Resen

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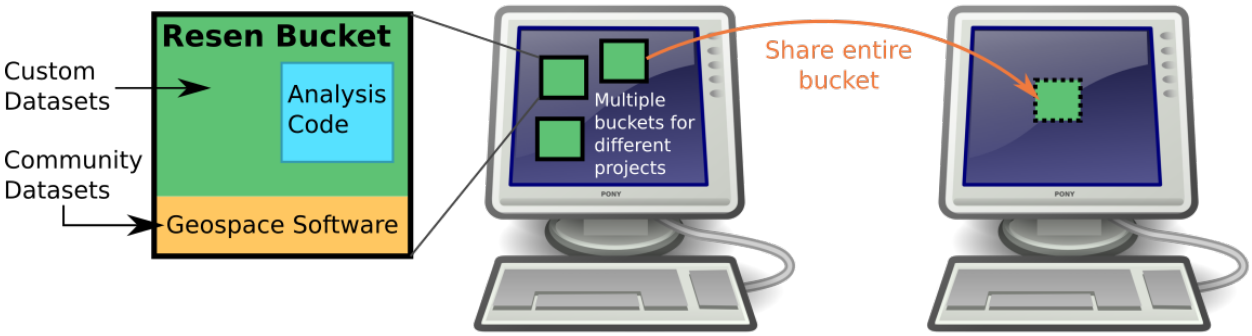
Contents

CHAPTER 1

Resen

Resen (REproducible Software ENvironment), is a tool that enables reproducible scientific data analysis, built using python and docker. It is designed to make it easier for geospace researchers to share analysis and results, as well as build off of work others have done. Resen was developed under the InGeO project, currently supported by the National Science Foundation's Cyberinfrastructure for Sustained Scientific Innovation (CSSI) program (Grant #1835573). For more information about the InGeO project, please visit the InGeO website.



Resen is based on the concept of portable environments, or buckets, where code can be developed and run independent of a users system. When you start a resen bucket, it has a variety of common geospace software packages preinstalled and ready for use. This means you have easy access to common models and datasets, and can start using them in your analysis immediately. You can also set up your bucket to access your own datasets, locally stored on your machine.

After you have completed your analysis, you can share an entire bucket with other researchers. Within the bucket, your analysis code will always run exactly the same way, regardless of what system the bucket is on. This means that other researchers should be able to reproduce your work and start building off of it immediately, instead of spending time configuring their system, installing new packages, and setting up file paths so their environment is compatible with your code.

1.1 Quickstart

1.1.1 Installation

Resen requires both python 3 and docker to be installed.

1. Install Python 3
2. Install docker
3. Install Resen with pip `pip install git+https://github.com/EarthCubeInGeo/resen.git@v2020.2.1`

Please refer to the *installation documentation* for more detailed instructions.

1.1.2 Usage

Resen is a command line tool. To start resen, simply enter `resen` at a command prompt:

```
$ resen
```

For a list of available commands, use the `help` command:

```
[resen] >>> help
```

Resen Workflow Example

1.2 Documentation

Complete documentation for Resen is available at https://resen.readthedocs.io/.

CHAPTER 2

Installation

2.1 Gerneral Instructions

Resen is built off of both python 3 and docker, so you must have both of these installed for Resen to function.

2.1.1 Python 3

Python (https://www.python.org/) is an open source, interpreted programming language that is both powerful and easily to learn. There are many ways you can install python on your system. For new users, we recommend downloading and installing the latest Python 3 Anaconda Distribution (https://www.anaconda.com/distribution/) for your system. This will save you the trouble of building a python distribution from scratch.

2.1.2 Docker

Docker CE is the recommended version of Docker to use with Resen. Installation instructions can be found in the docker documentation. Please read installation instructions carefully! For convenience, some OS specific links are provided below:

MacOS: Install Docker Desktop for Mac
Important! Docker Desktop only supports the latest two versions of MacOS. Earlier versions of MacOS should install Docker Toolbox.

