# Node.js and JavaScript at the Edge

## The why, what and how

# About Michael Dawson

Node.js lead for Red Hat and IBM

Active Node.js community member

- Node.js Collaborator, Node.js Technical Steering Committee,
- Active in a number of Working group(s)

Active OpenJS Foundation member

- Voting Cross Project Council Member
- Community Director 2020-2022


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# Overview

- Why Node.js at the Edge
- Running Node.js applications on the edge with RHEL/Fedora
  - The Hardware
  - The Software
- Containerizing your Node.js applications at the edge on RHEL/Fedora
- Advanced container management at the edge for Node.js applications

# Why Node.js at the edge

- Existing C/C++ Developers reaching for “just one more language”
- Evolution of Edge devices

# My journey through building an edge application

- What hardware?
- What Operating System
- How do I build my application
- How to I package and deploy my application
- How do update my application
- How do I monitor and manage my application

# What Hardware?

- Often ARM base for small size and low power
- Raspberry PI ok for experimentation
  - Supported by Fedora IoT

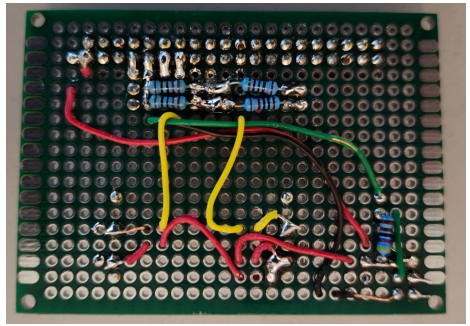
- More robust/commercially supported H/W often used for production deployments

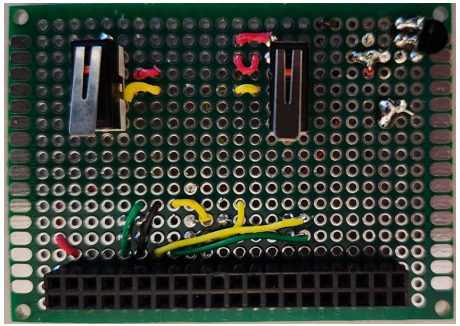
**Hardware**

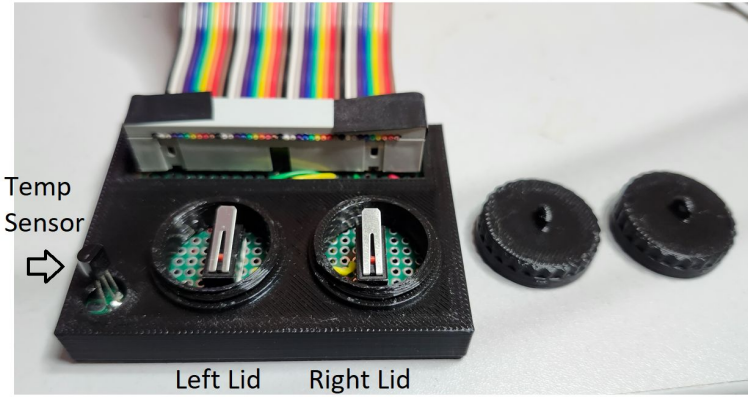
| | |
|---|---|
| Model name | fitlet2 |
| CPU model name | Intel® Atom x5-E3930 [CE3930] |
| Memory capacity | 4.00 GiB |

[Install RHEL for Edge on Compulab Fitlet 2]

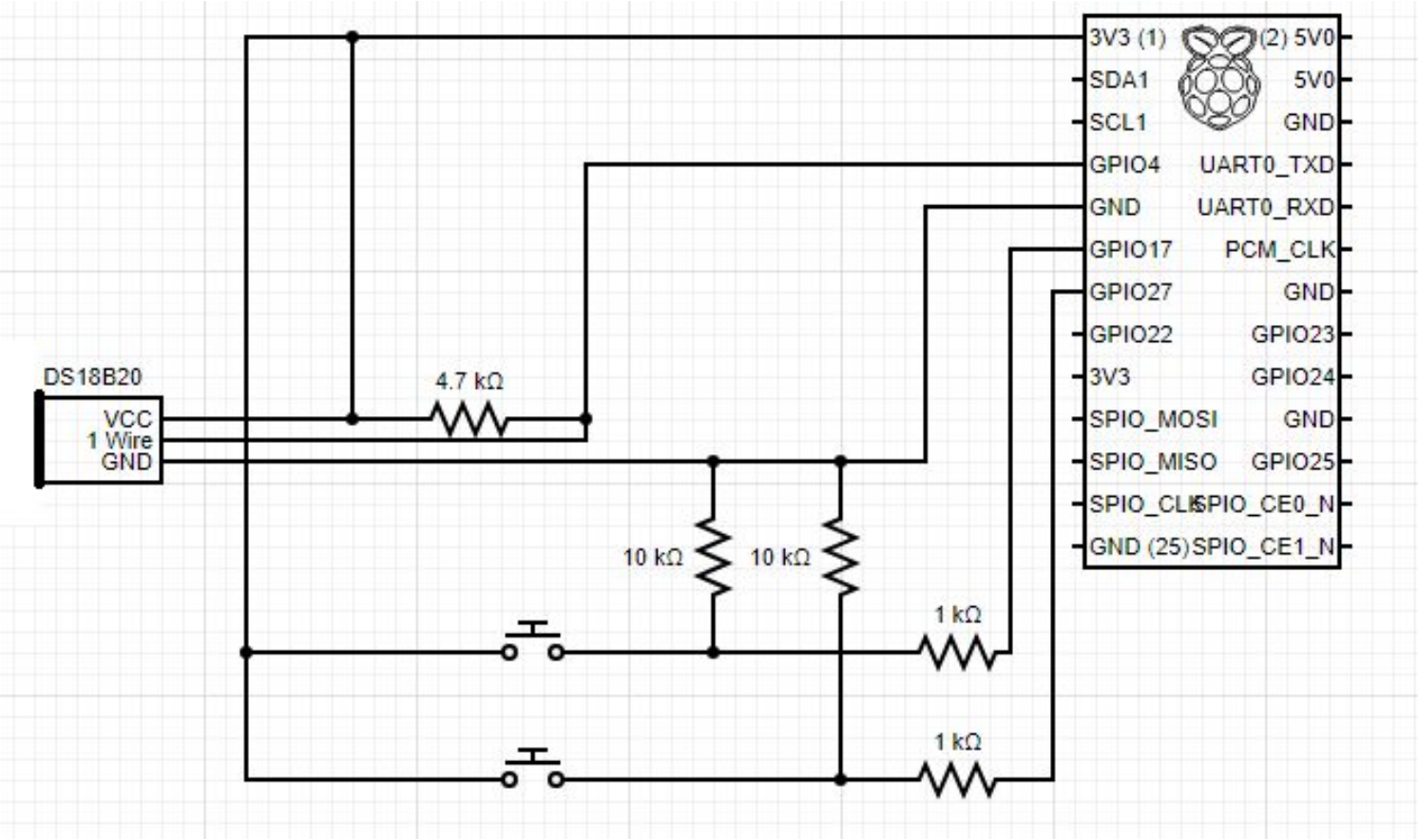
# A look at the hardware for our example







