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GeoHealthCheck (GHC) is a Python application to support monitoring OGC services uptime, availability and Quality of Service (QoS).

GHC can be used to monitor overall health of OGC services (OWS) like WMS, WFS, WCS, WMTS, SOS, CSW and more, plus some recent OGC APIs like SensorThings API and WFS v3 (OGC Features API). But also standard web REST APIs and ordinary URLs can be monitored.
FEATURES

- lightweight (Python with Flask)
- easy setup
- support for numerous OGC resources
- flexible and customizable: look and feel, scoring matrix
- user management
- database agnostic: any SQLAlchemy supported backend
- database upgrades: using Alembic with Flask-Migrate
- extensible healthchecks via Plugins
- per-resource scheduling and notifications
- per-resource HTTP-authentication like Basic, Token (optional)
- regular status summary report via email (optional)
3.1 Installation

Below are installation notes for GeoHealthCheck (GHC).

3.1.1 Docker

The easiest and quickest install for GHC is with Docker/Docker Compose using the GHC images hosted on Docker Hub.

See the GHC Docker Readme for a full guide.

3.1.2 Requirements

GeoHealthCheck is built on the awesome Flask micro-framework and uses Flask-SQLAlchemy for database interaction and Flask-Login for authorization. Flask-Migrate with Alembic and Flask-Script is used for database upgrades.

OWSLib is used to interact with OGC Web Services.

APScheduler is used to run scheduled healthchecks.

These dependencies are automatically installed (see below). Paver is used for installation and management. Cron was used for scheduling the actual healthchecks before v0.5.0.

Starting from version v0.8.0.0 GeoHealthCheck requires python 3. Previous versions require python 2.
3.1.3 Install

Note: It is strongly recommended to install GeoHealthCheck in a Python virtualenv. A virtualenv is self-contained and provides the flexibility to install/tear down/whatever packages without affecting system-wide packages or settings. If installing on Ubuntu, you may need to install the python-dev package for installation to complete successfully.

- Download a GeoHealthCheck release from https://github.com/geopython/GeoHealthCheck/releases, or clone manually from GitHub.

```bash
python3 -m venv ghc && cd ghc
source ghc/bin/activate
git clone https://github.com/geopython/GeoHealthCheck.git
cd GeoHealthCheck

# install paver dependency for admin tool
pip install Paver

# setup app
paver setup

# create secret key to use for auth
paver create_secret_key

# almost there! Customize config
vi instance/config_site.py

# edit:
# - SQLALCHEMY_DATABASE_URI
# - SECRET_KEY # from paver create_secret_key
# - GHC_RETENTION_DAYS
# - GHC_SELF_REGISTER
# - GHC_NOTIFICATIONS
# - GHC_NOTIFICATIONS_VERBOSITY
# - GHC_ADMIN_EMAIL
# - GHC_NOTIFICATIONS_EMAIL
# - GHC_SITE_TITLE
# - GHC_SITE_URL
# - GHC_RUNNER_IN_WEBAPP # see 'running' section below
# - GHC_REQUIRE_WEBAPP_AUTH # optional: to require authentication to access webapp
# - GHC_SMTP # if GHC_NOTIFICATIONS is enabled
# - GHC_MAP # or use default settings

# init database
python GeoHealthCheck/models.py create

# start web-app
python GeoHealthCheck/app.py  # http://localhost:8000/

# when you are done, you can exit the virtualenv
deactivate
```

NB GHC supports internal scheduling, no cronjobs required.
3.1.4 Upgrade

An existing GHC database installation can be upgraded with:

```
# In the top directory (e.g. the topdir cloned from github)
paver upgrade
# Notice any output, in particular errors
```

Notes:

- Always backup your database first!!
- make sure Flask-Migrate is installed (see requirements.txt), else: `pip install Flask-Migrate==2.5.2`, but best is to run `paver setup` also for other dependencies
- upgrading is “smart”: you can always run `paver upgrade`, it has no effect when DB is already up to date
- when upgrading from earlier versions without Plugin-support:
  - adapt your `config_site.py` to Plugin settings from `config_main.py`
  - assign Probes and Checks to each Resource via the UI

When running with Docker see the Docker Readme how to run `paver upgrade` within your Docker Container.

Upgrade notes v0.5.0

In GHC v0.5.0 a new run-architecture was introduced. By default, healthchecks run under the control of an internal scheduler, i.e. of external cron-jobs. See also the Architecture chapter and Healthcheck Scheduling and below.

Upgrade notes v0.6.0

In GHC v0.6.0 encryption was added for password storage. Existing passwords should be migrated via the `paver upgrade` command. Also password recovery was changed: a user can create a new password via a unique, personal URL that GHC sends by email. This requires a working email configuration and a reachable SITE_URL config value. See User Management for solving password problems.