Windows: Install Docker Desktop for Windows
Important! If you are already using virtualbox, do NOT install Docker Desktop. Instead, install Docker Toolbox.

CentOS: Get Docker CE for CentOS

Debian: Get Docker CE for Debian

Fedora: Get Docker CE for Fedora

Ubuntu: Get Docker CE for Ubuntu

If using a Linux system, consider following the Post-installation steps for Linux for smoother integration of docker with your host system.

2.1.3 Resen

Install Resen from a python 3 environment using `pip`:

```
pip install git+https://github.com/EarthCubeInGeo/resen.git@v2020.2.0
```

2.2 Windows Gotchas

Resen requires both python 3 and docker to function. Here we provide a basic guide for installing both python 3 and docker. We have tested this procedure and know it works. Python 3 and Resen are easy to install. Docker is also fairly easy, but there are some subtle details that need to be emphasized for a smooth installation process.

2.2.1 Install Anaconda and Resen

Anaconda: We recommend downloading and installing the Python 3 Anaconda Distribution (https://www.anaconda.com/distribution/). This simplifies the installation and usage of several common software tools needed to install and run Resen.

Resen: Using the start menu search, open the "Anaconda Powershell Prompt" and install Resen using `pip`:

```
pip install git+https://github.com/EarthCubeInGeo/resen.git@v2019.1.1
```

Once complete, this will provide the command line command `resen`. Next, we need to install Docker.

2.2.2 Docker

For Windows, there are 2 options for installing Docker, which depends on what else you use and do with your Windows system:

1. Docker Desktop for Windows
2. Docker Toolbox

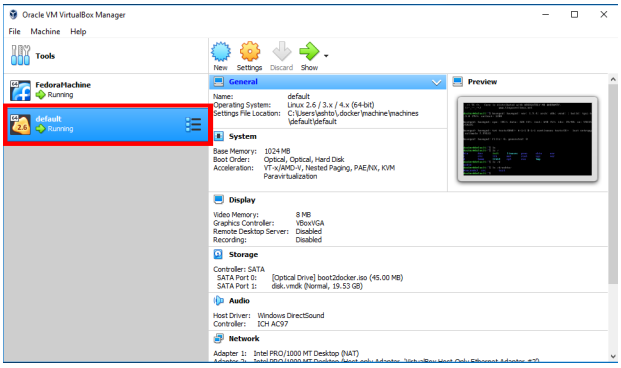
If you use Oracle VM VirtualBox to run virtual machines on your Windows system, DO NOT install Docker Desktop. You must instead install Docker Toolbox. Docker Desktop uses Hyper-V, which is not compatible with VirtualBox.

Docker Desktop TODO. If you can help fill this in, please make a PR to the develop branch for resen!

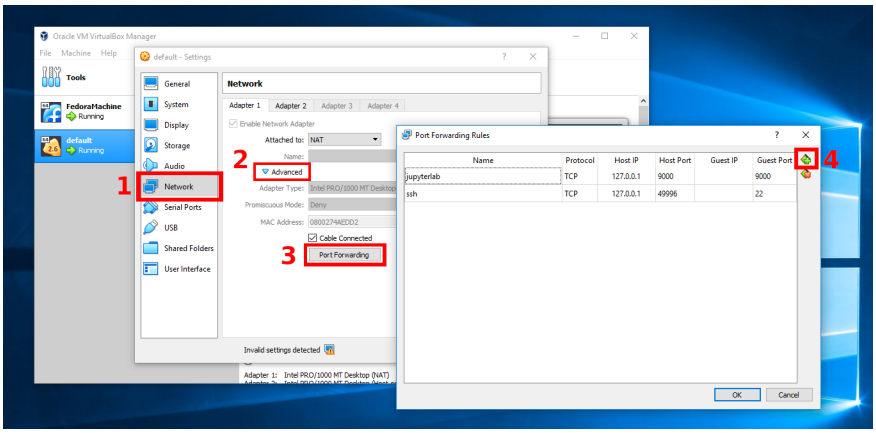
Docker Toolbox Docker Toolbox essentially works by running docker inside of a Linux virtual machine using VirtualBox. The VM that gets installed is name "default" and we will refer to this "default" Docker virtual machine as the "Docker VM". To install it Docker Toolbox, do the following:

