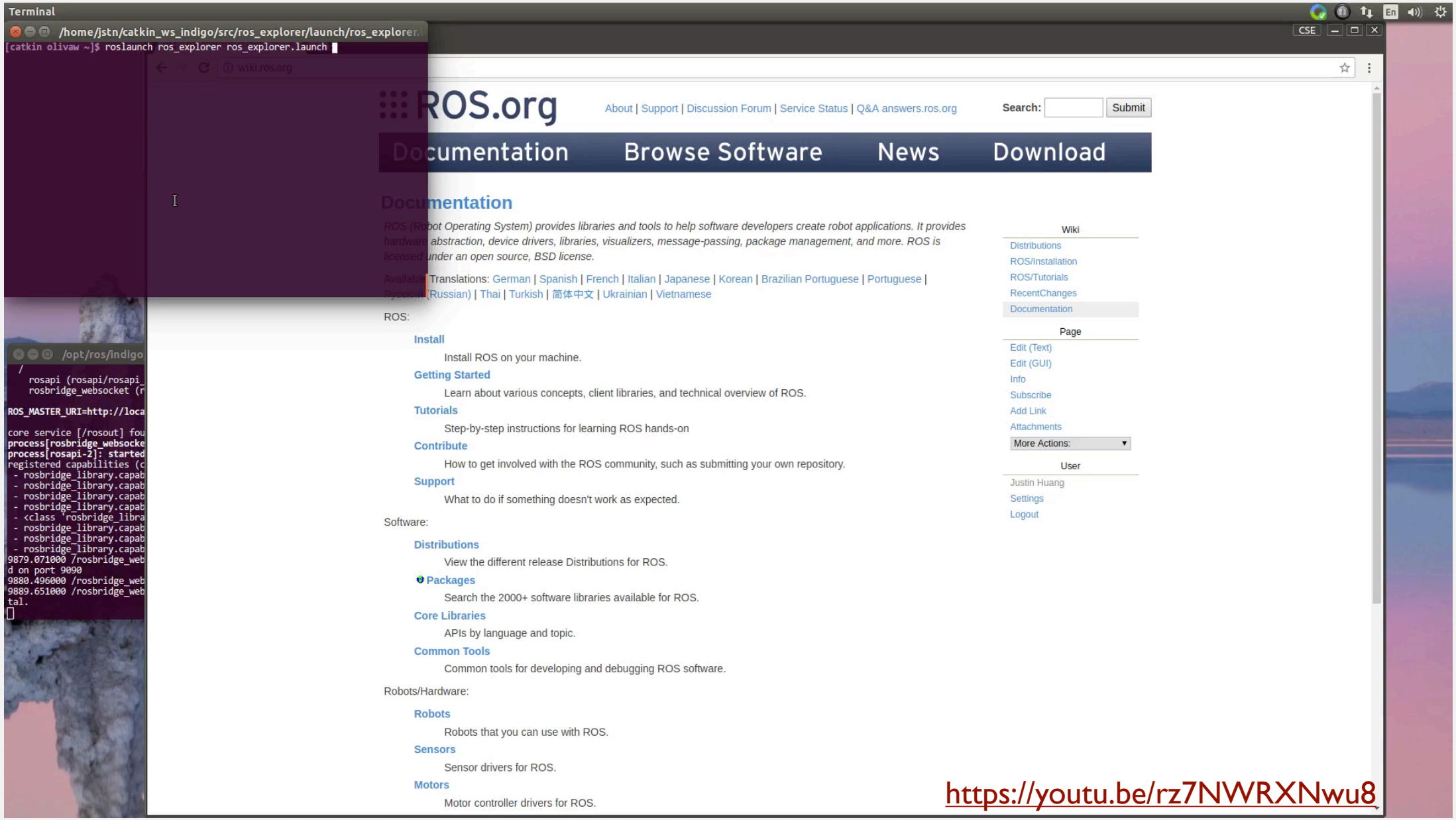


WHY THE WEB



- Cross platform, cross device
- Huge community of UI devs
- App-like features:
  - Add to Home Screen
  - Push Notifications
  - Loads even when offline

Example: ROS Explorer (https://wiki.ros.org/ros_explorer)



https://youtu.be/rz7NWRXNwu8

OUTLINE

- Web components
- ROS web components
- Examples

WEB COMPONENTS

- New HTML standard
- “Build your own HTML element”
- Works in all browsers (natively or with polyfill)