See [closed issues for related Milestone 0.6.0](https://github.com/geopython/GeoHealthCheck/milestone/6?closed=1)

Upgrade notes v0.7.0

No database changes. Many fixes and enhancements, see [closed issues for related Milestone 0.7.0](https://github.com/geopython/GeoHealthCheck/milestone/7?closed=1).

Upgrade notes v0.8.0

Main change: migrated from Python 2 to Python 3. No DB upgrades required. One major improvement was more robust (HTTP) retries using the requests Session object.

See [closed issues for related Milestone 0.8.0](https://github.com/geopython/GeoHealthCheck/milestone/8?closed=1)
3.1.5 Running

Start using Flask's built-in WSGI server:

```
python GeoHealthCheck/app.py  # http://localhost:8000
python GeoHealthCheck/app.py 0.0.0.0:8881  # http://localhost:8881
```

This runs the (Flask) **GHC Webapp**, by default with the **GHC Runner** (scheduled healthchecker) internally. See also **Healthcheck Scheduling** for the different options running the **GHC Webapp** and **GHC Runner**. It is recommended to run these as separate processes. For this set **GHC_RUNNER_IN_WEBAPP** to **False** in your **site_config.py**. From the command-line run both processes, e.g. in background or different terminal sessions:

```
# run GHC Runner, here in background
python GeoHealthCheck/scheduler.py &

# run GHC Webapp for http://localhost:8000
python GeoHealthCheck/app.py
```

To enable in Apache, use **GeoHealthCheck.wsgi** and configure in Apache as per the main Flask documentation.

3.1.6 Running under a sub-path

By default GeoHealthCheck is configured to run under the root directory on the webserver. However, it can be configured to run under a sub-path. The method for doing this depends on the webserver you are using, but the general requirement is to pass Flask's **SCRIPT_NAME** environment variable when GeoHealthCheck is started.

Below is an example of how to use nginx and gunicorn to run GeoHealthCheck in a directory “geohealthcheck”, assuming that you have nginx and gunicorn already set up and configured:

- In nginx add a section to the server block you are running GeoHealthCheck under:

```
location /geohealthcheck {
    proxy_pass http://127.0.0.1:8000/geohealthcheck;
}
```

- Include the parameter “-e SCRIPT_NAME=/geohealthcheck” in your command for running gunicorn:

```
gunicorn -e SCRIPT_NAME=/geohealthcheck app:app
```

3.1.7 Production Recommendations

**Use Docker!**

When running GHC in long-term production environment the following is recommended:

- use Docker, see the **GHC Docker Readme**

Using Docker, especially with Docker Compose (sample files provided) is our #1 recommendation. It saves all the hassle from installing the requirements, upgrades etc. Docker (Compose) is also used to run the GHC demo site and almost all of our other deployments.
Use PostgreSQL

Although GHC will work with SQLite, this is not a good option for production use, in particular for reliability starting with GHC v0.5.0:

- reliability: GHC Runner will do concurrent updates to the database, this will be unreliable under SQLite
- performance: PostgreSQL has been proven superior, especially in query-performance

Use a WSGI Server

Although GHC can be run from the commandline using the Flask internal WSGI web-server, this is a fragile and possibly insecure option in production use (as also the Flask manual states). Best is to use a WSGI-server as stated in the Flask deployment options.

See for example the GHC Docker run.sh script to run the GHC Webapp with gunicorn and the GHC Runner run-runner.sh script to run the scheduled healthchecks.

Use virtualenv

This is a general Python-recommendation. Save yourself from classpath and library hells by using virtualenv! Starting with python 3.3 a venv script <https://docs.python.org/3.3/library/venv.html> is provided and from python 3.6 the venv module <https://docs.python.org/3/library/venv.html> is included in the standard library.

Use SSL (HTTPS)

As users and admin may login, running on plain http will send passwords in the clear. These days it has become almost trivial to automatically install SSL certificates with Let’s Encrypt.

3.2 Configuration

This chapter provides guidance for configuring a GeoHealthCheck instance.

3.2.1 Configuration Parameters

The core configuration is in GeoHealthCheck/config_main.py. Optionally override these settings for your instance in instance/config_site.py. You can specify a configuration file in the environment settings that will override settings in both previous files. The configuration options are:

- SQLALCHEMY_DATABASE_URI: the database configuration. See the SQLAlchemy documentation for more info
- SECRET_KEY: secret key to set when enabling authentication. Use the output of paver create_secret_key to set this value
- GHC_RETENTION_DAYS: the number of days to keep Run history
- GHC_PROBE_HTTP_TIMEOUT_SECS: stop waiting for the first byte of a Probe response after the given number of seconds
- GHC_MINIMAL_RUN_FREQUENCY_MINS: minimal run frequency for Resource that can be set in web UI
- GHC_SELF_REGISTER: allow registrations from users on the website
• **GHC_NOTIFICATIONS**: turn on email notifications