1. Shutdown any VirtualBox VMs that you currently have running and take note of the VirtualBox version you have installed. Docker Desktop installs an older version of VirtualBox on your system, but this version you are currently running can be upgraded back to the version you are currently running.
2. Follow the instructions on here to install Docker Toolbox. Once installed, restart your computer and then run the `Docker Quickstart Terminal` from the start menu. `TODO: insert screenshot`

3. Now we need to add port forwarding and check the shared folders for the Docker VM in VirtualBox. To do this, open VirtualBox and open the "Settings" for the "default" VM, like so:

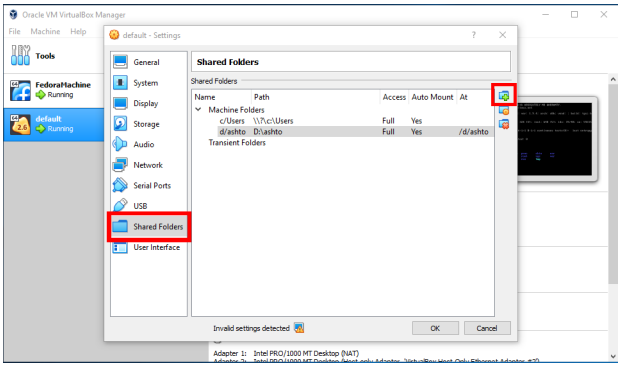


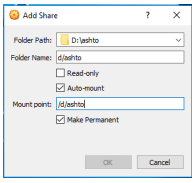
Add a new port forwarding rule by navigating to Settings->Network->Adapter 1->Advanced->Port Forwarding:



Here, we need to add a port forwarding rule for each bucket we create in Resen. Resen requires port 9000 for one bucket and then increments by 1 for every new bucket created. This means that if you have 5 buckets, you will need to make a port forward rule for ports 9000, 9001, 9002, 9003, and 9004. Change both the Host and Guest Ports as seen in the above screenshot.

Now we can optionally add Shared Folders. By default, Docker Toolbox shares the `C:\Users` directory with the Docker VM at `/c/Users`. If additional shared directory locations are desired add them. For example:





makes an additional location, `D:\ashto` available to the Docker VM at the location `/d/ashto`. After adding or removing Shared Folders, you must restart the Docker VM. This can be done by running:

```
docker-machine restart
```

in the "Docker Quickstart Terminal".

4. Optionally, you can now re-install the newer verions of VirtualBox that you had previously installed. Before doing this, shutdown the Docker Toolbox VM. After re-installing VirtualBox, restart your computer and then open the "Docker Quickstart Terminal" again.

Running Resen

Now you can run Resen! To do this, open an "Anaconda Powershell Prompt" and type "resen" and hit enter. A prompt should appear that asks if you are using Docker Toolbox:

```
Resen appears to be running on a Windows system.  Are you using Docker Toolbox? (y/n):
```

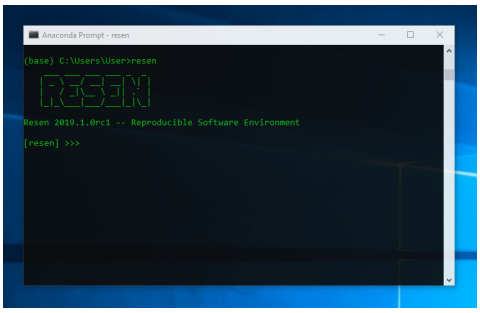
If you installed Docker Desktop for Windows, enter `n`. If you set up Docker Toolbox as described above enter `y`. If you respond `y`, you will be asked to specify the mapping between shared folders on the host machine and the Docker VM. This is referring to the Shared Folders set up in step 3 above. If you did not modify the default shared folder, the correct response should be:

```
Please specify the mapping between shared folders on the host machine and the Docker␣
↪VM.
Host machine path: C:\Users
Docker VM path: /c/Users
```