# Hardware - Circuit



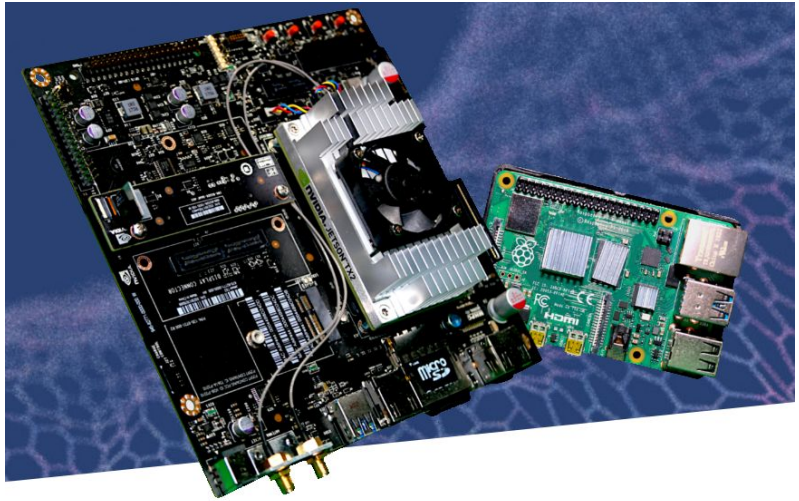
# Hardware - Live View

# The software

- Operating System
- Device Drivers
- Application

# The Operating System

- Fedora IoT
- RHEL for Edge



# The Operating System

- Key Attributes
  - Immutable
  - Image based
  - Atomic updates
  - Change on reboot/rollback
- rpm-ostree

# The Operating System

Image Builder - http://X1.X2.X3.X4:9090

Image Builder - user1@lc

Not secure | https://10.1.1.104:9090/composer

user1@
localhost

Administrative access | Help | Session

Search

Apps Edit

Image Builder

System

Overview

Logs

Storage

Networking

Accounts

Services

image builder

Import blueprint | Create blueprint | Create image

Blueprints | Images | Sources

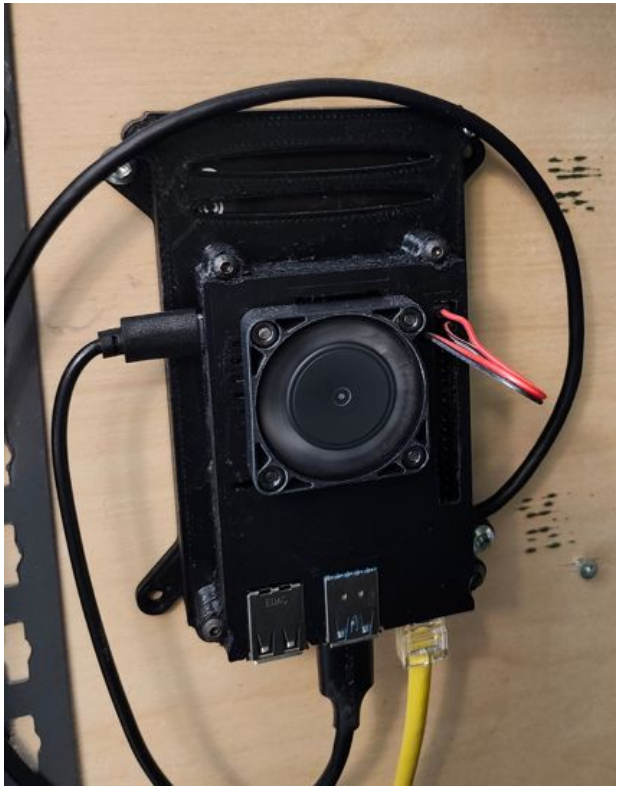
| Name | Version | Last image cre... | Images ... | Packages | | | |
|---|---|---|---|---|---|---|---|
| fedora-base | 0.0.0 | - | 0 | 2 | Create image | Export blueprint | Delete blueprint |
| fedora-base-iot | 0.0.4 | Dec 7, 2023 | 1 | 0 | Create image | Export blueprint | Delete blueprint |
| fedora-iot-microshift | 0.0.1 | - | 0 | 2 | Create image | Export blueprint | Delete blueprint |
| fedora-microshift | 0.0.2 | Dec 8, 2023 | 1 | 2 | Create image | Export blueprint | Delete blueprint |

"Introduction to Image builder"

# Blueprints

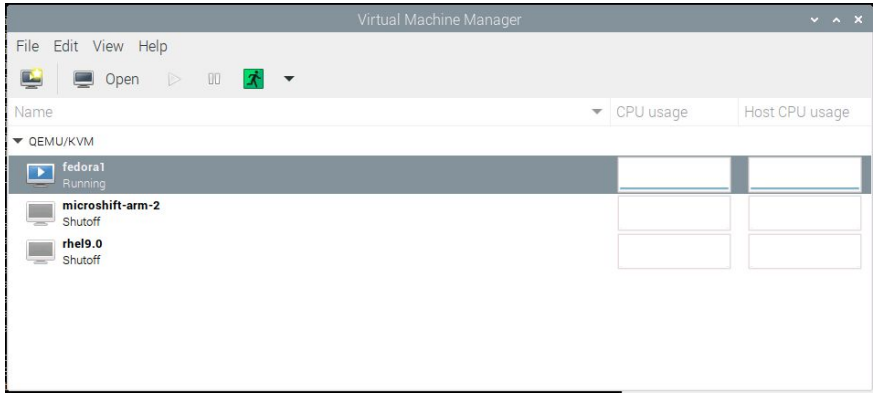
```
name = "fedora-base"
description = "base template for Node.js edge example"
version = "0.0.4"
modules = []
groups = []
distro = ""

[[packages]]
name = "nodejs20"

[[packages]]
name = "podman"

[customizations]
[customizations.timezone]
[customizations.locale]
[customizations.firewall]
ports = ["3000:tcp"]
[customizations.firewall.services]
enabled = ["http", "https", "ntp", "dhcp", "ssh"]
disabled = ["telnet"]
[customizations.services]
enabled = ["sshd"]
```