• **GHC_NOTIFICATIONS_VERBOSITY**: receive additional email notifications than just Failing and Fixed (default True)

• **GHC_WWW_LINK_EXCEPTION_CHECK**: turn on checking for OGC Exceptions in WWW:LINK Resource responses (default False)

• **GHC_ADMIN_EMAIL**: email address of administrator / contact- notification emails will come from this address

• **GHC_NOTIFICATIONS_EMAIL**: list of email addresses that notifications should come to. Use a different address to GHC_ADMIN_EMAIL if you have trouble receiving notification emails. Also, you can set separate notification emails to specific resources. Failing resource will send notification to emails from GHC_NOTIFICATIONS_EMAIL value and emails configured for that specific resource altogether.

• **GHC_SITE_TITLE**: title used for installation / deployment

• **GHC_SITE_URL**: full URL of the installation / deployment

• **GHC_SMTP**: configure SMTP settings if **GHC_NOTIFICATIONS** is enabled

• **GHC_RELIABILITY_MATRIX**: classification scheme for grading resource

• **GHC_PLUGINS**: list of Core/built-in Plugin classes or modules available on installation

• **GHC_USER_PLUGINS**: list of Plugin classes or modules provided by user (you)

• **GHC_PROBE_DEFAULTS**: Default Probe class to assign on “add” per Resource-type

• **GHC_METADATA_CACHE_SECS**: metadata, “Capabilities Docs”, cache expiry time, default 900 secs, -1 to disable

• **GHC_REQUIRE_WEBAPP_AUTH**: require authentication (login or Basic Auth) to access GHC webapp and APIs (default: False)

• **GHC_BASIC_AUTH_DISABLED**: disable Basic Authentication to access GHC webapp and APIs (default: False), see below when to set to True

• **GHC_RUNNER_IN_WEBAPP**: should the GHC Runner Daemon be run in webapp (default: True), more below

• **GHC_LOG_LEVEL**: logging level: 10=DEBUG 20=INFO 30=WARNING 40=ERROR 50=FATAL/CRITICAL (default: 30, WARNING)

• **GHC_MAP**: default map settings
  – **url**: URL of TileLayer
  – **centre_lat**: Centre latitude for homepage map
  – **centre_long**: Centre longitude for homepage map
  – **maxzoom**: maximum zoom level
  – **subdomains**: available subdomains to help with parallel requests

Example on overriding the configuration with an environment variable:

```bash
export GHC_SETTINGS=/tmp/my_GHC_settings.py
paver run_tests
```

As an example: the `my_GHC_settings.py` file can contain a single line to define a test database:

```python
SQLALCHEMY_DATABASE_URI='sqlite:///tmp/GHCtest.db'
```
NOTE: do not forget to reset the environment variable afterwards.

### 3.2.2 Email Configuration

A working email-configuration is required for notifications and password recovery. This can sometimes be tricky, below is a working configuration for the GMail account `my_gmail_name@gmail.com`.

```python
GHC_SMTP = {
    'server': 'smtp.gmail.com',
    'port': 587,
    'tls': True,
    'ssl': False,
    'username': 'my_gmail_name@gmail.com',
    'password': '<my gmail password>'
}
```

In your Google Account settings for that GMail address you should turn on “Allow less secure apps” as explained here.

### 3.2.3 Healthcheck Scheduling

Healthchecks (Runs) for each Resource can be scheduled via cron or (starting with v0.5.0) by running the GHC Runner app standalone (as daemon) or within the GHC Webapp.

#### Scheduling via Cron

Applies only to pre-0.5.0 versions.

Edit the file `jobs.cron` so that the paths reflect the path to the virtualenv. Set the first argument to the desired monitoring time step. If finished editing, copy the command line calls e.g. `~/YOURvirtualenv/bin_or_SCRIPTS/Windows/python /path/to/GeoHealthCheck/GeoHealthCheck/healthcheck.py run` to the commandline to test if they work sucessfully. On Windows - do not forget to include the ”.exe.” file extension to the python executable. For documentation how to create cron jobs see your operating system: on *NIX systems e.g. `crontab -e` and on windows e.g. the `nssm`.

NB the limitation of cron is that the per Resource schedule cannot be applied as the cron job will run healthchecks on all Resources.

#### GHC Runner as Daemon

In this mode GHC applies internal scheduling for each individual Resource. This is the preferred mode as each Resource can have its own schedule (configurable via Dashboard) and cron has dependencies on local environment. Later versions may phase out cron-scheduling completely.

The GHC Runner can be run via the command `paver runner_daemon` or can run internally within the GHC Webapp by setting the config variable `GHC_RUNNER_IN_WEBAPP` to True (the default). NB it is still possible to run GHC as in the pre-v0.5.0 mode using cron-jobs: just run the GHC Webapp with `GHC_RUNNER_IN_WEBAPP` set to False and have your cron-jobs scheduled.