This will be different if you have made a different location available to the Docker VM, such as `D:\ashto` as described above. In this case, the correct response will be:

```
Please specify the mapping between shared folders on the host machine and the Docker␣
↪VM.
Host machine path: D:\ashto
Docker VM path: /d/ashto
```

Now Resen should be configured and ready to go! You should see something similar to:



CHAPTER 3

Usage

To use resen, simply enter `resen` at the command line:

```
$ resen
```

This will open the resen tool:

```
    ___ ___ ___ ___ _  _
   | _ \ __/ __| __| \| |
   |   / _|\__ \ _|| .` |
   |_|_\___|___/___|_|\_|

Resen 2020.2.1 -- Reproducible Software Environment

[resen] >>>
```

Type `help` to see available commands:

```
[resen] >>> help
```

This will produce a list of resen commands you will use to manage your resen buckets:

```
Documented commands (type help <topic>):
========================================
EOF     exit    help    list  remove  status  update
create  export  import  quit  start   stop
```

To get more information about a specific command, enter `help <command>`.

3.1 Resen Workflow

To create, import, export, and remove buckets, we use Resen. Buckets are portable, system independent environments where code can be developed and run. Buckets can be shared between Windows, Linux, and macos systems and all

analysis within the bucket will be run exactly the same. Resen buckets come preinstalled with a variety of common geospace software that can be used immediately in analysis.

The interface to a resen bucket is a jupyter lab server and access to the bucket is provided through a web browser. The user home directory is `/home/jovyan`. Any mounted storage directories are available in `mount`.

Below are instructions on how to use Resen to work with buckets. A typical workflow will involve: creation of a bucket, performing scientific data analysis inside the bucket, exporting the bucket and sharing it with colleagues. Collaborators can then import the bucket, perform additional analysis, and then export the bucket for publication in an open access citable repository, such as Zenodo.

3.1.1 Update List of Available Cores

1. Before creating a new bucket, update the list of available cores with the command:

```
[resen] >>> update
```

When you install resen, it comes with a list of available core, but we will release new versions periodically. This update command fetches the most up to date list which allows you to use the latest version of resen-core.

3.1.2 Setup a New Bucket

1. Creating a new bucket is performed with the command:

```
[resen] >>> create
```

The `create` command queries the user for several pieces of information required to create a bucket. First it asks for the bucket name. Creating a bucket named `amber`:

```
Please enter a name for your bucket.
Valid names may not contain spaces and must start with a letter and be less than␣
↪20 characters long.``
>>> Enter bucket name: amber
```

Next, the user is asked to specify the version of resen-core to use:

```
Please choose a version of resen-core.
Available versions: 2019.1.0, 2020.1.0, 2020.2.0
>>> Select a version: 2020.2.0
```

Optionally, one may then specify a local directory to *mount* into the bucket at `/home/jovyan/mount`:

```
Local directories can be mounted to either /home/jovyan/work or /home/jovyan/
↪mount/ in
a bucket. The /home/jovyan/work location is a workspace and /home/jovyan/mount/␣
↪is intended
for mounting in data. You will have rw privileges to everything mounted in work,␣
↪but can
specify permissions as either r or rw for directories in mount. Code and data␣
↪created in a
bucket can ONLY be accessed outside the bucket or after the bucket has been␣
↪deleted if it is
saved in a mounted local directory.
>>> Mount storage to /home/jovyan/mount? (y/n): y
>>> Enter local path: /some/local/path
```

Finally, the user is asked if they want jupyterlab to be started:

```
>>> Start bucket and jupyterlab? (y/n): y
```

after which resen will begin creating the bucket. Example output for a new bucket named `amber` with jupyterlab started is:

```
...adding core...
...adding ports...
...adding mounts...
Bucket created successfully!
...starting jupyterlab...
Jupyter lab can be accessed in a browser at: http://localhost:9002/?
↪token=e7a11fc1ea42a445807b4e24146b9908e1abff82bacbf6f2
```