# Development system



- Raspberry PI 4 - 8 G
- 512G SSD

- KVM
  - Easy spin up/down of virtual machines

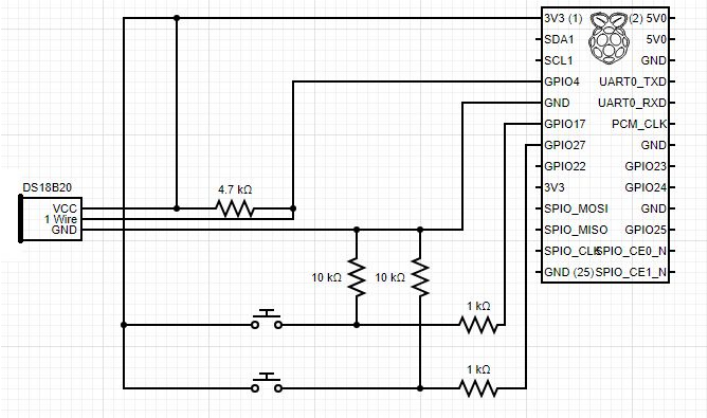


# Creating the SD card

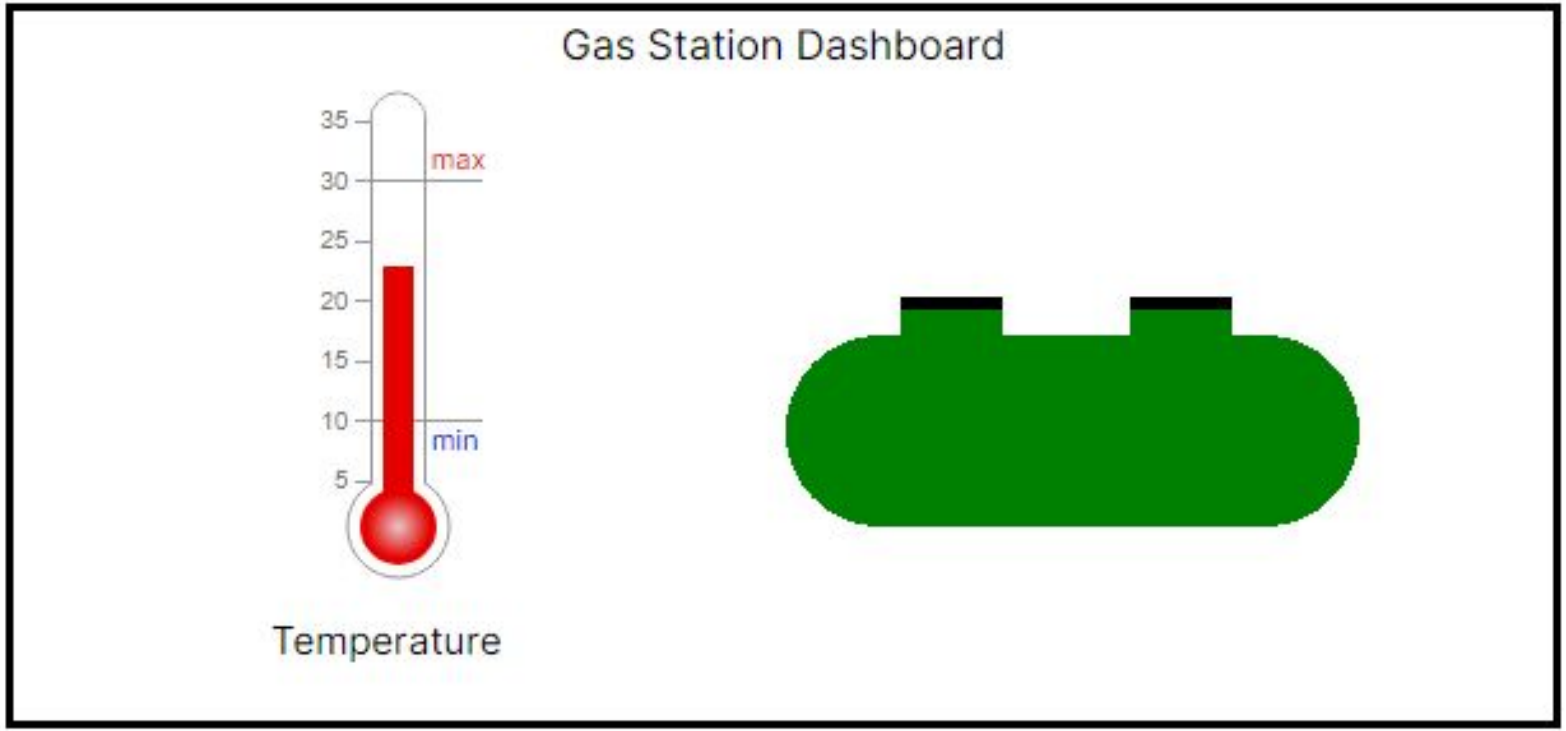
- Building the edge commit and starting a container which serves that commit
- Building a raw image
- Burning the raw image to an SD card

# Device Drivers

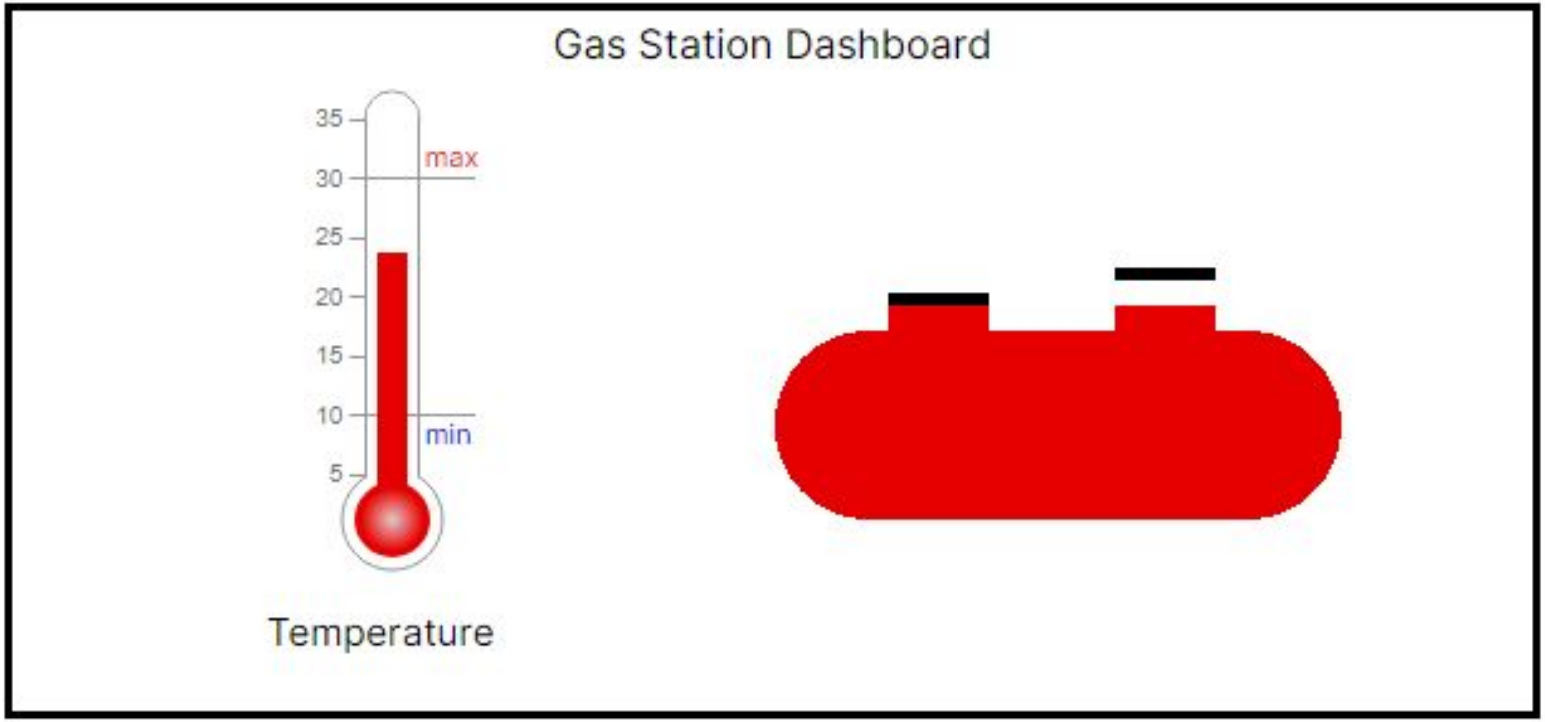
- GPIO
  - gpioget
  - /dev/gpiochip0
  - chmod to make accessible
  - /boot/efi/config.txt
    - dtoverlay=w1-gpio
- Temperature Sensor
  - DS18B20
  - kernel-modules-extra