In summary there are three options to run GHC and its healthchecks:

- run GHC Runner within the GHC Webapp: set `GHC_RUNNER_IN_WEBAPP` to True and run only the GHC webapp
• (recommended): run GHC Webapp and GHC Runner separately (set GHC_RUNNER_IN_WEBAPP to False)

• (deprecated): run GHC Webapp with GHC_RUNNER_IN_WEBAPP set to False and schedule healthchecks via external cron-jobs

3.2.4 Language Translations

GHC supports multiple languages by using [Babel](http://babel.pocoo.org) with [Flask-Babel](https://pythonhosted.org/Flask-Babel/).

“Babel is an integrated collection of utilities that assist in internationalizing and localizing Python applications, with an emphasis on web-based applications.”

Enabling/Disabling a Language

Open the file GeoHealthCheck/app.py and look for the language switcher (e.g. ‘en’, ‘fr’) and remove or add the desired languages. In case of a new language, a new translation file (called a *.po) has to be added as follows:

- make a copy of one of the folders in GeoHealthCheck/translations/;
- rename the folder to the desired language (e.g. ‘de’ for German) using the language ISO codes
- edit the file `<your_lang>/LC_MESSAGES/messages.po`, adding your translations to the msgstr

Don’t forget the change the specified language in the messages.po file as well. For example the messages.po file for the German case has an English msgid string, which needs to be translated in msgstr’ as seen below.

```python
#: GeoHealthCheck/app.py:394
msgid "This site is not configured for self-registration"
msgstr "Diese Webseite unterstützt keine Selbstregistrierung"
```

Compiling Language Files

At runtime compiled versions, *.mo files, of the language-files are used. Easiest to compile is via: `paver compile_translations` in the project root dir. This basically calls “pybabel compile” with the proper options. Now you can e.g. test your new translations by starting GHC.

Updating Language Files

Once a language-file (.po) is present, it will need updating as development progresses. In order to know what to update (which strings are untranslated) it best to first update the messages.po file with all language strings, their location(s) within project files and whether the translation is missing. Missing translations will have msgstr “” like in this excerpt:

```python
#: GeoHealthCheck/notifications.py:245 GeoHealthCheck/notifications.py:247
msgid "Passing"
msgstr "Jetzt geht's"

#: GeoHealthCheck/plugins/probe/ghcreport.py:115
msgid "Status summary"
msgstr ""
```

Next all empty ‘msgstr’s can be filled.

Updating is easiest using the command `paver update_translations` within the root dir of the project. This will basically call `pybabel extract` followed by `pybabel update` with the proper parameters.
3.2.5 Customizing the Score Matrix

GeoHealthCheck uses a simple matrix to provide an indication of overall health and/or reliability of a resource. This matrix drives the CSS which displays a given resource’s state with a colour. The default matrix is defined as follows:

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
<th>score/colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>49</td>
<td>red</td>
</tr>
<tr>
<td>50</td>
<td>79</td>
<td>orange</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>green</td>
</tr>
</tbody>
</table>

To adjust this matrix, edit `GHC_RELIABILITY_MATRIX` in `instance/config_site.py`.

3.2.6 Securing GHC Webapp

In some cases it is required that only logged-in (authenticated) users like the `admin` user can access the entire GHC webapp and its APIs. In that case the config setting `GHC_REQUIRE_WEBAPP_AUTH` should be set to `True` (version 0.7+). Non-authenticated users will be presented with the login screen. Initially only the `admin` user will be able to login, but it is possible to register and allow additional users by registering these within the `admin` login session. Note that password reset is still enabled. For remote REST API calls standard HTTP Basic Authentication (via the HTTP Authentication request header) can be used.

In some cases where an external web- or proxy server provides HTTP Basic Authentication, a conflict may arise when GHC also checks the `Authorization` HTTP header used for the external Basic Auth. In those cases GHC Basic Auth checking can be disabled using the `GHC_BASIC_AUTH_DISABLED` to `True`. TODO: provide API Token auth to allow both external Basic Auth and GHC API auth.

3.3 Administration

This chapter describes maintenance tasks for the administrator of a GHC instance. There is a separate User Guide that provides guidance to the end-user to configure the actual Resource healthchecks.

Each of the sections below is geared at a specific administrative task area.

3.3.1 Database

For database administration the following commands are available.

**create db**

To create the database execute the following:

Open a command line, (if needed activate your virtualenv), and do

```
python GeoHealthCheck/models.py create
```

**drop db**

To delete the database execute the following, however you will loose all your information. So please ensure backup if needed:

Open a command line, (if needed activate your virtualenv), and do

```
...```
Note: you need to create a Database again before you can start GHC again.

load data

To load a JSON data file, do (WARN: deletes existing data!)