2. Check the status of the bucket:

```
[resen] >>> status amber

amber
=====

Resen-core Version:  2020.2.0
Status:  running
Jupyter Token:  e7a11fc1ea42a445807b4e24146b9908e1abff82bacbf6f2
Jupyter Port:  9002
Jupyter lab URL: http://localhost:9002/?
↪token=e7a11fc1ea42a445807b4e24146b9908e1abff82bacbf6f2

Storage:
Local                                   Bucket                                  ␣
↪Permissions
/some/local/path                        /home/jovyan/mount/path                  rw

Ports:
Local          Bucket
9002           9002
```

At this point, the bucket should have a name, an image, at least one port, and optionally one or more storage locations. Status should be `running` if the user decided to have jupyterlab started, otherwise the status will be `None`.

3.1.3 Work with a Bucket

1. Check what buckets are available with `list`:

```
[resen] >>> list
Bucket Name          Docker Image              Status
amber                2020.2.0                  running
```

If a bucket is running, it will consume system resources accordingly.

2. Stop the bucket `amber`:

```
[resen] >>> stop amber
```

The status of `amber` should now be `exited`:

```
[resen] >>> list
Bucket Name          Docker Image              Status
amber                2020.2.0                  exited
```

The bucket will still exist and can be restarted at any time, even after quitting and restarting resen.

3. Start the bucket `amber` that was just stopped:

```
[resen] >>> start amber
```

The status of `amber` should now be `running`:

```
[resen] >>> status
Bucket Name          Docker Image              Status
amber                2020.2.0                  running
```

4. Export bucket `amber`:

```
[resen] >>> export amber
```

The `export` command will ask a series of question. First, provide a name for the output *.tar file:

```
>>> Enter name for output tar file: /path/for/output/amber.tar
```

If desired, change the default name and tag for the exported image:

```
By default, the output image will be named "amber" and tagged "latest".
>>> Would you like to change the name and tag? (y/n): y
>>> Image name: custom_name
>>> Image tag: custom_tag
```

Specify if you want all mounted directories to be included in the exported bucket. Answering *n* to this query will allow you to see how large each mount is and specify which you would like to include. Consider excluding any mounts that are not necessary for the analysis to reduce the size of the output file:

```
The following local directories are mounted to the bucket (total 2212 MB):
/home/usr/mount1
/home/usr/mount2
/home/usr/mount3
>>> Would you like to include all of these in the exported bucket? (y/n): n
>>> Include /home/usr/mount1 [154.68095 MB]? (y/n): y
>>> Include /home/usr/mount2 [2005.28493 MB]? (y/n): y
>>> Include /home/usr/mount3 [53.59823 MB]? (y/n): y
```

Confirm that you want to continue with the export. The values shown should be considered a "high-side" approximation and may not be the actual final size:

```
This export could require up to 13337 MB of disk space to complete and will␣
↪produce an output file up to 4600 MB.
>>> Are you sure you would like to continue? (y/n): y
Exporting bucket amber.  This will take several minutes.
```

If a full path is not provided for the output file name, the default location for the output file is whatever directory resen was started in. For example, if you start resen in `~\Desktop\MyStuff` and respond to the first prompt with `new_bucket`, the output tar file will be `~\Desktop\MyStuff\new_bucket.tar`.