# The application



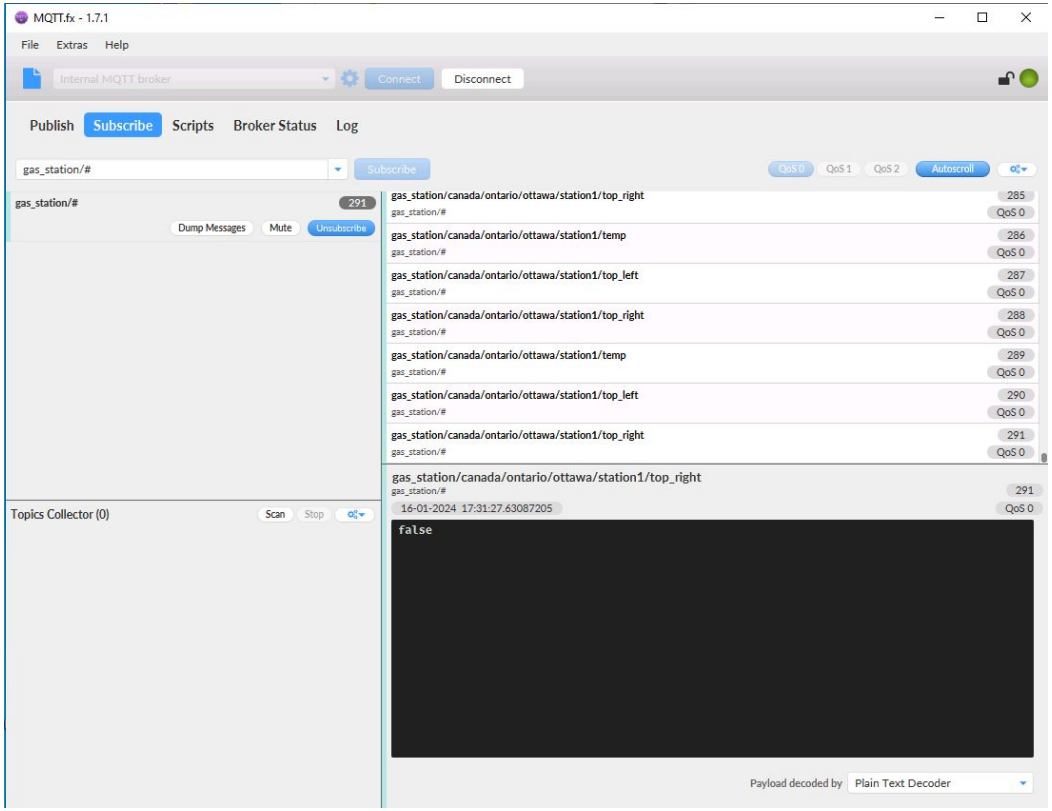
# The application



# The application

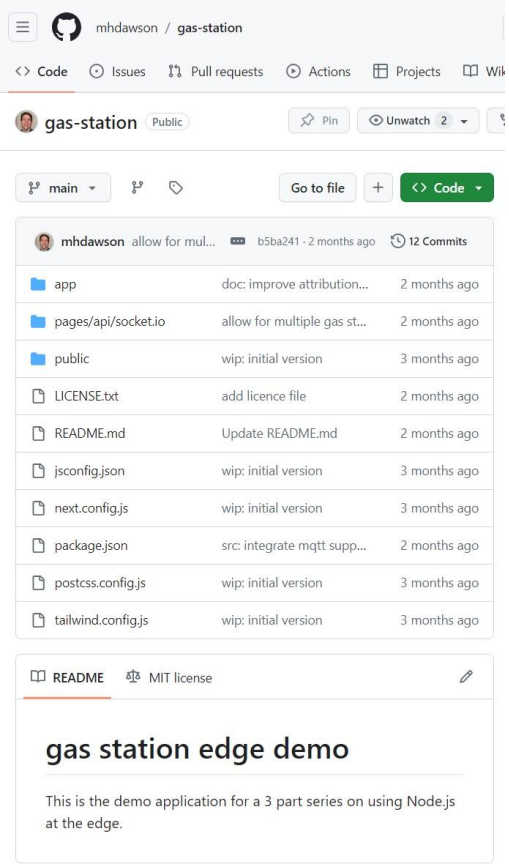
Publishing to MQTT

- gas_station/XXX/temp
- gas_station/XXX/top_left
- gas_station/XXX/top_right



# The application - Live View

# The application - Next.js based application




https://github.com/mhdawson/gas-station

# The application - Next.js based application

```
  return (
    <div >
      <div style={{ paddingLeft: '10px', paddingTop: '10px',
height:'250px', width:'100%'}}>
        <table style={{ border: '3px solid black' }}>
          <tbody>
            <tr><td colSpan='2' style={{textAlign: 'center'}}>Gas
Station Dashboard</td></tr>
            <tr><td><Thermometer data={currentTemp}/></td>
                <td><GasTank data={{Left: topLeft, Right:
topRight}}/></td></tr>
          </tbody>
        </table>
      </div>
    </div>
  )
```

# The application - Next.js based application

```
React.useEffect(() => {
  // Create a socket connection
  const socket = io({ path: '/api/socket.io'});

  // Listen for incoming messages
  socket.on('message', (message) => {
    if (message.temp)
      setTemp(message.temp);

    if (message.topLeft !== undefined)
      setLeft(message.topLeft);

    if (message.topRight !== undefined)
      setRight(message.topRight);
  });

  // Clean up the socket connection on unmount
  return () => {
      socket.disconnect();
  };
}, []);
```

# The application - Next.js based application

```
setInterval(() => {
  const temp = readTemp(tempSensorFile);
  readGpio(TOP_LEFT_PIN, (left) => {
    readGpio(TOP_RIGHT_PIN, (right) => {
      io.emit('message', {temp: temp, topLeft: left, topRight: right});
      mqttClient.publish(TEMP_TOPIC, temp.toString());
      mqttClient.publish(TOP_LEFT_TOPIC, left.toString());
      mqttClient.publish(TOP_RIGHT_TOPIC, right.toString());
    });
  });
} , POLL_INTERVAL);
```

# The application - Next.js based application

```
function readGpio(pin, callback) {
  exec('gpioget gpiochip0 ' + pin, (err, stdout, stderr) => {
    const pinValueString = stdout.replace(/\s+/g,'');

    let pinValue = false;
    if (pinValueString === '0')
      pinValue = true;

    callback(pinValue);
  });
};
```

# The application - Next.js based application

```
function readTemp(tempSensorFile) {
  if (tempSensorFile) {
    const valueRead = readFileSync(tempSensorFile);
    return valueRead/1000;
  }
  return 0;
};
```