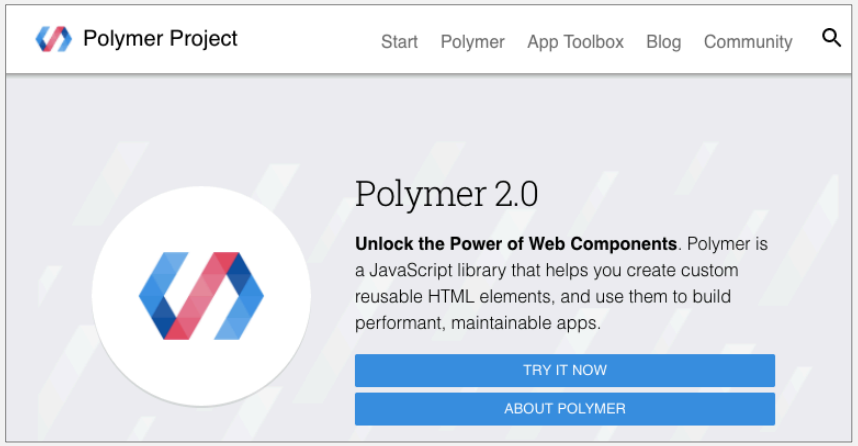
ANATOMY OF A WEB COMPONENT

```
<head>
  <!-- Web components polyfill -->
  <script src="path/to/webcomponents-loader.js"></script>

  <!-- Import web component to use -->
  <link rel="import" href="path/to/ros-websocket.html />
</head>

<body>
  <!-- Add component to document -->
  <ros-websocket id="websocket"></ros-websocket>
</body>
```

```
<ros-websocket id="websocket"></ros-websocket>

<script>
  var websocket = document.getElementById("websocket");

  // Add event listener
  websocket.addEventListener("connection", onConnected);

  // Get / set properties
  console.log(websocket.url);
  websocket.url = "ws://demo.robotwebtools.org:9090";

  // Call methods
  websocket.connect();
</script>
```

POLYMER

- JavaScript library for creating web components
- Provides declarative syntax and data binding, other conveniences
- https://www.polymer-project.org
- Not needed to use web components



DATA BINDING WITH POLYMER

```
<ros-websocket url="{{url}}"></ros-websocket>

<paper-dialog modal id="disconnected">
  <h2>Disconnected from websocket server</h2>
  <paper-input label="Websocket URL" value="{{url}}">
  </paper-input>
  ...
</paper-dialog>
```

← Back to dashboard

Websocket URL

ws://localhost:9090

CONNECT

Nodes

Loading...

Topics

Loading...

Services

Loading...

Parameters

CREATE

Loading...

