A Concise Strategy to get your Shiny App Online, Securely and Continuously Updated.

gitlab, Docker-compose, EC2 version

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Photo by Nathan Waters

1 Introduction

This is the second in a series of posts offering suggested strategies to solving one of the central challenges in the practice of data science, i.e. how to effectively communicate analysis results to clients and collaborators. The strategies are all based on a set of open source tools: linux, R, Shiny, Docker, docker-compose, Git, and Caddy. In this post we'll make use of two cloud services: Gitlab and Amazon Web Service (AWS). Further posts will describe alternative cloud services, e.g. using the low cost cloud service: Hetzner.

A similarly straightforward strategy, but one that avoids Gitlab and docker-compose is described here (here). This approach provides a simpler initial construction, but a more labor intensive updating process.

This post provides a proof-of-concept example of how to apply these technologies for hosting an interactive Shiny application. We start with a simple, stand-alone Shiny app on our local workstation, and end with an app running securely on a dedicated website with a custom domain name.

2 Methods

We'll start by creating a workspace for the project locally. We accomplish this indirectly by initiating a repo on `Gitlab` and then `clone` it to our local workstation. In other words, log into Gitlab and create a new empty private repo, call it, e.g. `power1_app`. Then on your local workstation navigate to your Shiny development directory, say e.g. `~/prj/shiny`, and clone the `power1_app` repo from Gitlab:

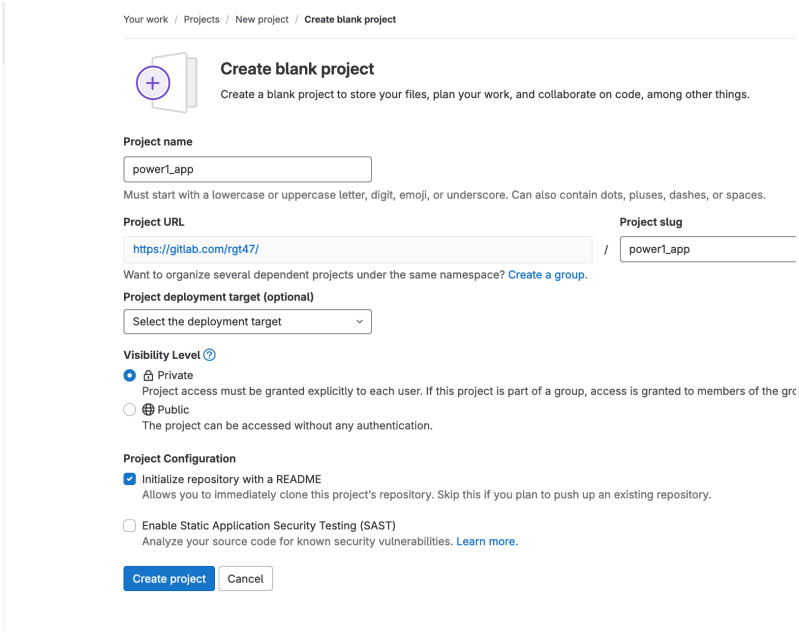
```
> cd ~/prj/power
> git clone https://gitlab.com/rgt47/power1_app.git
> git clone https://gitlab.com/rgt47/images.git
```

After cloning the repo to change directories into `~/prj/power1_app` and create two new sub-directories, `power1_shiny` and `site`. These directories will house our shiny app and our web site landing page, respectively.

Details for creating a gitlab repo follow:

- login to `gitlab` (see screenshot in margin)
- click on `New project`. Then in `repository name` field enter `power1_app`.
- make the repo private,
- leave `deployment target` empty.
- Click `Create project` blue button at the bottom of the page to create the repo.
- on your laptop cd to development directory, say ~/prj/power and clone the gitlab repo:

```
cd ~/prj/power
git clone https://gitlab.com/rgt47/power1_app.git
git clone https://gitlab.com/rgt47/images.git
cd power1_app
mkdir power1_shiny
mkdir site
```



Now begin shiny code development in the `~/prj/power/power1_app/power1_shiny` directory. See the `Shiny` code for our `power1_shiny` app (`app.R`).

For illustration we'll use the following example code:

The following is a Shiny app that is a balance of simple and functional: it calculates the power for a 2-sample t-test as a function of the standardized effect size.