# Deploying the Application

- Challenges with using rpm-ostree or image builder
  - It requires a different development workflow from how typical hybrid cloud applications are delivered.
  - It results in a tight binding to operating system components, versions and dependencies, beyond those needed by the code integrating the devices.
  - Potential conflicts between different pieces of an application in terms of operating system component versions.
  - A reboot would be required each time the application was updated

# Deploying the Application

- We already have existing flows to build/package cloud native applications
  - Dockerfiles -> Containers

# Containerizing the Application

```
# Install dependencies only when needed
FROM registry.access.redhat.com/ubi8/nodejs-20 AS deps
USER 0
WORKDIR /app

# Install dependencies based on the preferred package manager
COPY package.json yarn.lock* package-lock.json* pnpm-lock.yaml* ./
RUN \
  if [ -f yarn.lock ]; then yarn --frozen-lockfile; \
  elif [ -f package-lock.json ]; then npm ci; \
  elif [ -f pnpm-lock.yaml ]; then yarn global add pnpm && pnpm i; \
  else echo "Lockfile not found." && exit 1; \
  fi

# Rebuild the source code only when needed
FROM registry.access.redhat.com/ubi8/nodejs-20 AS builder
USER 0
WORKDIR /app
COPY --from=deps /app/node_modules ./node_modules
COPY . .

# Next.js collects completely anonymous telemetry data about general usage.
# Learn more here: https://nextjs.org/telemetry
# Uncomment the following line in case you want to disable telemetry during the build.
ENV NEXT_TELEMETRY_DISABLED 1

# If using yarn uncomment out and comment out npm below
# RUN yarn build

# If using npm comment out above and use below instead
RUN npm run build
```

https://github.com/mhdawson/gas-station/blob/main/Dockerfile

# Containerizing the Application

```
ENV NODE_ENV production
# Uncomment the following line in case you want to enable telemetry during runtime.
ENV NEXT_TELEMETRY_DISABLED 1

COPY --from=builder /app/public ./public

# Set the correct permission for prerender cache
RUN mkdir .next
RUN chown 1001:1001 .next

# Automatically leverage output traces to reduce image size
# https://nextjs.org/docs/advanced-features/output-file-tracing
COPY --from=builder --chown=1001:1001 /app/.next/standalone ./
COPY --from=builder --chown=1001:1001 /app/.next/static ./.next/static

# add in libpiod for access to Raspberry PI IO pins
RUN rpm -ivh https://dl.fedoraproject.org/pub/epel/epel-release-latest-8.noarch.rpm
RUN microdnf install libgpiod-utils


USER 1001

EXPOSE 3000

ENV PORT 3000

CMD ["node", "server"]
```

# Building the containers

```
podman build . -t gas-station:latest
```

```
podman build . --arch=arm64 -t gas-station:latest
```

```
[user1@localhost gas-station]$ podman images |grep gas-station
localhost/gas-station                                   latest
30ded1b2fcb5  2 hours ago  295 MB
```

# Podman/Podman Desktop

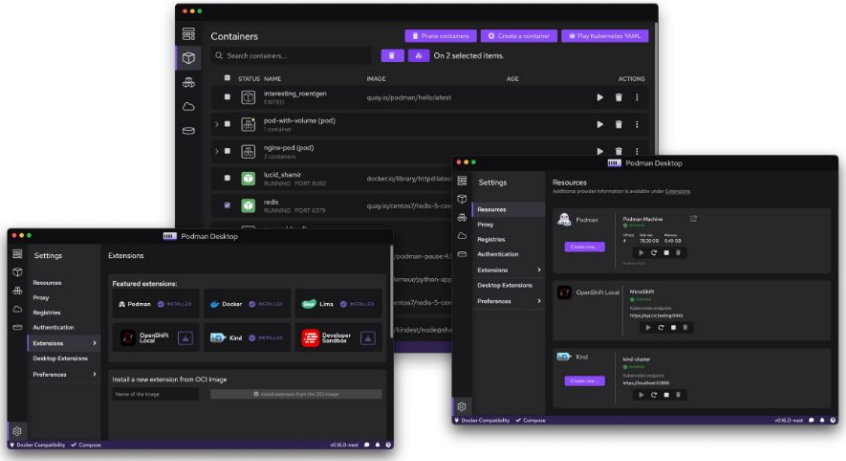
## Containers and Kubernetes for application developers

Podman Desktop is an open source graphical tool enabling you to seamlessly work with containers and Kubernetes from your local environment.

Download Now

For **Windows** *(browser-detected)*

Other downloads



# Getting the container onto the edge device

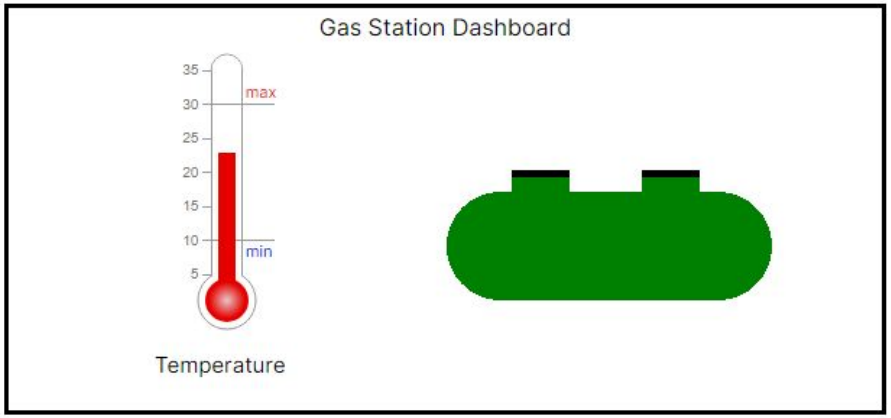
```
name = "fedora-base"
description = "base template for Node.js edge example"
version = "0.0.4"
modules = []
groups = []
distro = ""

[[packages]]
name = "nodejs20"

[[packages]]
name = "podman"

[customizations]
[customizations.timezone]
[customizations.locale]
[customizations.firewall]
ports = ["3000:tcp"]
[customizations.firewall.services]
enabled = ["http", "https", "ntp", "dhcp", "ssh"]
disabled = ["telnet"]
[customizations.services]
enabled = ["sshd"]
```

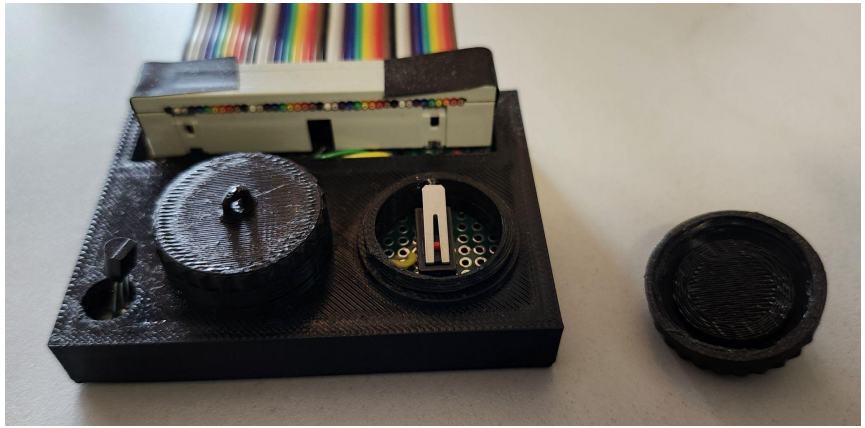
# Getting the container onto the edge device

```
podman tag 30ded1b2fcb5 quay.io/midawson/gas-station:latest
podman push quay.io/midawson/gas-station:latest
```

```
podman pull quay.io/midawson/gas-station:latest
podman run -d -p 3000:3000 quay.io/midawson/gas-station:latest
```