Disconnected from websocket server

Websocket URL

ws://localhost:9090

RETRY

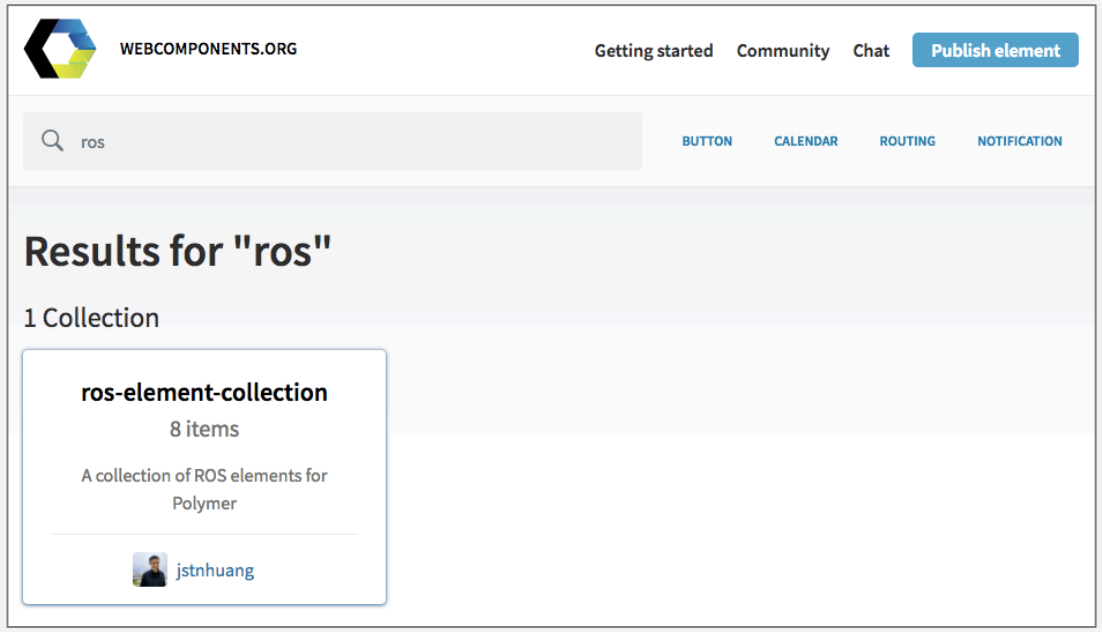
DATA BINDING: SECOND EXAMPLE

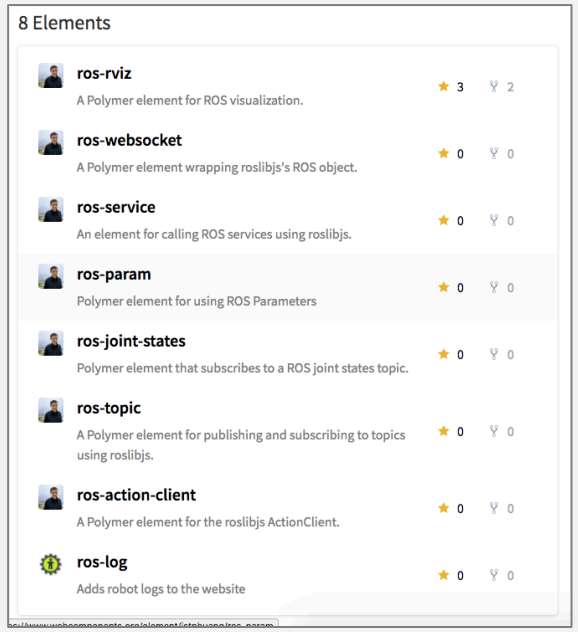
```
<ros-websocket auto ros="{{ros}}"></ros-websocket>

<ros-topic auto ros="{{ros}}"
 topic="/clock" msg-type="rosgraph_msgs/Clock"
 last-message="{{time}}"></ros-topic>

<p>Time: {{time.clock.secs}}.{{time.clock.nsecs}}</p>
```

https://youtu.be/-X7cuDufCQ8

ROS WEB COMPONENTS

- A collection of ROS-related web components
- Search for “ROS” at https://www.webcomponents.org/





Click on an element to see documentation, sample code, and demos

by jstnhuang

0 0 0 0