5. Import a new bucket, `amber2`, from a tar file `amber.tar`:

```
[resen] >>> import
```

This command will also ask a series of questions. First provide a name for the imported bucket:

```
Please enter a name for your bucket.
Valid names may not contain spaces and must start with a letter and be less␣
↪than 20 characters long.
>>> Enter bucket name: amber2
```

Specify the *.tar file to import the bucket from:

```
>>> Enter name for input tar file: /path/to/file/amber.tar
```

If desired, enter a custom image name and tag. If not provided, the name an image saved on export will be used:

```
>>> Would you like to keep the default name and tag for the imported image?␣
↪(y/n): n
>>> Image name: amber2
>>> Image tag: new_tag
```

When a bucket that had mounts is imported, the mounted directories must be extracted and saved on the local machine. Resen will do this automatically, but you have the option to specify where these files should be saved instead of the default location:

```
The default directory to extract the bucket metadata and mounts to is /
↪default/save/path/resen_amber2.
>>> Would you like to specify and alternate directory? (y/n): y
>>> Enter path to directory: /new_save_path
```

Aside from the existing mounts, you can add new mounts to a imported bucket. This is useful if you would like to repeat the analysis with a different dataset:

```
>>> Mount additional storage to the imported bucket? (y/n): y
>>> Enter local path: /new/local/path/new_mount
>>> Enter bucket path: /home/jovyan/mount/new_mount
>>> Enter permissions (r/rw): r
>>> Mount additional storage to /home/jovyan/mount? (y/n): n
```

Similar to `create`, you have the option to start jupyter lab immediately after the bucket is imported:

```
>>> Start bucket and jupyterlab? (y/n): y
...starting jupyterlab...
Jupyter lab can be accessed in a browser at: http://localhost:9003/?
↪token=70532767bab0ddc4febe2790efaaf974961e961e78e6025a
```

3.1.4 Sudo-enabled buckets

When starting a bucket with resen, *sudo* is enabled for the jovyan user to allow special installation and configuration where root security privileges are needed. The password for running *sudo* commands with user jovyan is: *ganimede*.

3.1.5 Remove a Bucket

WARNING: This will permanently delete the bucket. Any work that was not saved in a mounted storage directory or downloaded from the bucket will be **permanently lost**.

The user can delete a bucket with the following command:

```
[resen] >>> remove amber
```

A bucket that is running needs to be stopped before being removed.

CHAPTER 4

Tutorials

The InGeO team has collected a variety of tutorials to help new users get started with everything from python basics to using specific geospace packages included in Resen. These tutorials are available as jupyter notebooks and are automatically mounted in Resen Online, however, in deference to users who may want a cleaner starting environment, they have not been automatically included in the resen-core image. The simplest way to access a tutorial is to download it directly into your resen bucket.

1. Start a bucket.
2. Launch a terminal window.
3. Navigate to where you would like the tutorial to be saved with *cd*. For instance, to save tutorials to the work directory:

```
$ cd /home/jovyan/work
```

4. Copy/paste the appropriate fetching command from the table below to download the tutorial, for example:

```
$ wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/
↪tutorials/GetStartedWithPython.ipynb
```

After downloading completes, the tutorial notebook should be visible in the navigation toolbar. By double-clicking, you can launch the jupyter notebook, read through descriptions, try example code, and even modify the notebook to try new things.

Tutorials	Fetch Command
GetStartedWith-Python.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/GetStartedWithPython.ipynb`
GetStartedWith-Jupyter.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/GetStartedWithJupyter.ipynb`
GetStartedWith-Resen.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/GetStartedWithReSEn.ipynb`
GeospacePackagesInResen.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/GeospacePackagesInResen.ipynb`
CaseStudy.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/CaseStudy.ipynb`
Intro-Swarm-viresclient.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/Intro-Swarm-viresclient.ipynb`
ICON-Data-Demo.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/ICON-Data-Demo.ipynb`
Citation-Helper.ipynb	`wget https://raw.githubusercontent.com/EarthCubeInGeo/resen-core/v2020.2.1/tutorials/CitationHelper.ipynb`