The app is intentionally minimal. Using only base R functions, with a minimum of reactive widgets and layout commands to keep it simple while still performing a useful function.

The code is here:

```
ui <- fluidPage(
titlePanel("Power Calculator for Two Group Parallel Designs"),
sliderInput("N", "Total Sample Size:", min = 0, max = 300, value = 100),
plotOutput("plot"),
verbatimTextOutput("eff"))

server <- function(input, output, session) {
  delta = seq(0, 1.5,.05)
  pow = reactive(sapply(delta, function(x) power.t.test(input$N, d=x)$power ))
  eff =  renderText(power.t.test(input$N, power=.8)$d)
  output$plot <- renderPlot({
  plot(delta, pow(), cex=1.5, ylab="power")
  abline(h = .8,  col = "red", lwd =2.5, lty = 4)
  abline(v = eff(), col = "blue",lwd =2.5, lty = 4)})
  output$eff <- renderText(
    paste0("Std. effect detectable with power 80% = ", eff()) )
}
shinyApp(ui, server)
```

We can test the app locally in our development directory, `power1_app`, by runnning the following command.

```
> R -e "library(shiny); runApp('power1_shiny/app.R', launch=T)"
```

This command will run the R program, load the Shiny package, and launch the app in our default browser.

Figure 1 shows the Shiny app running locally in a browser, it consists of a widget to select the sample size and provide a dynamic visualization (2D plot) of the statistical power as a function of the standardized effect size:

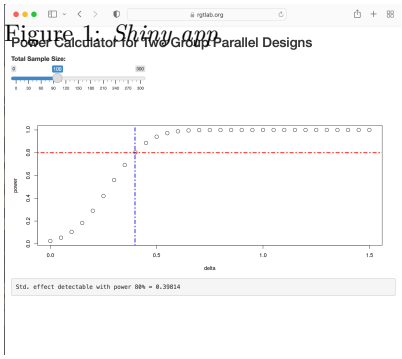


Figure 1: *Shiny app*

After determining the app is working as designed, the next step is to set up a secure host on the web and migrate the code. Once the app is hosted we simply need to send a link and security credentials to our collaborators for them to have secure access to the Shiny app.

"A **reverse proxy** is a server, app, or cloud service that sits in f"ront of one or more web servers to intercept and inspect incoming client requests before forwarding them to the web

server and subsequently returning the server's response to the client." reference

How to set up the hosting server? There are many ways to accomplish the hosting. Here we'll describe a straightforward and efficient approach using mainstream cloud services and open source tools. In other words, we'll describe how to 'spin' up a virtual server on Amazon Web Service EC2, and use Docker, R, Shiny, and Caddy to put in place a secure web app to share with our colleagues.