LICENSED UNDER BSD-3-CLAUSE, LAST UPDATED 4 MONTHS AGO, & INSTALLED VIA BOWER +

View on GitHub

Star on GitHub
Requires authentication

Overview

Elements

<ros-topic>

Demo DEMO

Dependencies

polymer 1.9 - 2

ros-websocket ^3.0.0

ros-topic v1.0.0

A Polymer element for publishing and subscribing to topics using roslibjs.

Element <ros-topic>

`class extends HTMLElement`
Path: `ros-topic.html`

Description

An element for publishing and subscribing to topics using roslibjs.

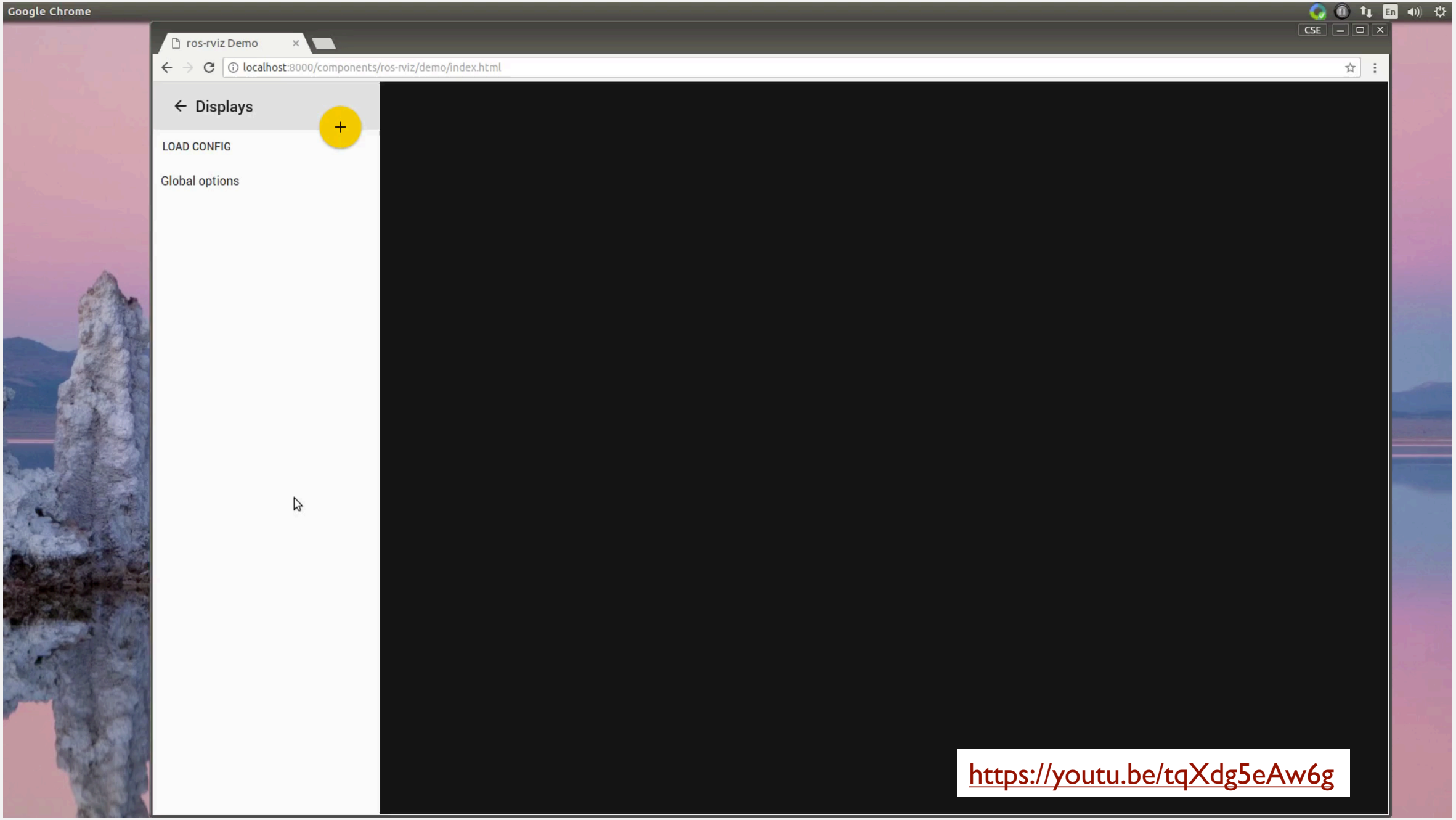
Example:

```
<ros-websocket ros="{{ros}}"></ros-websocket>
<ros-topic
  auto
  id="topic"
  on-message="handleMessage"
  topic="/clock"
  ros="{{ros}}"
  msg-type="rosgraph_msgs/Clock"
></ros-topic>
```