```
python GeoHealthCheck/models.py load <datafile.json> [y/n]
```

Hint: see tests/data for example JSON data files.

export data

Exporting database-data to a .json file with or without Runs is still to be done.

Exporting Resource and Run data from a running GHC instance can be effected via a REST API, for example:

- all Resources: https://demo.geohealthcheck.org/json (or as CSV)
- one Resource: https://demo.geohealthcheck.org/resource/1/json (or CSV)
- all history (Runs) of one Resource: https://demo.geohealthcheck.org/resource/1/history/json (or in csv)

NB for detailed reporting data only JSON is supported.

3.3.2 User Management

During initial setup, a single admin user is created interactively.

Via the GHC_SELF_REGISTER config setting, you allow/disallow registrations from users on the webapp (UI).

Passwords

Passwords are stored encrypted. Even the same password-string will have different “hashes”. There is no way that GHC can decrypt a stored password. This can become a challenge in cases where a password is forgotten and somehow the email-based reset is not available nor working. In that case, password-hashes can be created from the command-line using the Python library passlib within an interactive Python-shell as follows:

```
$ pip install passlib
# or in Debian/Ubuntu: apt-get install python-passlib

python from passlib.hash import pbkdf2_sha256

>>> hash = pbkdf2_sha256.hash("mynewpassword")
>>> print hash
$pbkdf2-sha256$29000$da51rlVKKWVsLSWEsBYCoAS2/shIdqAxGJkDq6TTTeI0gQKbtYAOFSi5EADjiL6Y
>>> pbkdf2_sha256.verify("mynewpassword", hash)
True
```

Or more compact within the root dir of your GHC installation:
>>> from GeoHealthCheck.util import create_hash
>>> create_hash('mynewpassword')
'$pbkdf2-sha256$29000$8X4PAUAIAcC4V2rNea9Vqg
→XnMx1SfEiBzBAMQOOC7uxCcyzVuKaHENLj3IfXvfuo'

Or even more compact within the root dir of your GHC installation via Paver:

$ paver create_hash -p mypass
---> pavement.create_hash
Copy/paste the entire token below for example to set password
$pbkdf2-sha256$29000$FkJoTYnxPqc0pjQG4HxP6Q$C3SZb8jqtM7zKS1DScouc/
→CL9XMI9cL5xT6DRT0Ed4

Then copy-paste the hash-string into the password-field of the User-record in the User-table. For example in SQL something like:

$ sqlite3 data.db
# or psql equivalent for Postgres
sqlite> UPDATE user SET password = '<above hash-value>' WHERE username == 'myusername
→';

3.3.3 Build Documentation

Open a command line, (if needed activate your virtualenv) and move into the directory GeoHealthCheck/doc/. In there, type make html plus ENTER and the documentation should be built locally.

3.4 User Guide

This chapter provides guidance for configuring GeoHealthCheck’s (GHC) actual tasks: healthchecking API services on (OGC) URL Endpoints. It is written from the perspective of the end-user who interacts with GHC’s webapp (UI).

This chapter contains figures of screenshots. Click on a figure to see a larger version of the image. Use the back-button to get back into this document. This chapter can also be found by pressing Help (top menu) within the Web UI.

3.4.1 Terminology

The following terminology applies:

- **Resource**: basically an endpoint URL, like an OGC WMS, FTP URL, or plain old weblink. For OGC-Resources this is always the root-URL, *not the Capabilities-URL*. Each Resource has a Type (see below).

- **Probe**: each Resource is tested via one or more Probes, a Probe is typically a single HTTP request, like GetCapabilities, GetMap etc. Each Resource (Type) has a default Probe.

- **Check**: each Probe invokes one or more Checks, typically on the HTTP response. For example if a WMS GetMap returns an image object.

- **Run**: the execution and scoring of a single Probe. Its Checks determine the Run outcome.

- A Run in addition has a single verdict: Ok or NotOk.

- Each User owns one or more Resources
The main user task within the web UI is to manage (add, update, delete) a set of Resources. For each Resource its various properties (scheduling, notifications, tags etc) and Probes is managed. Subsequently, for each Probe its various Checks are managed.

### 3.4.2 Registration

If the administrator of the GHC instance has enabled User Registration (GHC_SELF_REGISTER = True), any person can register and manage Resources on that GHC instance. A User can only manage its own Resources. The Admin user can always edit/manage any Resource.

![Registration](image)

**Fig. 1: Registration**

Start registration by clicking Login in menu and then the Register link within the Login screen. When registering, a working email address is required if you want to receive Resource notifications by email and for password-recovery.

### 3.4.3 Home Screen

The initial home screen always shows failing Resources (if any). The badges on the top show percentages:

- **Operational**: percentage of all Resources that is currently “up”/healthy
- **Failing**: percentage of all Resources that is currently “down”/failing
- **Reliable**: percentage of time that Resources are “up”/healthy within the retention window
Fig. 2: Home Screen
Using the vertical menu items on the left different lists of Resources can be shown: either by Resource Type (like WMS in Figure below), or by Tags (discussed later).

![WMS Type Resource List](image)

