Kernel Gateway Documentation

Release 0.5.0.dev

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Jupyter Kernel Gateway is a web server that supports different mechanisms for spawning and communicating with Jupyter kernels, such as:

- A Jupyter Notebook server-compatible HTTP API for requesting kernels and talking the Jupyter kernel protocol with them over Websockets
- A HTTP API defined by annotated notebook cells that maps HTTP verbs and resources to code to execute on a kernel

The server launches kernels in its local process/filesystem space. It can be containerized and scaled out by a cluster manager (e.g., tmpnb).

Contents:

CHAPTER 1

Getting started

This document describes some of the basics of installing and configuring Jupyter Kernel Gateway.

1.1 Installation

The Jupyter Kernel Gateway can be installed using `pip`.

```
# install from pypi
pip install jupyter_kernel_gateway
```

As an alternative to installing the kernel gateway from pypi, one can also use the minimal-kernel image from the docker-stacks project to try out its functionalities.

Additional information about using Docker with Jupyter Kernel Gateway is found in the Developer Installation section.

1.2 Try It

These command allow you to quickly configure and run the kernel gateway:

```
# show all config options
jupyter kernelgateway --help-all

# run it with default options
jupyter kernelgateway
```

CHAPTER 2

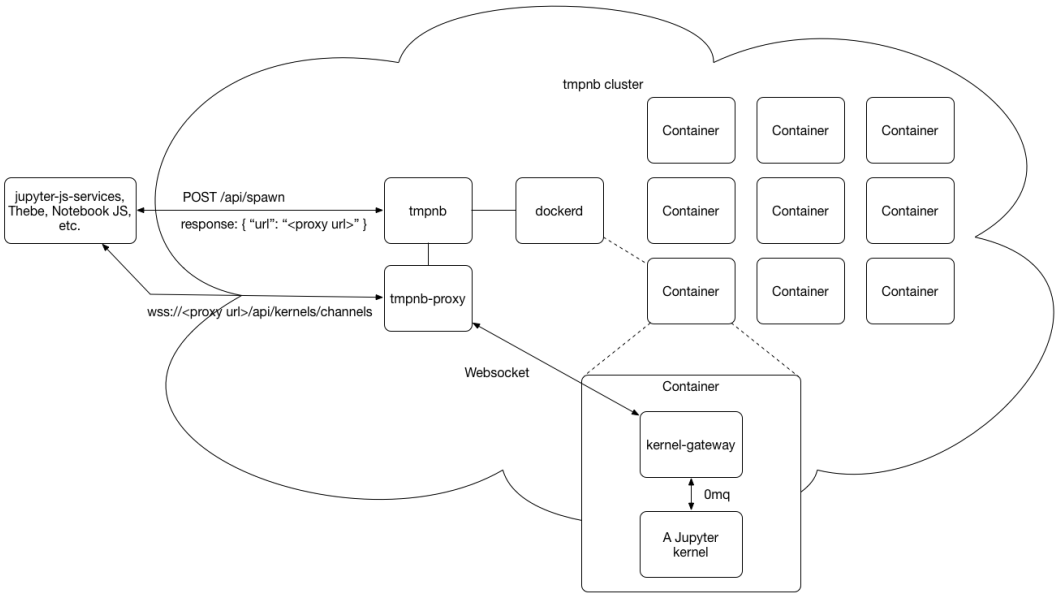
Interesting Uses

These are just some of the interesting deployments by current users of the Jupyter Kernel Gateway:

- Attach a local Jupyter Notebook server to a compute cluster in the cloud running near big data (e.g., interactive gateway to Spark)
- Enable a new breed of non-notebook web clients to provision and use kernels (e.g., dashboards using jupyter-js-services)
- Scale kernels independently from clients (e.g., via tmpnb, Binder, or your favorite cluster manager)
- Create microservices from notebooks via `notebook-http` *mode*

2.1 Example use with tmpnb

The following diagram shows how `tmpnb` might deploy Jupyer Kernel Gateway and kernel containers:



2.2 Demos

See the jupyter/kernel_gateway_demos repository for additional ideas.