Subscribing to a topic

Simple specify the topic name and msgType. If `auto` is set, then the element will automatically subscribe and fire `message` events.

<ros-rviz>: like RViz, but an HTML element

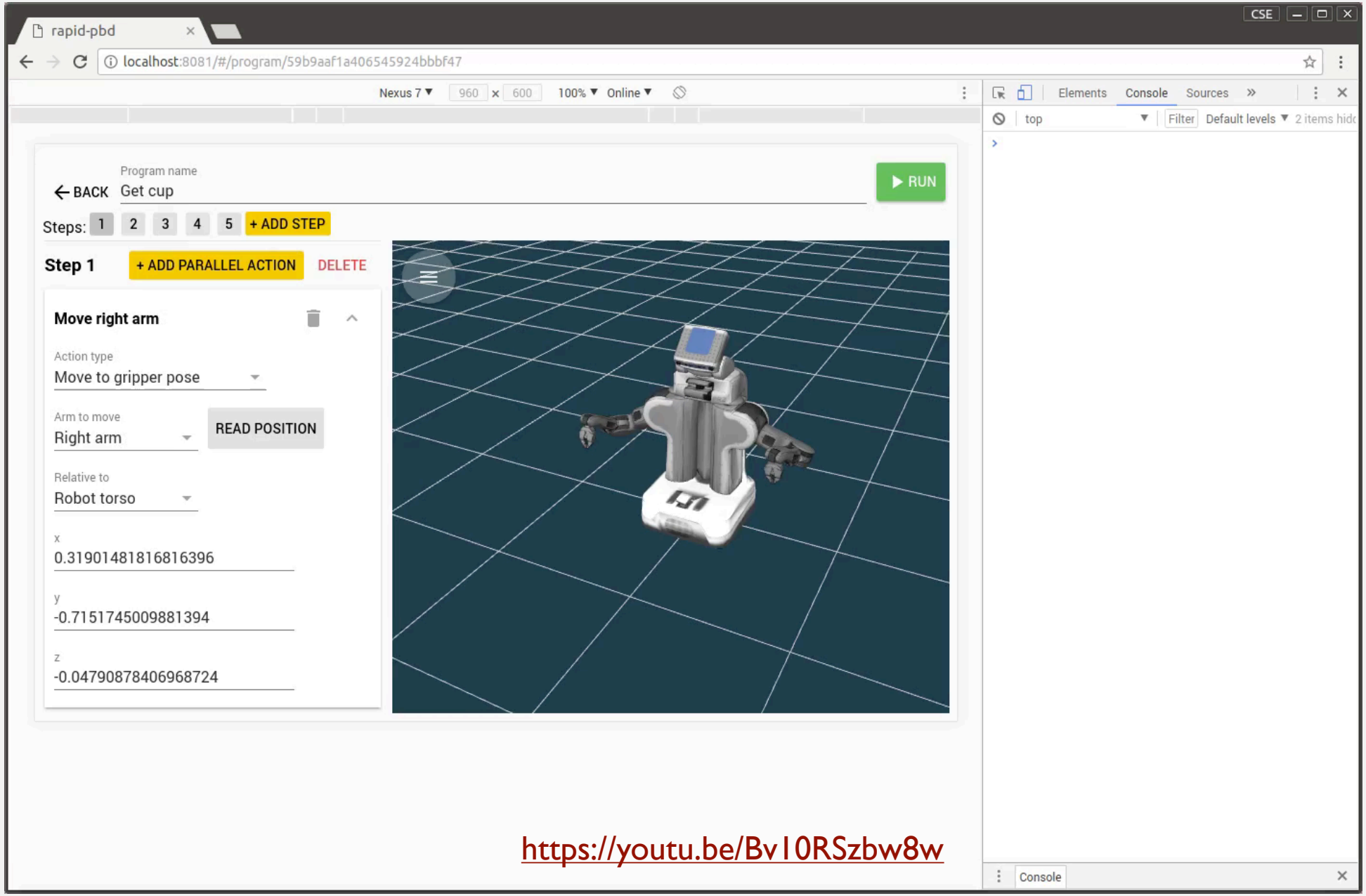


https://youtu.be/tqXdg5eAw6g

BUILDING BLOCKS FOR WEB APPS

- Using web components like <ros-rviz>
- Reactive database pattern
- User event pattern

<ros-rviz> embedded inside rapid_pbd, a programming by demonstration system



https://youtu.be/Bv10RSzbw8w

REACTIVE DATABASE PATTERN

- Publish state using latched publisher, republish when state changes

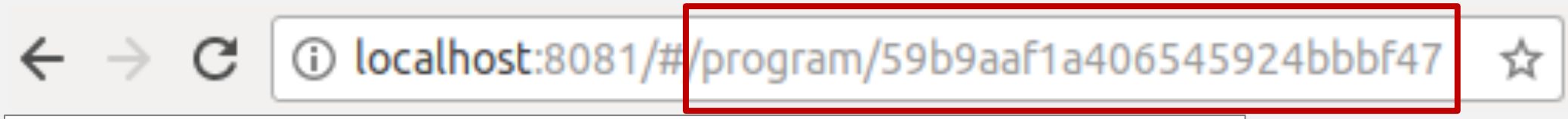
```
Database::Update(const string& id, const Program& program) {
  db_->updateID(id, program);
  if (publishers_.find(id) == publishers_.end()) {
    int queue_size = 1;
    bool latched = true;
    publishers_[id] = nh_.advertise<Program>(
      "program/" + id, queue_size, latched);
  }
  publishers_[id].publish(program);
}
```

Do database update

Create latched publisher to topic /program/59b9aa.. if it doesn't already exist

Publish updated data

- Web clients get data by subscribing to a topic
- Can use data binding from URL all the way to view




```
<app-route route="route"
  pattern="/program/:id"
  data="{{routeData}}"
></app-route>

<ros-topic auto ros="{{ros}}"
  topic="program/{{routeData.id}}" msg-type="pbd_msgs/Program"
  last-message="{{program}}"
></ros-topic>

<pbd-program program="{{program}}"></pbd-program>
```

Parse URL and set routeData.id to 59b9aaf1a4065...

Subscribe to /program/59b9aaf...