2.1 Hosting

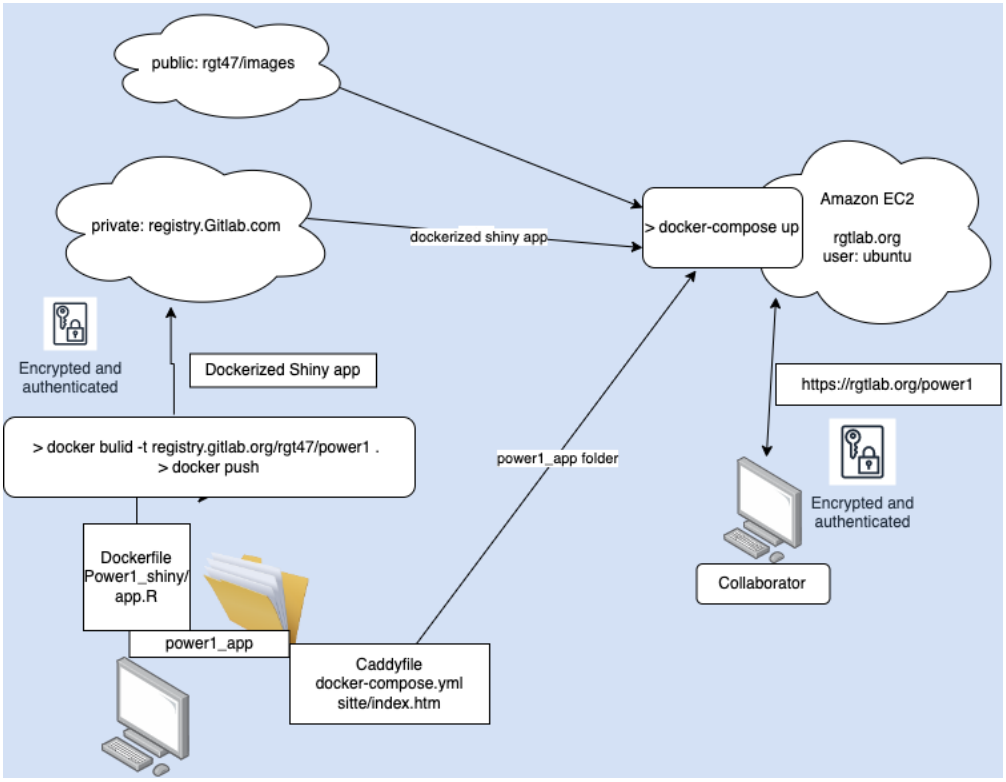


Figure 2: *Data flow*

Figure 2 illustrates the tools we'll use and the flow of program and configuration files. In order to host `power1_app` online we'll need to complete the following tasks:

1. Generate a virtual server with a firewall on EC2.
2. Obtain a static IPv4 address (to identify the server online)
3. Obtain a custom domain name (name to associate with static IP address) from a domain registration provider.
4. Install and configure a webserver (tool to interact with https protocol requests)
5. Obtain and install an TLS (transport layer security) security certificate (to allow encrypted communication between the server and other machines on the network)
6. Configure authentication for web site.
7. configure a reverse proxy method (translate https, port 443, requests to Shiny, port 3838 requests)

"What Is An SSL/TLS Certificate?

*An **SSL/TLS certificate** is a digital object that allows systems to verify the identity & subsequently establish an encrypted network connection to another system using the Secure Sockets Layer/Transport Layer Security (SSL/TLS) protocol. Certificates are used within a cryptographic system known as a public key infrastructure (PKI). PKI provides a way for one party to establish the identity of another party using certificates if they both trust a third-party - known as a certificate authority. SSL/TLS certificates thus act as digital identity cards to secure network communications, establish the identity of websites over the Internet as well as resources on private networks."*

reference

2.2 Select a hosting service

There are a number of cloud based server options: Microsoft Azure, Oracle, Google Cloud, Amazon AWS EC2, Digital Ocean to name a few. Each has their own approach to setting up a custom virtual server. Several have free or low-cost service tiers available.

An overview of the process using AWS EC2 follows. Detailed instructions for setting up a server on EC2, both via the console and the command line interface are covered in an earlier post (here) and (here).

Step 0. Create an account or sign in to the `AWS EC2` dashboard.

Step 1. Set up an interactive environment with AWS server. This entails:

a. define ssh key-pair.

b. configure firewall.

c. obtain static IP.

d. obtain domain name.

e. select an instance (AMI, type and disk size), generate and launch server.

Once the server is available, connect via ssh, and login,

The only software necessary to install is docker (assuming it wasn't installed in the server setup process). Install with the following commands:

```
sudo snap install docker.io
```

Once the host is set up and the requisite software installed, we'll have accomplished items 1, 2, and 3 from our `hosting` list above. i.e. a customized virtual server wtih a static IP address, with a unique domain name and firewall in place.

3 Configure

To configure the web server and containerize our app we need to add three files to the repo, to go along with our Shiny app. We'll also need a landing page for our web site.

We'll use `Gitlab` as an intermediate repository between our workstation and the EC2 server in an indirect route to create and place the necessary files on the server. This approach

will allow us to do all our continuing development on our local workstation and have the web app be automatically continually undated. We'll create the configuration files we need on our workstation and push them to `Gitlab` and from there they can be accessed from our server.

These three configuation files are:

3.1 Docker

Photo by Ian Taylor on Unsplash

We'll use docker to access Shiny, and docker-compose to access Caddy, our webserver. The first file is the dockerfile. Here is our minimal dockerfile:

```
FROM rocker/shiny:4.2.0
RUN rm -rf /srv/shiny-server
COPY /power1_shiny/* /srv/shiny-server/
USER shiny
CMD ["/usr/bin/shiny-server"]
```

This configuration file instructs Docker to build a container based on a Rocker/Shiny image (constructed as a ubuntu image with R and Shiny installed), then copy the `power1_shiny/app.R` code into the container

and finally launch Shiny on (default) port 3838. We placed the `power1_app/app.R` code in the default location `/srv/shiny-server` we only need to start the server and it will find the shiny program.