CHAPTER 3

Features

The Jupyter Kernel Gateway provides a rich set of features and options:

- *`jupyter-websocket` mode* which provides a Jupyter Notebook server-compatible API for requesting kernels and communicating with them using Websockets
- *`notebook-http` mode* which maps HTTP requests to cells in annotated notebooks
- Option to set a shared authentication token and require it from clients
- Options to set CORS headers for servicing browser-based clients
- Option to set a custom base URL (e.g., for running under tmpnb)
- Option to limit the number kernel instances a gateway server will launch (e.g., to force scaling at the container level)
- Option to pre-spawn a set number of kernel instances
- Option to set a default kernel language to use when one is not specified in the request
- Option to pre-populate kernel memory from a notebook
- Option to serve annotated notebooks as HTTP endpoints, see *notebook-http*
- Option to allow downloading of the notebook source when running `notebook-http` mode
- Automatic Swagger spec for a notebook-defined API in `notebook-http` mode
- A CLI for launching the kernel gateway: `jupyter kernelgateway OPTIONS`
- A Python 2.7 and 3.3+ compatible implementation

CHAPTER 4

`jupyter-websocket` Mode

The `KernelGatewayApp.api` command line argument defaults to `jupyter-websocket`. In this mode, the kernel gateway defines the following web resources:

- `/api` (metadata)
- `/api/kernelspecs` (what kernels are available)
- `/api/kernels` (kernel CRUD, with discovery disabled by default, see `--list_kernels`)
- `/api/kernels/:kernel_id/channels` (Websocket-to-ZeroMQ transformer for the Jupyter kernel protocol)
- `/api/sessions` (session CRUD, for associating information with kernels, discovery disabled by default, see `--list_kernels`)
- `/_api/activity` (activity metrics for all running kernels, enabled with `--list_kernels`)

Discounting features of the kernel gateway (e.g., token auth), the behavior of these resources is equivalent to that found in the Jupyter Notebook server. The kernel gateway simply imports and extends the handler classes from the Jupyter Notebook.

CHAPTER 5

`notebook-http` Mode

The `KernelGatewayApp.api` command line argument can be set to `notebook-http`. In this mode, the kernel gateway exposes annotated cells in the `KernelGatewayApp.seed_uri` notebook as HTTP resources.

To turn a notebook cell into a HTTP handler, you must prefix it with a single line comment. The comment describes the HTTP method and resource, as in the following Python example:

```
# GET /hello/world
print("hello world")
```

The annotation above declares the cell contents as the code to execute when the kernel gateway receives a HTTP GET request for the path `/hello/world`. For other languages, the comment prefix may change, but the rest of the annotation remains the same.

Multiple cells may share the same annotation. Their content is concatenated to form a single code segment at runtime. This facilitates typical, iterative development in notebooks with lots of short, separate cells: The notebook author does not need to merge all of the cells into one, or refactor to use functions.

```
# GET /hello/world
print("I'm cell #1")

# GET /hello/world
print("I'm cell #2")
```

5.1 Getting the Request Data

Before the gateway invokes an annotated cell, it sets the value of a global notebook variable named `REQUEST` to a JSON string containing information about the request. You may parse this string to access the request properties.

For example, in Python:

```
# GET /hello/world
req = json.loads(REQUEST)
# do something with req
```

You may specify path parameters when registering an endpoint by prepending a `:` to a path segment. For example, a path with parameters `firstName` and `lastName` would be defined as the following in a Python comment:

```
# GET /hello/:firstName/:lastName
```

The `REQUEST` object currently contains the following properties:

- `body` - The value of the body, see the [Body And Content Type](#Request Content-Type and Request Body Processing) section below
- `args` - An object with keys representing query parameter names and their associated values. A query parameter name may be specified multiple times in a valid URL, and so each value is a sequence (e.g., list, array) of strings from the original URL.
- `path` - An object of key-value pairs representing path parameters and their values.
- `headers` - An object of key-value pairs where a key is a HTTP header name and a value is the HTTP header value. If there are multiple values are specified for a header, the value will be an array.