Bind data and pass it to program element

Google Chrome

rapid-pbd

localhost:8081/#/

+ CREATE NEW PROGRAM

Name	Actions	
Get cup	OPEN	DELETE

rapid-pbd

localhost:8081/#/

+ CREATE NEW PROGRAM

Name	Actions	
Get cup	OPEN	DELETE

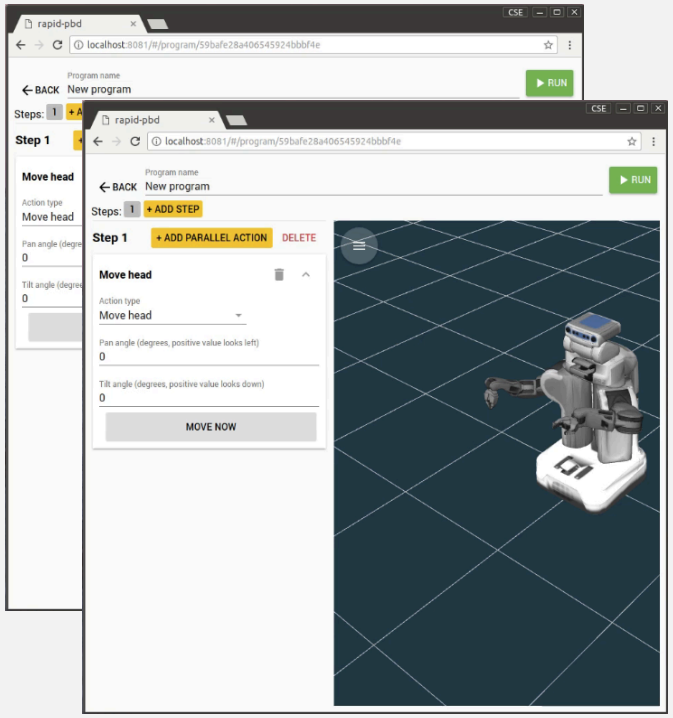
https://youtu.be/KlNBqsMW7iY

USER EVENT PATTERN

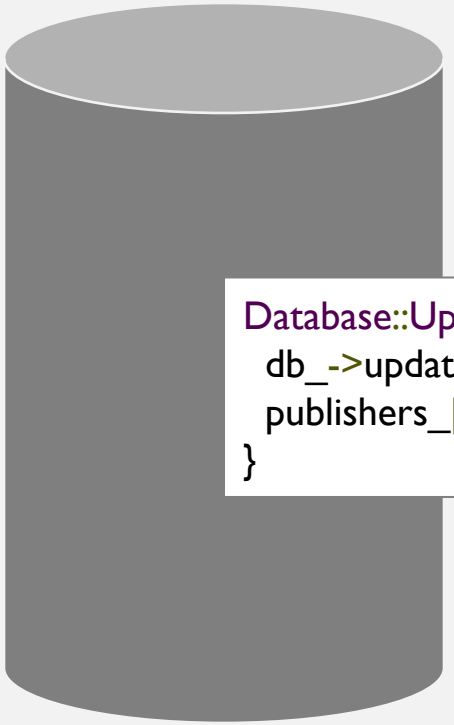
- Frontend publishes events to server to modify data
- Server interprets event, modifies data, and republishes it
- Easy to record frontend interactions with rosbag
- Downside: frontend is sluggish if server connection is slow

Browsers

Server



UserEvent.msg
type: Add step
program_id: 59b9aaf...
step: { ... }



```
Database::Update(id, program) {
  db_->updateID(id, program);
  publishers_[id].publish(program);
}
```

Modify program
Save to DB
Republish program

QUICKSTART

INSTALL NODE.JS

- Install Node.js if you don't already have it.
- Recommended: install Node using NVM (Node Version Manager)

```
> curl -o- https://raw.githubusercontent.com/creationix/nvm/v0.33.4/install.sh | bash
> source ~/.bashrc
> nvm install node
```

INSTALL BOWER AND POLYMER

- Bower is a package manager for frontend projects

```
> npm install -g bower polymer-cli
```

CREATE A NEW PROJECT

```
> mkdir my_project
> cd my_project
> bower init
(Answer questions)
```

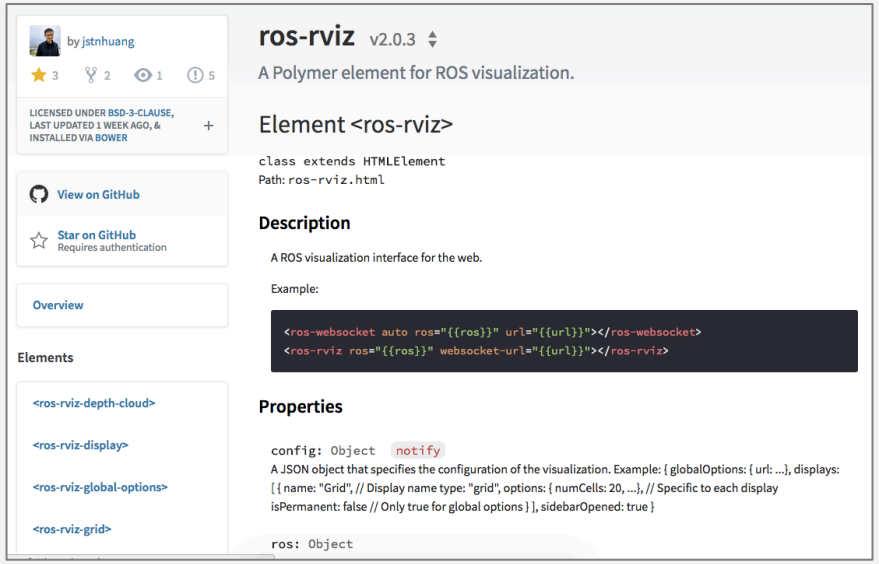
DOWNLOAD WEB COMPONENTS

- Bower will download projects at specified GitHub URLS, as well as its dependencies, to the bower_components/ folder
- --save adds the entry to bower.json
- Future developers just run "bower update" to download/update components

```
> bower install --save jstnhuang/ros-websocket
> bower install --save jstnhuang/ros-rviz
```

FIND DOCUMENTATION

- Find documentation on webcomponents.org
- https://www.webcomponents.org/element/jstnhuang/ros-rviz/elements/ros-rviz
- https://www.webcomponents.org/element/jstnhuang/ros-websocket/elements/ros-websocket
- Learn more about Polymer at https://www.polymer-project.org/2.0/start/