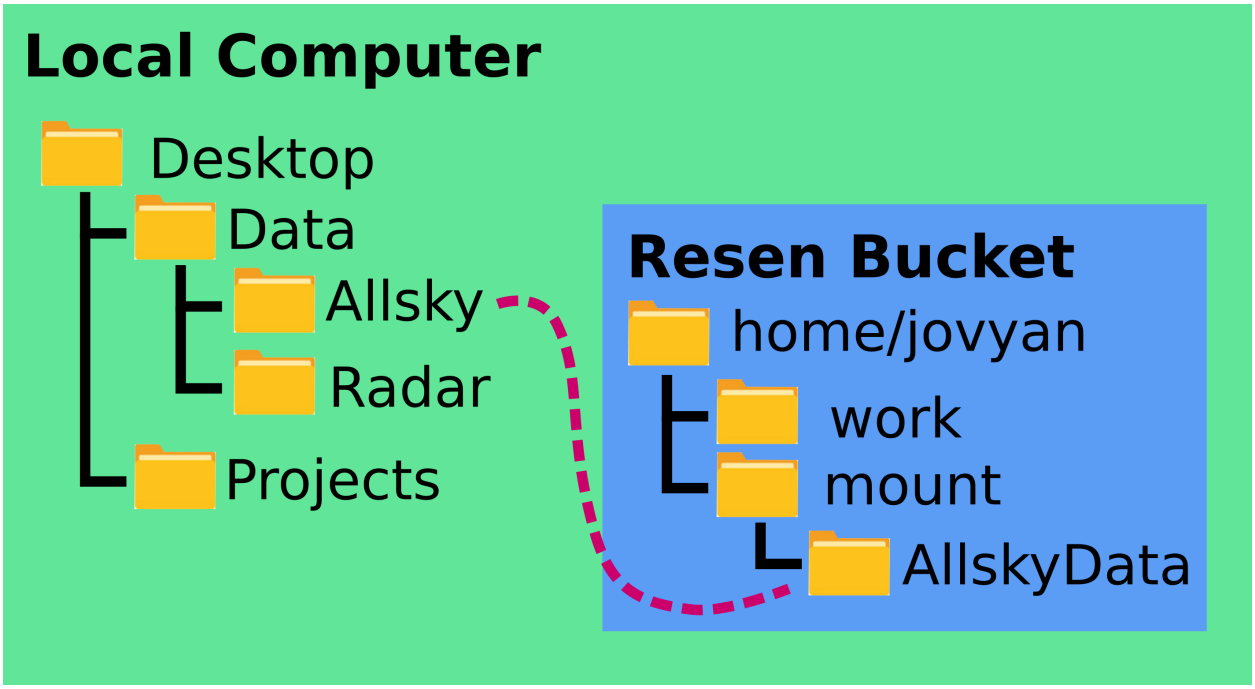
CHAPTER 5

Mounting

Mounting directories is a confusing topic if you've never done it before. This page describes what mounting is, why and how you mount directories into buckets, and some frequent asked questions regarding mounting directories to resen buckets.

5.1 What's the deal with mounting?

When you create a bucket, you have the option to mount local directories into the bucket, but what does this actually mean? Buckets are self-contained "mini-systems" that are isolated from the rest of your system. This allows us to have an environment and workspace that is operating system agnostic, which is highly useful for reproducing and sharing scientific results. The downside to this is that you cannot usually access any files on your local (host) system, a significant roadblock for scientists who often work with large amounts of data and reuse standard scripts and utilities they've written for multiple projects. Mounting is the standard solution to these problems.



Mounting a directory to a bucket gives the bucket sub-system access to that directory on the local system. This is typically useful if your project involves analyzing a large amount of data you have on your local computer, or if you have some set of standard scripts or utilities you would like to be able to use in your project. Mounting the directory containing these files lets you use them in your bucket.

5.2 Mounting a directory in Resen

The `create` command at the resen prompt allows you to mount local directories to the bucket that is being created. After entering the bucket name and choosing a version of resen-core, you will be given to option to mount local directories:

```
Local directories can be mounted to /home/jovyan/mount in a bucket.  You can specify␣
↪either r or rw privileges for each directory mounted.
>>> Mount storage to /home/jovyan/mount? (y/n):
```

If you would like to mount local directories, enter `y`. The tool will then ask to you specify the local path:

```
>>> Enter local path:
```

This should be a VALID path on your local computer, something like `/users/my_username/Desktop/Data/AllSkyImager`. The resen tool will check to confirm that this is a valid path; if it cannot find the path you entered, it will ask you to enter the local path again.