5.1.1 Request Content-Type and Request Body Processing

If the HTTP request to the kernel gateway has a `Content-Type` header the value of `REQUEST.body` may change. Below is the list of outcomes for various mime-types:

- `application/json` - The `REQUEST.body` will be an object of key-value pairs representing the request body
- `multipart/form-data` and `application/x-www-form-urlencoded` - The `REQUEST.body` will be an object of key-value pairs representing the parameters and their values. Files are currently not supported for `multipart/form-data`
- `text/plain` - The `REQUEST.body` will be the string value of the body
- All other types will be sent as strings

5.2 Setting the Response Body

The response from an annotated cell may be set in one of two ways:

1. Writing to stdout in a notebook cell
2. Emitting output in a notebook cell

The first method is preferred because it is explicit: a cell writes to stdout using the appropriate language statement or function (e.g. Python `print`, Scala `println`, R `print`, etc.). The kernel gateway collects all bytes from kernel stdout and returns the entire byte string verbatim as the response body.

The second approach is used if nothing appears on stdout. This method is dependent upon language semantics, kernel implementation, and library usage. The response body will be the `content.data` structure in the Jupyter `execute_result` message.

In both cases, the response defaults to status `200 OK` and `Content-Type: text/plain` if cell execution completes without error. If an error occurs, the status is `500 Internal Server Error`. If the HTTP request method is not one supported at the given path, the status is `405 Not Supported`. If you wish to return custom status or headers, see the next section.

See the api_intro.ipynb notebook for basic request and response examples.

5.3 Setting the Response Status and Headers

Annotated cells may have an optional metadata companion cell that sets the HTTP response status and headers. Consider this Python cell that creates a person entry in a database table and returns the new row ID in a JSON object:

```
# POST /person
req = json.loads(REQUEST)
row_id = person_table.insert(req['body'])
res = {'id' : row_id}
print(json.dumps(res))
```

Now consider this companion cell which runs after the cell above and sets a custom response header and status:

```
# ResponseInfo GET /hello/world
print(json.dumps({
    "headers" : {
        "Content-Type" : "application/json"
    },
    "status" : 201
}))
```

Currently, `headers` and `status` are the only fields supported. `headers` should be an object of key-value pairs mapping header names to header values. `status` should be an integer value. Both should be printed to stdout as JSON.

Given the two cells above, a `POST` request to `/person` produces a HTTP response like the following from the kernel gateway, assuming no errors occur:

```
HTTP/1.1 200 OK
Content-Type: application/json

{"id": 123}
```

See the setting_response_metadata.ipynb notebook for examples of setting response metadata.

5.4 Swagger Spec

The resource `/_api/spec/swagger.json` is automatically generated from the notebook used to define the HTTP API. The response is a simple Swagger spec which can be used with the Swagger editor, a Swagger ui, or with any other Swagger-aware tool.

Currently, every response is listed as having a status of `200 OK`.

5.5 Running

The minimum number of arguments needed to run in HTTP mode are `--KernelGatewayApp.api=notebook-http` and `--KernelGatewayApp.seed_uri=some/notebook/file.ipynb`

If you development, you can run the kernel gateway in `notebook-http` mode using the Makefile in this repository:

```
make dev ARGS="--KernelGatewayApp.api='notebook-http' \
--KernelGatewayApp.seed_uri=/srv/kernel_gateway/etc/api_examples/api_intro.ipynb"
```

With the above Make command, all of the notebooks in `etc/api_examples` are mounted into `/srv/kernel_gateway/etc/api_examples/` and can be run in HTTP mode.