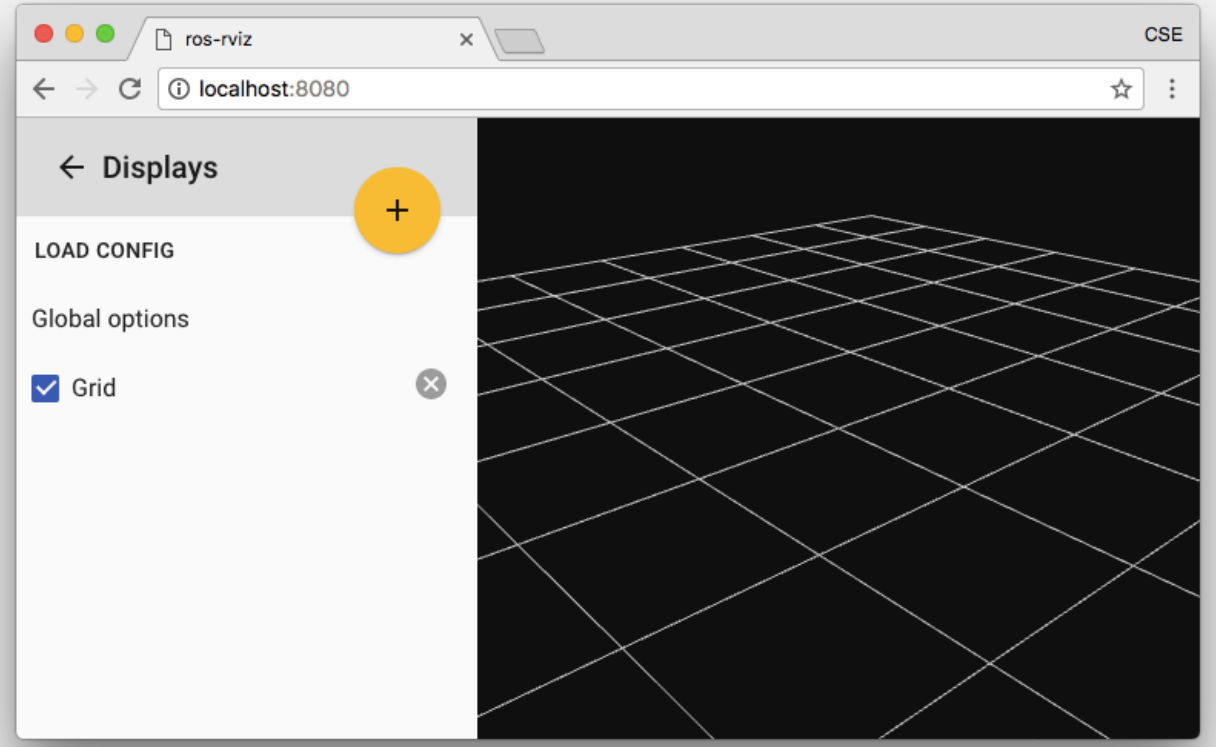
CREATE INDEX.HTML

```
<!doctype html>
<html>
 <head>
  <title>ros-rviz</title>
  <meta charset="utf-8">
  <meta name="viewport" content="width=device-width, minimum-scale=1.0, initial-scale=1.0, user-scalable=yes">
  <script src="bower_components/webcomponentsjs/webcomponents-loader.js"></script>
  <link rel="import" href="bower_components/ros-websocket/ros-websocket.html" />
  <link rel="import" href="bower_components/ros-rviz/ros-rviz.html" />
  <link rel="import" href="bower_components/polymer/lib/elements/dom-bind.html" />
  <style>
    html, body {
      height: 100%;
      margin: 0;
    }
  </style>
 </head>
 <body>
  <dom-bind>
    <template is="dom-bind">
      <ros-websocket auto id="websocket" ros="{{ros}}" url="{{url}}"></ros-websocket>
      <ros-rviz ros="{{ros}}" websocket-url="{{url}}"></ros-rviz>
    </template>
  </dom-bind>
 </body>
</html>
```

SERVE THE WEBPAGE

- At this point, you should see <ros-rviz> and be able to add a grid
- Adding more displays will require backend support

```
> cd my_project
> python -m SimpleHTTPServer 8080 .
```

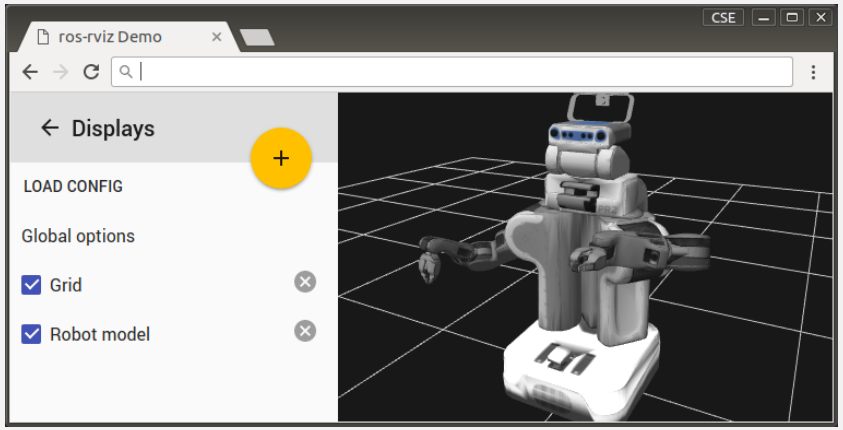


VISUALIZE A URDF

- Set up and run a mesh file server according to https://github.com/hcrlab/wiki/blob/master/web_development/serving_urdf.md

- Run rosbridge_server and tf2_web_republisher as shown below

```
roslaunch rosbridge_server rosbridge_websocket.launch
rosrun tf2_web_republisher tf2_web_republisher
```



FOR REACT USERS

- React data-binding sets *attributes* rather than *properties*. To set object/array properties or listen to events, get a ref to the element.