# But there are problems



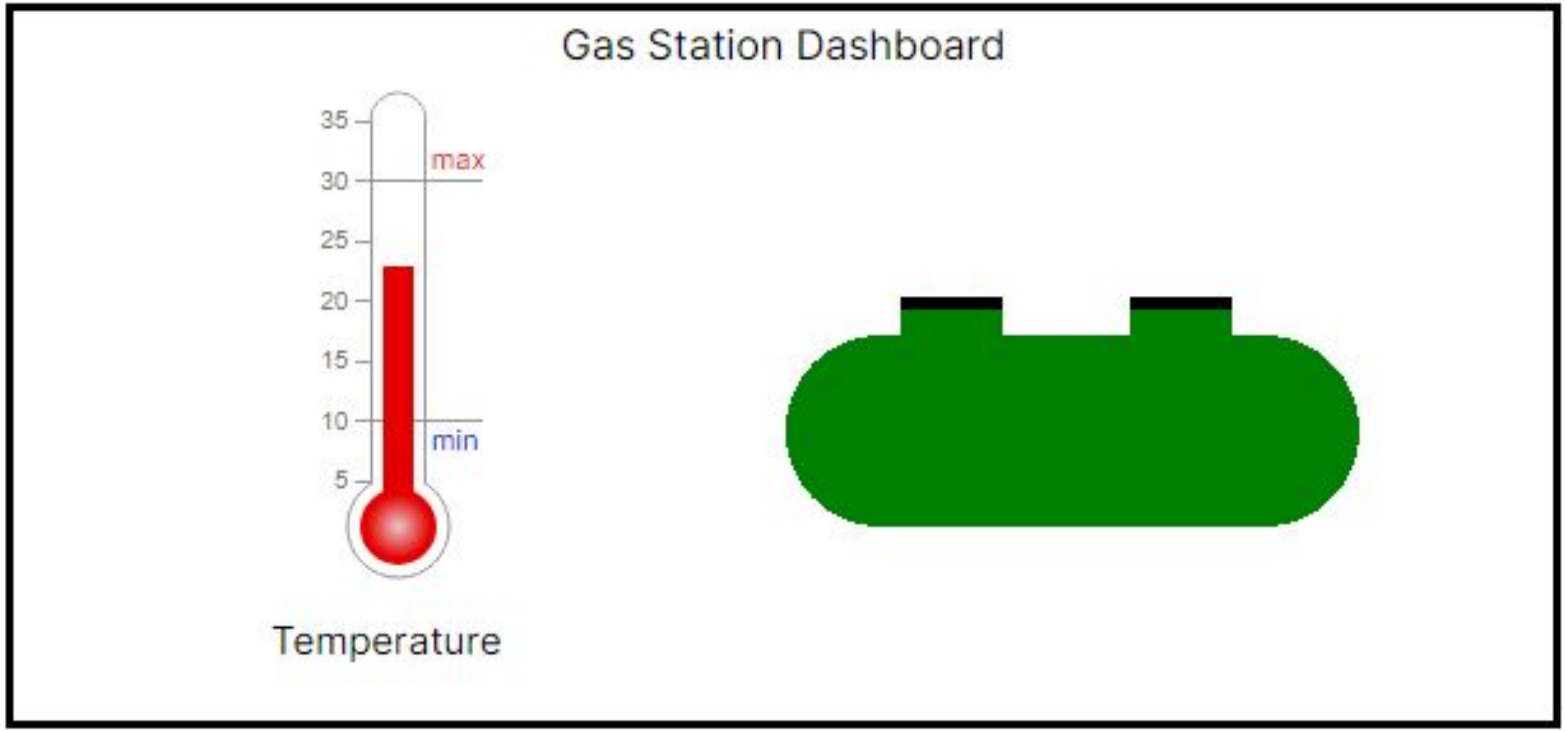
# Passing devices into the container

```
podman run --device=/dev/gpiochip0 -d -p 3000:3000
quay.io/midawson/gas-station:latest
```

```
podman run --group-add keep-groups --device=/dev/gpiochip0 -d -p
3000:3000 quay.io/midawson/gas-station:latest.
```

Using files and devices in Podman rootless containers”

# Why did the thermometer work in the container?



# Starting at Boot

## Podman Quadlet

```
/etc/containers/systemd/gas-station.container

[Service]
Restart=always
ExecStartPre=chmod 666 /dev/gpiochip0
ExecStartPre=modprobe w1-therm
ExecStartPre=/bin/sleep 30

[Container]
ContainerName=gas-station
Environment=STATION_TOPIC_PATH=gas_station/ottawa/bank-street
Image=quay.io/midawson/gas-station:latest
Label="io.containers.autoupdate=image"
PublishPort=3000:3000
AddDevice=/dev/gpiochip0
PodmanArgs=--group-add keep-groups

[Install]
WantedBy=multi-user.target
```