**Fig. 3: WMS Type Resource List**

Clicking the Home icon (top left) brings back the initial home screen.

### 3.4.4 Adding Resources

Click the Add+ button in the top menu to add a new Resource.

First choose a Resource Type from the dropdown menu. The following Resource Types are available:

- Web Map Service (WMS)
- Web Feature Service (WFS)
- Web Map Tile Service (WMTS)
- Tile Map Service (TMS)
- Web Coverage Service (WCS)
- Catalogue Service (CSW)
- Web Processing Service (WPS)
- Sensor Observation Service (SOS)
Fig. 4: Add Resource - Select Type
• SensorThings API (STA)
• OGC Features API (WFS3)
• Web Accessible Folder (WAF)
• Web Address (URL)
• File Transfer Protocol (FTP)
• GeoNode autodiscovery (see GeoNode Resource Type)
• GeoHealthCheck Reporter (GHC-R) (see GeoHealthCheck Reporter Type)

Next fill in the URL and optional tags for the Resource.

Fig. 5: Add Resource - specify URL and optional Tags

Fill in the endpoint URL, like an OGC WMS, FTP URL or a weblink for the Web Address Type. For OGC-Resources this should be the root-endpoint-URL, not the Capabilities-URL.

You can add new or existing tags as well here. On Submit, the Resource will get a single default Probe assigned. For OGC-Resources this is usually a CapabilitiesProbe. If successful you are directed to the Resource Edit screen (see next).

### 3.4.5 Editing Resources

Open the Resource details by clicking its name in the Resources list at the Dashboard/Home page. Under the Resource title is a blue Edit button (if you own the Resource or as admin). When Adding a Resource (see above), you are
automatically directed to the Resource Edit Screen.

Fig. 6: Edit Resource - Basics

The following general aspects of a Resource can be edited:

- Resource name (initial Name may come from Capabilities or HTML title element if present)
- Resource Tags
- Resource active/non-active (makes Probes (in)active, e.g. when repairing a Resource)
- Notification: recipient(s) for email (see Per-Resource Notifications)
- Notification: target(s) and parameters for webhooks (advanced: see Per-Resource Notifications)
- Resource run schedule, “Run Every” N minutes
- Optional HTTP authentication (Basic or Bearer Token) for secured Resource endpoints

By default, when a Resource is created, the owner’s email will be added to the email-notifications.

The most important/functionual aspects for a Resource are its Probes.

- Manage Probes for the Resource: select a Probe from “Probes Available”
- Optionally edit Probe parameters, fixed values have grey background
- Manage Checks for the Probe, add by selecting from “Checks Available”
- Optionally edit Check parameters
Fig. 7: Edit Resource - Edit Probe
Fig. 8: Edit Resource - Add Probe
Note that all “Edit” buttons with Probes and Checks are toggles to show/hide a Probe and/or Check.

Click Save to save all Resource settings and then click Test to test your Probes and Checks. NB Test only works on the Resource settings as saved! So Save, then Test.

### 3.4.6 Deleting Resources

Open the Resource details by clicking its name in the Resources list. Under the Resource title is a red Delete button.

### 3.4.7 Tagging

Each Resource can be tagged with multiple tags. This provides a handy way to structure your Resources into any kind of categories/groups, like *Production* and *Test*, common servers any other grouping.

### 3.4.8 Failure Analysis

As history builds up for each Resource, Users may get notified, usually by email, when one or more Probes fail for a Resource (and again when the Resource is healthy again). In this section we analyse a failing Resource (WMS).

![Email Notification - Failing Resource](image)

This kind of email is received when the Resource has failed. We can already see in the message (showing the last message from one or more failing Probes) that something is wrong with an `.ecw` (compressed raster image) file within the WMS. We can click on the link to go directly to the Resource view within the GHC demo site.

NB: Dependent on the `GHC_NOTIFICATIONS_VERBOSITY` config setting, this email is received only once on the first failure (False) or on each failing Run.

In order to analyse “what happened”, the graph shown in the Resource view can be inspected. Below, this WMS Resource is shown.

As can be seen, this WMS Resource is now up (*Last Run Result* on top right) but has a Reliability of 57.56 percent. This means that within the retention window (one week for the demo site) it has been down for about half of the time. This Resource als has quite some Probes active, so is thoroughly tested each hour.

Scrolling down within the Resource view the History Graph is shown. Each Resource Run is presented by a dot. Red dots indicate that one or more Probes have failed in a Run. Green that all Probes gave success.
Fig. 10: WMS Type Resource View
Fig. 11: WMS Type Resource View - History
We see that this WMS has failed from somewhere on March 7, 2019 until March 11, 2019 when it became healthy again (last green dot right). Also the Resource has been made inactive for some time during failure as no dots are shown. The WMS itself may have been up though all the time! The is a classic case: the Capabilities Probe always succeeds, but more detailed WMS GetMap Probes may have failed. We can inspect this in more detail from the history graph.