The notebook-http mode will honor the `prespawn_count` command line argument. This will start the specified number of kernels and execute the `seed_uri` notebook on each one. Requests will be distributed across the pool of prespawned kernels, providing a minimal layer of scalability. An example which starts a pool of 5 kernels follows:

```
make dev ARGS="--KernelGatewayApp.api='notebook-http' \
    --KernelGatewayApp.seed_uri=/srv/kernel_gateway/etc/api_examples/api_intro.ipynb" \
    --KernelGatewayApp.prespawn_count=5
```

CHAPTER 6

KernelGatewayApp configuration options

Run `jupyter kernelgateway --help-all` after installation to see the full set of server options. A snapshot of this help appears below:

```
KernelGatewayApp options
------------------------
--KernelGatewayApp.allow_credentials=<Unicode>
    Default: ''
    Sets the Access-Control-Allow-Credentials header. (KG_ALLOW_CREDENTIALS env
    var)
--KernelGatewayApp.allow_headers=<Unicode>
    Default: ''
    Sets the Access-Control-Allow-Headers header. (KG_ALLOW_HEADERS env var)
--KernelGatewayApp.allow_methods=<Unicode>
    Default: ''
    Sets the Access-Control-Allow-Methods header. (KG_ALLOW_METHODS env var)
--KernelGatewayApp.allow_notebook_download=<Bool>
    Default: False
    Optional API to download the notebook source code in notebook-http mode,
    defaults to not allow
--KernelGatewayApp.allow_origin=<Unicode>
    Default: ''
    Sets the Access-Control-Allow-Origin header. (KG_ALLOW_ORIGIN env var)
--KernelGatewayApp.answer_yes=<Bool>
    Default: False
    Answer yes to any prompts.
--KernelGatewayApp.api=<Unicode>
    Default: 'jupyter-websocket'
    Controls which API to expose, that of a Jupyter kernel or the seed
    notebook's, using values "jupyter-websocket" or "notebook-http" (KG_API env
    var)
--KernelGatewayApp.auth_token=<Unicode>
    Default: ''
    Authorization token required for all requests (KG_AUTH_TOKEN env var)
--KernelGatewayApp.base_url=<Unicode>
    Default: ''
    The base path on which all API resources are mounted (KG_BASE_URL env var)
--KernelGatewayApp.config_file=<Unicode>
    Default: ''
    Full path of a config file.
--KernelGatewayApp.config_file_name=<Unicode>
    Default: ''
    Specify a config file to load.
--KernelGatewayApp.default_kernel_name=<Unicode>
```

```
    Default: ''
    The default kernel name to use when spawning a kernel
    (KG_DEFAULT_KERNEL_NAME env var)
--KernelGatewayApp.expose_headers=<Unicode>
    Default: ''
    Sets the Access-Control-Expose-Headers header. (KG_EXPOSE_HEADERS env var)
--KernelGatewayApp.generate_config=<Bool>
    Default: False
    Generate default config file.
--KernelGatewayApp.ip=<Unicode>
    Default: ''
    IP address on which to listen (KG_IP env var)
--KernelGatewayApp.list_kernels=<Bool>
    Default: False
    Enables listing the running kernels through /api/kernels and /api/sessions
    (KG_LIST_KERNELS env var). Note: Jupyter Notebook allows this by default but
    kernel gateway does not .
--KernelGatewayApp.log_datefmt=<Unicode>
    Default: '%Y-%m-%d %H:%M:%S'
    The date format used by logging formatters for %(asctime)s
--KernelGatewayApp.log_format=<Unicode>
    Default: '[%(name)s]%(highlevel)s %(message)s'
    The Logging format template
--KernelGatewayApp.log_level=<Enum>
    Default: 30
    Choices: (0, 10, 20, 30, 40, 50, 'DEBUG', 'INFO', 'WARN', 'ERROR', 'CRITICAL')
    Set the log level by value or name.
--KernelGatewayApp.max_age=<Unicode>
    Default: ''
    Sets the Access-Control-Max-Age header. (KG_MAX_AGE env var)
--KernelGatewayApp.max_kernels=<Int>
    Default: 0
    Limits the number of kernel instances allowed to run by this gateway.
    (KG_MAX_KERNELS env var)
--KernelGatewayApp.port=<Int>
    Default: 0
    Port on which to listen (KG_PORT env var)
--KernelGatewayApp.prespawn_count=<Int>
    Default: None
    Number of kernels to prespawn using the default language. (KG_PRESPAWN_COUNT
    env var)
--KernelGatewayApp.seed_uri=<Unicode>
    Default: ''
    Runs the notebook (.ipynb) at the given URI on every kernel launched.
    (KG_SEED_URI env var)
```

CHAPTER 7

Troubleshooting

This document is under active development.