# Starting at Boot

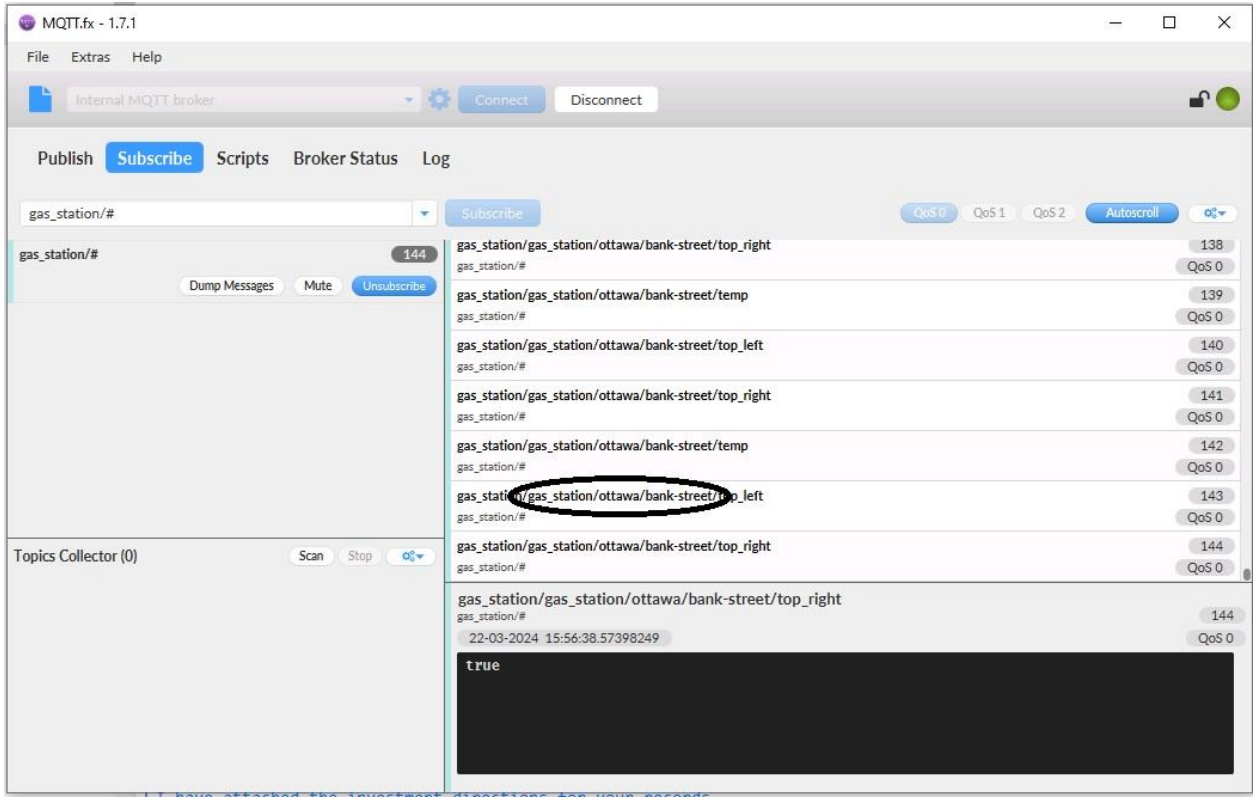
```
systemctl stop gas-station
systemctl start gas-station
systemctl restart gas-station
```

```
bash-5.2# systemctl status gas-station
● gas-station.service
     Loaded: loaded (/etc/containers/systemd/gas-station.container; generated)
    Drop-In: /usr/lib/systemd/system/service.d
             └─10-timeout-abort.conf
     Active: active (running) since Fri 2024-03-22 19:47:21 UTC; 15min ago
    Process: 29720 ExecStartPre=chmod 666 /dev/gpiochip0 (code=exited, status=0/SUCCESS)
    Process: 29722 ExecStartPre=modprobe w1-therm (code=exited, status=0/SUCCESS)
    Process: 29723 ExecStartPre=/bin/sleep 30 (code=exited, status=0/SUCCESS)
   Main PID: 29857 (conmon)
      Tasks: 12 (limit: 8976)
     Memory: 55.2M
        CPU: 22.441s
     CGroup: /system.slice/gas-station.service
             ├─libpod-payload-484377384e684b45377a90e3f5d220684145d81f1c8bfafb66efabd4d340f108
             │ └─29859 next-server
             └─runtime
               └─29857 /usr/bin/conmon --api-version 1 -c 484377384e684b45377a90e3f5d220684145d81f1c8bfafb66efabd4d340f108
-u 484377384e684b45377a90e3f5d220684145d81f1c8bfafb66efabd4d340f108 -r /usr/bin/>

Mar 22 19:47:21 localhost.localdomain podman[29774]: 2024-03-22 19:47:21.289284965 +0000 UTC m=+0.844523639 container init
484377384e684b45377a90e3f5d220684145d81f1c8bfafb66efabd4d340f108 (image=quay.io/>
```

# Starting at Boot

```
/etc/containers/systemd/gas-station.container

[Service]
Restart=always
ExecStartPre=chmod 666 /dev/gpiochip0
ExecStartPre=modprobe w1-therm
ExecStartPre=/bin/sleep 30

[Container]
ContainerName=gas-station
Environment=STATION_TOPIC_PATH=gas_station/ottawa/bank-street
Image=quay.io/midawson/gas-station:latest
Label="io.containers.autoupdate=image"
PublishPort=3000:3000
AddDevice=/dev/gpiochip0
PodmanArgs=--group-add keep-groups

[Install]
WantedBy=multi-user.target
```

# Starting at Boot



# Updating the application

1) building a new version of the application and pushing it to the registry with podman push quay.io/midawson/gas-station:latest

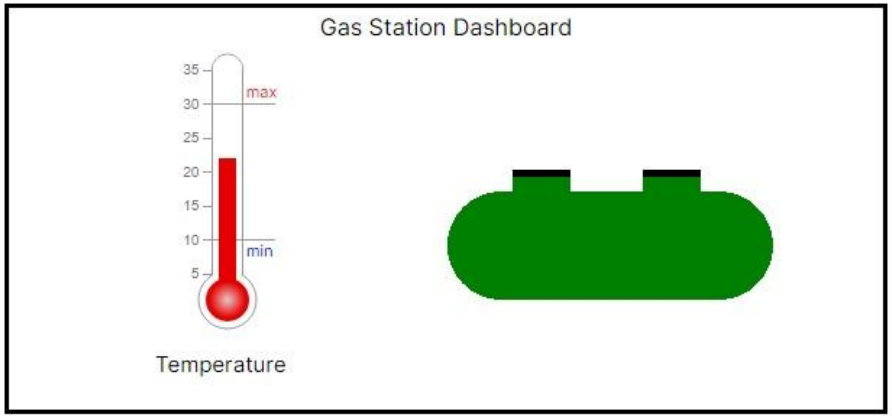
2) logging into the device and running:

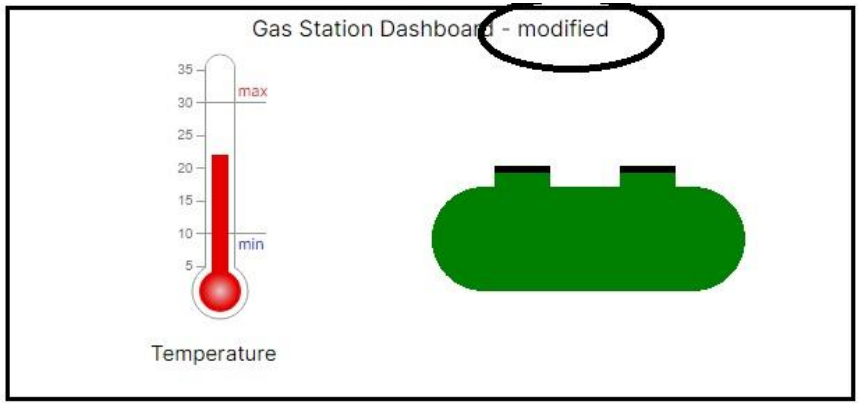
```
podman pull quay.io/midawson/gas-station:latest
systemctl restart gas-station
```

# Updating the application

```
/etc/containers/systemd/gas-station.container

[Service]
Restart=always
ExecStartPre=chmod 666 /dev/gpiochip0
ExecStartPre=modprobe w1-therm
ExecStartPre=/bin/sleep 30

[Container]
ContainerName=gas-station
Environment=STATION_TOPIC_PATH=gas_station/ottawa/bank-street
Image=[illegible]/mlawson/gas-station:latest
Label="io.containers.autoupdate=image"
PublishPort=3000:3000
AddDevice=/dev/gpiochip0
PodmanArgs=--group-add keep-groups

[Install]
WantedBy=multi-user.target
```