Start by building and pushing the image to the `gitlab` container registry.

Note: We placed the `power1_shiny/app.R` code in the default location `/srv/shiny-server` so we only need to start the Shiny server and it will find the shiny program

```
# login to gitlab

cat gitlab_access_token | docker login \
registry.gitlab.com -u rgt47 --password-stdin

docker build -t \
registry.gitlab.com/rgt47/power1_app/power1_image:v1.0 \
        --platform linux/x86_64 .
docker push \
registry.gitlab.com/rgt47/power1_app/power1_image:v1.0
```

3.2 Caddy

A Caddy web server configuration file (default name `Caddyfile`)

We'll use `Caddy` as our web server. Caddy is an open-source tool that has the very useful feature of automating the acquisition and installing of an SSL certificate. An SSL cert is required by most browsers to use the encrypted communication protocol https.

We use the caddy configuration file to specify three critical things.

1. the site domain name.
2. the 'reverse proxy' map that redirects requests to port 443 (ssl port) to port 3838 (Shiny port).
3. add login credentials for all users (e.g. bob/vanilla47):

Our barebones `Caddyfile` looks like this:

```
# use caddy auth tool to generate a password via the `bcrypt` algorithm.
# > caddy hash-password --plaintext hiccup

rgtlab.org {
basicauth /power1/* {
    Bob $2a$14$Zkx19XLiW6VYouLHR5NmfOFU0z2GTNmpkT/5qqR7hx4IjWJPDhjvG
}
    root * /srv
    handle_path /power1/* {
        reverse_proxy power1:3838
    }
    file_server
}
```

We can accomplish what we need for items 4, 5, and 7 through the Caddyfile.

Note:

- rgtlab.org is our domain name
- `handle_path` maps all https requests to port 3838 where Shiny is listening.

Providing our servers domain name, `rgtlab.org` is sufficient to initiate an exchange with the `letsencrypt` service to generates an SSL certificate.

3.3 Docker Compose

And a third file is a config file for Docker Compose. Docker Compose is a Docker module that provides a framework for running multi-container applications. This docker compose YAML file instructs Docker to containerize our Shiny app, pull a caddy webserver image from Docker Hub and create a local network for the two containers to communicate in.

A Docker-compose configuration file (default name `docker-compose.yml`).

The `docker-compose.yml` file:

```
version: "3.7"

services:
  power1:
    image: registry.gitlab.com/rgt47/power1_app/power1_image:v1.0
    restart: unless-stopped
    expose:
      - "3838"
  caddy:
    image: caddy:2.6.4-alpine
    restart: always
    ports:
      - "443:443"
    volumes:
      - $PWD/Caddyfile:/etc/caddy/Caddyfile
      - $PWD/site:/srv
      - caddy_data:/data
      - caddy_config:/config
    depends_on:
      - power1
    environment:
      - HOST="rgtlab.org"
      - EMAIL="rgthomas@ucsd.edu"
volumes:
  caddy_data:
  caddy_config:
```

3.4 Landing Page

Lastly, we need an html file, `index.html` in a subdirectory named `site` that provides the landing page for our server.

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title>Power Calculators</title>
```

```
    <link rel="stylesheet" href="https://unpkg.com/bulma@0.9.0/css/bulma.min.css" />
  </head>
  <body>
    <div id="app">
      <section class="hero is-small">
        <div class="hero-body">
          <div class="container has-text-centered">
            <h1 class="title">RGT Lab Power Calculators</h1>
          </div>
        </div>
      </section>
            <hr>

            <div class="columns">
              <div class="column is-4 is-offset-1">
      <img src="https://github.com/rgt47/power0/blob/master/power1.png?raw=true"
        width="200" height="250"  "float: left; padding: 3px 3px 0px 3px;" >
              </div>
              <div class="column is-6">
                <h1 class="title"> Power1 App </h1>
                <p> Power for two-sample t-test </p>
                <br>
                <a href="./rebecca/" class="button is-info">Go to app</a>
              </div>
            </div>

    </div>
  </body>
</html>
```

At this point our `power1_app` repo looks like this:

```
.
   Caddyfile
   Dockerfile
   docker-compose.yml
   site
       index.html
```

4 Gitlab

Push the new content to gitlab.