CHAPTER 8

Development Installation

This document gives instructions for setup of a Dockerized development environment for the Jupyter Kernel Gateway.

8.1 Prerequisites

8.1.1 Docker installation for Mac users (optional)

On a Mac, do this one-time setup if you don't have a local Docker environment yet.

```
brew update

# make sure you're on Docker >= 1.7
brew install docker-machine docker
docker-machine create -d virtualbox dev
eval "$(docker-machine env dev)"
```

8.2 Clone the repo

Clone this repository in a local directory that docker can volume mount:

```
# make a directory under ~ to put source
mkdir -p ~/projects
cd !$

# clone this repo
git clone https://github.com/jupyter/kernel_gateway.git
```

8.3 Run the tests

To run the tests:

```
make test-python3
make test-python2
```

8.4 Run the gateway server

To run the gateway server:

```
cd kernel_gateway
make dev
```

8.5 Access the gateway

To access the gateway instance:

1. Run `docker-machine ls` and note the IP of the dev machine.
2. Visit http://THAT_IP:8888/api in your browser where `THAT_IP` is the IP address returned from the previous step. (Note that the route `/api/kernels` is not enabled by default for greater security. See the `--KernelGatewayApp.list_kernels` parameter documentation if you would like to enable the `/api/kernels` route.)

CHAPTER 9

Summary of changes

See `git log` and `CHANGELOG.md` for a more detailed summary of changes.

9.1 0.5

9.2 0.4

9.2.1 0.4.0 (2016-02-17)

- Enable `/_api/activity` resource with stats about kernels in `jupyter-websocket` mode
- Enable `/api/sessions` resource with in-memory name-to-kernel mapping for non-notebook clients that want to look-up kernels by associated session name
- Fix prespawn kernel logic regression for `jupyter-websocket` mode
- Fix all handlers so that they return application/json responses on error
- Fix missing output from cells that emit display data in `notebook-http` mode

9.3 0.3

9.3.1 0.3.1 (2016-01-25)

- Fix CORS and auth token headers for `/_api/spec/swagger.json` resource
- Fix `allow_origin` handling for non-browser clients
- Ensure base path is prefixed with a forward slash
- Filter stderr from all responses in `notebook-http` mode
- Set Tornado logging level and Jupyter logging level together with `--log-level`

9.3.2 0.3.0 (2016-01-15)

- Support setting of status and headers in `notebook-http` mode
- Support automatic, minimal Swagger doc generation in `notebook-http` mode

- Support download of a notebook in `notebook-http` mode
- Support CORS and token auth in `notebook-http` mode
- Expose HTTP request headers in `notebook-http` mode
- Support multipart form encoding in `notebook-http` mode
- Fix request value JSON encoding when passing requests to kernels
- Fix kernel name handling when pre-spawning
- Fix lack of access logs in `notebook-http` mode

9.4 0.2

9.4.1 0.2.0 (2015-12-15)

- Support notebook-defined HTTP APIs on a pool of kernels
- Disable kernel instance list by default

9.5 0.1

9.5.1 0.1.0 (2015-11-18)

- Support Jupyter Notebook kernel CRUD APIs and Jupyter kernel protocol over Websockets
- Support shared token auth
- Support CORS headers
- Support base URL
- Support seeding kernels code from a notebook at a file path or URL
- Support default kernel, kernel pre-spawning, and kernel count limit
- First PyPI release

CHAPTER 10

Indices and tables

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