# Updating the application



# Fully configured SD Card - Updated blueprint

```
name = "fedora-base-container"
description = "base container launch template for Node.js edge example"
version = "0.0.1"
modules = []
groups = []
distro = ""

[[packages]]
name = "podman"

[[packages]]
name = "kernel-modules-extra"

[customizations]
[customizations.timezone]
[customizations.locale]
[customizations.firewall]
ports = ["3000:tcp"]
[customizations.firewall.services]
enabled = ["http", "https", "ntp", "dhcp", "ssh"]
disabled = ["telnet"]
[customizations.services]
enabled = ["sshd"]
```

# Fully configured SD Card

```
[[customizations.files]]
path = "/etc/containers/systemd/gas-station.container"
user = "root"
group = "root"
mode = "644"
data = "[Service]\nRestart=always\nExecStartPre=chmod 666 /dev/gpiochip0\nExecStartPre=modprobe
w1-therm\nExecStartPre=/bin/sleep
30\n\n[Container]\nContainerName=gas-station\nEnvironment=STATION_TOPIC_PATH=gas_station/ottawa/bank-street\nIma
ge=quay.io/midawson/gas-station:latest\nLabel=\"io.containers.autoupdate=image\"\nPublishPort=3000:3000\nAddDevi
ce=/dev/gpiochip0\nPodmanArgs=--group-add keep-groups\n\n[Install]\nWantedBy=multi-user.target\n"
```

# Advanced container management

- Red Hat Advance Cluster Management for Kubernetes
- Microshift
- Red Hat Device Edge with Microshift

# Advanced container management

OpenShift Local cluster is for development and testing purposes. DON'T use it for production.

Red Hat OpenShift | All Clusters | kubeadmin

- Home
- Infrastructure
- Applications
- Governance
- Credentials

## Clusters

Cluster list | Cluster sets | Cluster pools | Discovered clusters

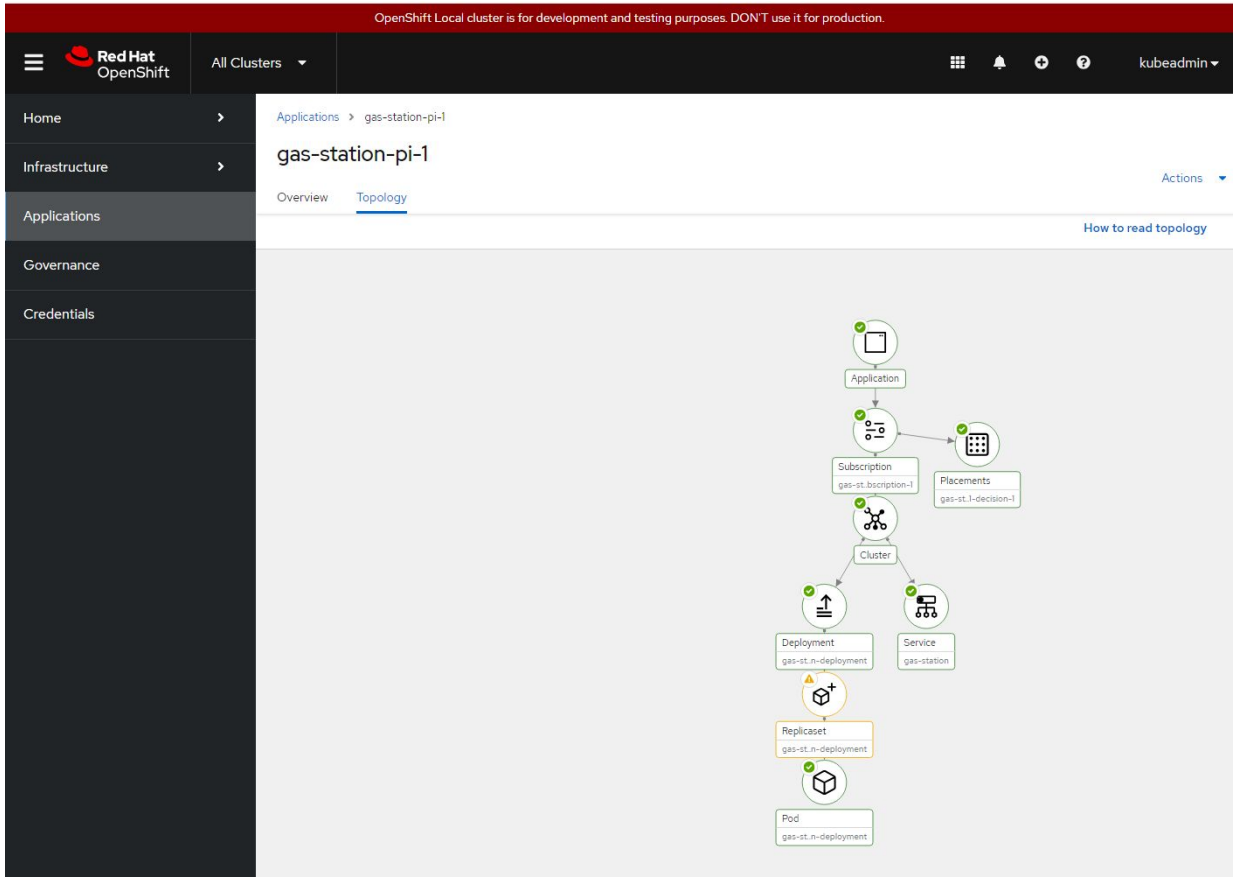
Get started with Multicluster Hub

Search | Filter | Create cluster | Import cluster | Actions | 1 - 3 of 3

| Name | Namespace | Status | Infrastructure | Control plane type | Distribution version | Labels | Nodes | Add-ons | Creation date |
|---|---|---|---|---|---|---|---|---|---|
| gas-station-pi-4 | gas-station-pi-4 | Ready | Red Hat Device Edge | Standalone | MicroShift 4.14.5 | microshiftVersi... 13 more | 1 | 9 | 4/10/2024, 8:33:54 PM |
| local-cluster | local-cluster | Ready | Other | Hub | OpenShift 4.15.3 Upgrade available | openshiftVersi... openshiftVersi... velero.io/exclu... 16 more | 1 | 9 | 4/9/2024, 8:31:43 AM |
| microshift-new-1 | microshift-new-1 | Ready | Red Hat Device Edge | Standalone | MicroShift 4.14.20 | microshiftVersi... 13 more | 1 | 9 | 4/9/2024, 9:20:07 PM |

1 - 3 of 3 items | 1 of 1 page

# Advanced container management



# Advanced container management

```
user1@microshift-new:~
bash-5.2#
bash-5.2#
bash-5.2#
bash-5.2#
bash-5.2#
bash-5.2#
bash-5.2#
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bash-5.2#
bash-5.2# oc get pods
NAME                                    READY   STATUS    RESTARTS   AGE
gas-station-deployment-5df5dbf989-dgsk4   1/1     Running   2          15h
bash-5.2#
```

# To dive into more details

- Three part blog post series:
  - Run Node.js applications on the edge with RHEL and Fedora
  - Containerizing your Node.js applications at the Edge on RHEL/Fedora
  - Advanced container management at the Edge for Node.js applications (coming soon)

# Q/A and Discussion

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