```
git push
```

Login to `gitlab` and issue a personal access token. Save it as `gitlab_access_token` in the `power1_app` directory.

Next login to the virtual server and clone the repo from gitlab.

```
ssh rgtlab.org
cat gitlab_access_token | \
  docker login registry.gitlab.com -u rgt47 --password-stdin
git clone https://gitlab.com/rgt47/power1_app.git
```

Lastly, cd into `power1_app` directory and run

```
docker compose up -d
```

and you're good to go! The `power1_shiny` app is available at:

```
https://rgtlab.org/
```

5 Appendices

5.1 Tip 1. Docker on M1 macbook.

To get docker functioning properly with `rocker` images on M1 Mac desktop use `--platform` option.

```
docker build -t power1_shiny --platform linux/x86_64 .
docker run -d -p 80:3838 --platform linux/x86_64 power1_shiny
```

5.2 Tip 2 add user to docker group on server.

Add ubuntu to the docker group to allow docker to run without sudo.

```
sudo usermod -aG docker ${USER}
```

5.3 Tip 3 ssh config file.

For convenience, construct a `config` file in `~/.ssh` as:

```
Host rgtlab.org
HostName 13.57.139.31 # static IP
User ubuntu # default user on ubuntu server
Port 22  # the default port ssh uses
IdentityFile ~/.ssh/power1_app.pem
```

then you can ssh into the new server with

```
sh> ssh rgtlab.org
```

6 References

- Focus on R: a new qblog - Set up a virtual server on AWS (in anticipation of hosting Shiny apps)
- Focus on R: a new qblog - Set up a virtual server on AWS with AWS CLI
- Shiny Apps with Docker Compose, Part 1: Development
- Shiny Apps with Docker Compose, Part 2: Production

7 APPENDIX

```
2023-12-02

workflow. steps to go from
a) have an idea for a shiny app to help rebecca
to
b) a secure app available at https://rgtlab.org/rebecca_stats

1. log into gitlab to set up the private holding repositories:
rgt47/rebecca_data and rgt47/rebecca_images

-   click on `New project`.
Then in `repository name` field enter ` rebecca_data`.
-   make the repo private,
-   leave `deployment target` empty.
-   Click `Create project` blue button at the bottom of
    the page to create the repo.

 repeat for a second project named rebecca_images.

 create a personal access token

a) left sidebar click avatar.
edit profile
  access tokens
    name: rebecca_prj
    expiration date: one month 1/1/24
    scope: api
copy token to clipboard
glpat-hUKXsZKkhVAb4CT7hTZj

back on laptop
git clone both new directories to ~/sbx
git clone https://gitlab.com/rgt47/rebecca_data.git
git clone https://gitlab.com/rgt47/rebecca_images.git

cd rebecca_data

cat gitlab_token
glpat-hUKXsZKkhVAb4CT7hTZj
```

```
^D

mkdir shiny_app
mkdir website
cd shiny_app
develop shiny code (app.R) in shiny_app directory.
run code to validate.
R -e "library(shiny); runApp('app.R', launch=T)"

cd back up to repo root
cd ~/sbx/rebecca_data

create dockerfile :

# Dockerfile
FROM rocker/shiny:4.2.0
RUN rm -rf /srv/shiny-server
COPY /shiny_app/* /srv/shiny-server/
USER shiny
CMD ["/usr/bin/shiny-server"]

run docker build

docker build -t registry.gitlab.com/rgt47/rebecca_data/shiny_image:v1.0 --platform linux/x86_64

push image to gitlab
# login to gitlab
cat gitlab_token | docker login registry.gitlab.com -u rgt47 --password-stdin

docker push registry.gitlab.com/rgt47/rebecca_data/shiny_image:v1.0

create Caddyfile, docker-compose.yml, website/index.html


git add .
git commit -m "commit support files for Shiny app."
git push

all shiny app files now in gitlab in rgt47:rebecca_data
```

```
spin-up server on aws rgtlab.org
need keypair, security group, and instance (other parameters known:
vpc id, subnet id, ami id, storage size, static ip