The History Graph can be explored in detail by simply hovering the mouse over its dots. Also the graph can be zoomed in/out and panned, even with the mouse wheel. For each dot the overall result is shown: Date/Time of Run, Duration (of all Probe runs), Message (Ok, or error message). By clicking the Show-button the full Run report, i.e. all Probe and Check results for that Date/Time are shown in a popup panel.

Here we can see more detail for this WMS: the WMS GetMap and two other WMS GetMap-related Probes like WMSDrillDown, have failed, because an image file (.ecw file) could not be opened/Found. This is a classical example why you would need GeoHealthCheck: GetCapabilities always succeeds on the service endpoint, but more detailed GetMap requests fail!

The last run within the history is again success, so apparently the underlying issues have been repaired and the WMS is healthy again! For the last Run (green dot in graph), the email below is received.

This kind of email is received when the Resource is healthy (Ok, True) again.
3.4.9 Per-Resource Notifications

Notifications for each Resource can be configured in the Resource edit form:

Note: if left empty, the global (email-)notification settings will apply.

Two notification channel-types are currently available:

**Email**

Notifications can be sent to designated emails. If set in the config, GeoHealthCheck will send notifications for all resources to emails defined in `GHC_NOTIFICATIONS_EMAIL`. Additionally, each resource can have arbitrary list of emails (filled in Notify emails field in edit-form). By default, when a Resource is created, the owner’s email is added to the list. The editing User can add any email address, even for Users not registered in the GeoHealthCheck instance. When editing an email-list for a resource, the user will get address suggestions based on emails added for other Resources by that User. Multiple emails should be separated with comma (,) chars.

**Webhook**

Notifications can be also sent as webhooks (through POST requests). A Resource can have an arbitrary number of webhooks configured.

In the edit form, the User can configure webhooks. Each webhook should be entered in a separate field. Each webhook should contain at least a URL to which the POST request will be send. GeoHealthCheck will send following fields with that request:
A webhook configuration can hold additional form payload that will be sent along with GHC fields. Syntax for configuration:

- first line should be URL to which webhook will be sent
- second line should be empty
- third line (and subsequent) are used to store the custom payload, and should contain either:
  - pairs of field and value in separate lines (field=value)
  - a JSONified object, whose properties will be used as form fields

Configuration samples:

- URL-only:

  `http://server/webhook/endpoint`

- URL with fields as field-value pairs:

  `http://server/webhook/endpoint
  foo=bar
  otherfield=someothervalue`

- URL with payload as JSON:

  `http://server/webhook/endpoint
  {"foo":"bar","otherfield":"someothervalue"}`
3.4.10 GeoNode Resource Type

`GeoNode` Resource is a virtual Resource. It represents one GeoNode instance, but underneath auto-discovery is applied of OWS endpoints available in that instance. Note, that the OWS auto-discovery feature is optional, and you should check if your GeoNode instance has this feature enabled.

When a adding `GeoNode instance` Resource, you have to enter the URL to the GN instance’s home page. GeoHealthCheck will construct the URLs to fetch the list of OWS endpoints and create relevant Resources (WMS, WFS, WMTS, and other OWS Resources). It will check all endpoints provided by the GeoNode API, and will reject those which responded with an error.

All Resources added in this way will have at least one tag, which is constructed with the template: `GeoNode _hostname_`, where `_hostname_` is a host name from url provided. For example, let’s assume you add GeoNode instance that is served from `demo.geonode.org`. All resources created in this way will have `GeoNode demo.geonode.org` tag.

3.4.11 GeoHealthCheck Reporter Type

The `GeoHealthCheck Reporter (GHC-R)` Resource type allows users to receive a regular status summary report by email for the Resources in any local or remote GHC instance. Typically this is used for the local GHC instance. To setup:

- in top-menu select `Add | GeoHealthCheck Reporter (GHC-R)`
- in `Add Resource` screen add the site URL of the target GHC instance

Then in `Resource Edit` screen

- if the target GHC instance requires authentication: in `Authentication` form field select `Basic` and fill in username and password
- set `Run Every` field to a high value, typically 1440 minutes (every 24 hour)
- click `Edit` button for the assigned `GHC Email Reporter`
- set `email` field in `Probe Parameters` to one or more email addresses (comma-separated)