Next, resen will ask you to enter the bucket path:

```
>>> Enter bucket path:
```

This is the location where you will be able to find the directory you mounted within the bucket. The path you enter MUST start with `/home/jovyan/mount`, but then can be any directory structure you choose, for instance `/home/jovyan/mount/AllSkyImagerData`. The name of the directory in the bucket file system need not be the same as its name in the local files system (you can mount the local directory `/users/my_username/Desktop/Dinosaurs/TRex` to the bucket location `/home/jovyan/mount/Alpaca`).

The resen will then ask if you would like the mounted directory to have read only or read/write permissions:

```
>>> Enter permissions (r/rw):
```

Enter either `r` for read only or `rw` for read/write.

Finally, resen will ask if you would like to mount any additional storage:

```
>>> Mount additional storage to /home/jovyan/mount? (y/n):
```

If you have additional directories you would like to mount, enter `y` and repeat the process, otherwise, enter `n`.

5.2.1 Local Path

The local path is the full path to the directory you would like to mount on your local computer. If you are within the desired directory on the command line, you can find this by running `pwd` on Linux or Mac computers and `cd` on Windows computers.

5.2.2 Bucket Path

The bucket path is where you would like the directory you're mounting to appear in the bucket. Resen buckets can only have directories mounted within `/home/jovyan/mount`, so all bucket paths MUST start with `/home/jovyan/mount`.

5.2.3 Permissions: Read vs Read/Write

Directories can be mounted with either read or read/write permissions. Read permissions let the bucket user just see and read files from the mounted directory without allowing them to make changes to that directory. Read/Write permissions allow the user to add, delete, and edit any file in the mounted directory. If your mounted directory contains scripts that you may want to modify, edit, or add to in the course of your project, you should set the permissions as read/write. On the other hand, if your mounted directory contains data you don't want to risk overwriting accidentally, set the permissions as read only.

5.3 Frequently Asked Questions

1. Can I add a mounted directory after a bucket is created?
No, you can only add mounted directories when creating a bucket.

2. I only need a small utility script I wrote for an earlier project. Is there a simpler way to get access to this in my bucket?
Yes! The jupyter lab interface includes the option to import files into your bucket file system. Simply click the "Upload Files" button above the navigation panel and select the file you want from your local file system. The disadvantages to this approach are a) it becomes kind of a pain to manually import a large number of files, and b) technically this creates two copies of the file (the original in your host file system and the new copy in the bucket), which is not an efficient use of memory for large amounts of data.

3. Can I mount a directory anywhere in my bucket?
No, right now `/home/jovyan/mount` is the only allowed mount location in resen buckets.

CHAPTER 6

Changelog

6.1 2020.2.1 (2020-11-12)

- Fixed #73, a bug affecting the update command
- Added documentation for the update command

6.2 2020.2.0 (2020-11-06)

- Changed valid core list to be read from JSON file downloaded from resen-core repo rather than hardcoded in source code
- Fixed #63, bug which caused odd behavior with progress bar when downloading cores in narrow terminal window
- Read version number from init file
- Improve documentation on mounting, bucket exporting, and Linux post-installation steps
- Fixed #14, an issue with the resen lockfile

6.3 2020.1.0 (2020-06-24)

- Add new available resen-core: 2020.1.0
- Bug fixed when importing a bucket: now tar files of mounted paths are removed after a successful import.
- Fixed bug causing enabling sudo access for user jovyan failed

6.4 2019.1.1 (2019-12-10)

- Raise exceptions added when local storage not found
- Add detection of resen running on a windows system
- If docker toolbox, change path to be the docker VM path instead of the host machine path
- Find a port that is available

6.5 2019.1.0 (2019-11-24)

- Initial release.