> ~/bin/aws/aws_create_keypair.sh -k rebecca_app
key_pair_name is rebecca_app
> ~/bin/aws/aws_create_security_group.sh -s rebecca_app
error in command line parsing. Expect options n and p
> ~/bin/aws/aws_create_security_group.sh -n rebecca_app -p 22 -p 443
sg group name = rebecca_app
security group ID = sg-008cace70d32f6267
> vz (vim .zshrc)
> #update sg id and project name in .zshrc and source
> sz (source .zshrc)
> ~/bin/aws/aws_create_instance.sh -p rebecca_app
i-06c9b50e6c6e03874
should be only one instance id. if more than one, check aws console for multiple
instances with same prj name
wait 15 seconds for instance to generate and then associate static IP

check ~/.ssh/config to be sure it has correct keypair name and IP
address.

# check that domain name, hostname, and secret key are correct
Host rgtlab.org
    HostName 13.56.101.209
    StrictHostKeyChecking no
    User ubuntu
    Port 22
    IdentityFile ~/.ssh/rebecca_app.pem

   should be able to log in as
   > ssh rgtlab.org

scp files to rgtlab for
gitlab access
> scp gitlab_token rgtlab.org:~

login to rgtlab.org
check aws_start_up code worked
```

```
cat /var/log/cloud-init-output.log
clone the code directory from gitlab

git clone https://gitlab.com/rgt47/rebecca_data.git
login for docker

:~/rebecca_data$ docker login registry.gitlab.com -u rgt47 -p glpat-hUKXsZKkhVAb4CT7hTZj

registry.gitlab.com/rgt47/rebecca_data/shiny_image:v1.0
docker compose stop
docker compose rm -f
docker compose pull
docker compose up -d


~/master-repo (main  )    cat Caddyfile

rgtlab.org {
basicauth /rebecca/* {
    Bob $2a$14$Zkx19XLiW6VYouLHR5NmfOFU0z2GTNmpkT/5qqR7hx4IjWJPDhjvG
}

    root * /srv
    handle_path /rebecca/* {
        reverse_proxy rebecca:3838
    }
    file_server
}

> cat docker-compose.yml


version: "3.7"

services:
  watchtower:
    container_name: watchtower
    restart: always
    environment:
      WATCHTOWER_POLL_INTERVAL: 3600
```

```
      TZ: America/Los_Angeles
      WATCHTOWER_CLEANUP: "true"
      WATCHTOWER_DEBUG: "true"
    image: containrrr/watchtower
    volumes:
      - /var/run/docker.sock:/var/run/docker.sock
      - /home/ubuntu/.docker/config.json:/config.json
  rebecca:
    image: registry.gitlab.com/rgt47/rebecca_data/shiny_image:v1.0
    restart: unless-stopped
    ports:
      - "9000:3838"
  caddy:
    image: caddy:2.6.4-alpine
    ports:
      - "80:80"
      - "443:443"
    volumes:
      - $PWD/Caddyfile:/etc/caddy/Caddyfile
      - $PWD/website:/srv
      - caddy_data:/data
volumes:
    caddy_data:

~/master-repo (main )    cat site/index.html

<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title>Power Calculators</title>
    <link rel="stylesheet" href="https://unpkg.com/bulma@0.9.0/css/bulma.min.css" />
  </head>
  <body>
    <div id="app">
      <section class="hero is-small">
        <div class="hero-body">
          <div class="container has-text-centered">
```

```
            <h1 class="title">RGT Lab Power Calculators</h1>
          </div>
        </div>
      </section>
            <hr>

            <div class="columns">
              <div class="column is-4 is-offset-1">
      <img src="https://github.com/rgt47/power0/blob/master/power1.png?raw=true"
        width="200" height="250"  "float: left; padding: 3px 3px 0px 3px;" >
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                <p> Power for two-sample t-test </p>
                <br>
                <a href="./rebecca/" class="button is-info">Go to app</a>
              </div>
            </div>


    </div>
  </body>
</html>
```

todo

move images to gitlab repo

work on streamlining changes for a new project name i.e. change
rebecca to new_project where?