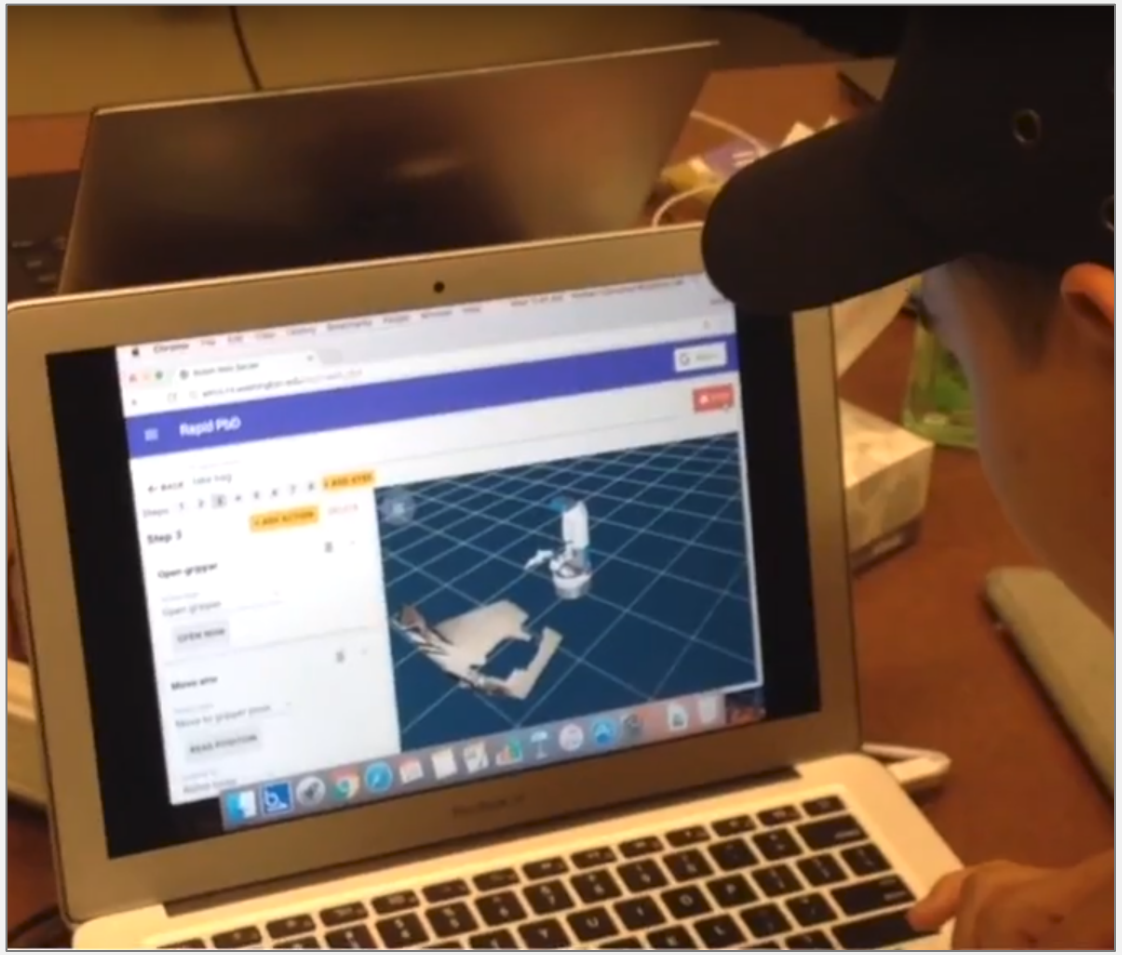
- See https://robdodson.me/interoperable-custom-elements/ and https://custom-elements-everywhere.com

REFERENCE

Learn more about web components	
Find web components	https://www.webcomponents.org
Polymer library	https://www.polymer-project.org

ROS components and web applications	
ROS web components	https://www.webcomponents.org/search/ros
ROS Explorer	https://wiki.ros.org/ros_explorer
Rapid PbD	https://github.com/jstnhuang/rapid_pbd
CodeIt!	https://github.com/hcrlab/code_it
Robot Web Server	https://github.com/hcrlab/rws

WEB INTERFACES IN THE WILD



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