**Warning:** The Resource form-field “Notify emails” is **not** the target for the Email Report! It is used to report any possible errors for report assembly and email delivery.

**Warning:** Summary email reports may in cases be marked as spam by your email provider. In those cases you should greenlist (mark as non-spam) the sender email address.

**Note:** Tip: The ` GeoHealthCheck Reporter Probe` uses the `/api/v1.0/summary` API call. You can always get the last status report message as text via the URL `<GHC Instance URL>/api/v1.0/summary.txt` for example `https://demo.geohealthcheck.org/api/v1.0/summary.txt`

3.4.12 Resource Authentication

Resource authentication allows a user to optionally add credentials to access a secured `Resource` endpoint. Currently two (HTTP) authentication methods are supported:

- `Basic Authentication`: “classic” username and password based
• **Bearer Token**: single token based

The default is *None*, i.e. no authentication.

Within the Resource Edit screen, whenever a user selects an authentication method, the related input form-fields are shown. Any credentials added are stored encrypted.

Resource Authentication has been implemented using GHC Plugins, thus may be extended at will.

### 3.5 Architecture

GeoHealthCheck (GHC) consists of three cooperating parts as depicted in the figure below.

![GHC Parts Diagram](image)

**Fig. 15: Figure - GHC Parts**

The **GHC Webapp** provides the Dashboard where users configure web services (Resources) for (scheduled) health-checks and view the status of these checks. The **GHC Runner** performs the actual health-checks and notifications, based on what the user configured via the GHC Webapp.

The third part is the **Database** that stores all information like users, resources, checks, schedules, results etc.
The **GHC Webapp** is run as a standard Python (Flask) webapp. The **GHC Runner** runs as a daemon process using an internal scheduler to invoke the actual healthchecks.

**GHC Webapp** and **GHC Runner** can run as separate processes (preferred) or both within the **GHC Webapp** process. This depends on a configuration option. If **GHC_RUNNER_IN_WEBAPP** is set to True (the default) then the **GHC Runner** is started within the **GHC Webapp**.

A third option is to only run the **GHC Webapp** and have the **GHC Runner** scheduled via **cron**. This was the (only) GHC option before v0.5.0 and will be phased out as starting with v0.5.0, per-Resource scheduling was introduced and cron support is highly platform-dependent (e.g. hard to use with Docker-based technologies).

Dependent on the database-type (Postgres or SQLite) the **Database** is run within the above processes (SQLite) or as a separate process (Postgres).

So in the most minimal setup, i.e. **GHC Webapp** and **GHC Runner** running within a single process and using SQLite as the database, only a single GHC process instance is required.

### 3.5.1 Core Concepts

GeoHealthCheck is built with the following concepts in mind:

- **Resource**: a single, unique endpoint, like an OGC WMS, FTP URL, or plain old web link. A GeoHealthCheck deployment typically monitors numerous **Resources**.
- **Run**: the execution and scoring of a test against a **Resource**. A **Resource** may have multiple **Runs**
- Each **User** owns one or more **Resources**
- Each **Resource** is tested, “probed”, via one or more **Probes**
- Each **Probe** typically runs one or more requests on a **Resource** URL
- Each **Probe** invokes one or more **Checks** to determine **Run** result
- **Probes** and **Checks** are extensible **Plugins** via respective **Probe** and **Check** classes
- One or more **Tags** can be associated with a **Resource** to support grouping
- One or more **Recipient** can be associated with a **Resource**. Each **Recipient** describes:
  - communication channel
  - target identifier

### 3.5.2 Data Model

### 3.5.3 GHC Webapp Design

The **GHC Webapp** is realized as a standard **Flask** web-application using **SQLAlchemy** for ORM database support. It is the user-visible part of GHC as it runs via the browser. Its main two functionalities are to allow users to:

- manage (create, update, delete) Resources, their attributes and their Probes and Checks, and
- view results and statistics of Resources (Dashboard function)

Deployment can be realized using the various standard Flask deployment methods: standalone, within a WSGI server etc.

As an option (via configuration, see above) the **GHC Runner** may run within the **GHC Webapp**. Note that in case that when the **GHC Webapp** runs as multiple processes and/or threads “Resource Locking” (see below) will prevent inconsistencies.
Fig. 16: Figure - GHC Data Model
3.5.4 GHC Runner Design

The GHC Runner in its core is a job scheduler based on the Python library APScheduler. Each job scheduled is a healthcheck runner for a single Resource that runs all the Probes for that Resource. The run-frequency follows the per-Resource run frequency (since v0.5.0).

The GHC Runner is thus responsible for running the Probes for each Resource, storing the Results and doing notifications when needed.

The GHC Runner can run as a separate (Python) process, or within the GHC WebApp (see above). Separate processes is the preferred mode of running.

Job Runner Synchronization

As multiple instances of the job scheduler (i.e. APScheduler) may run in different processes and even threads within processes, the database is used to synchronize and assure only one job will run for a single Resource.

This is achieved by having one lock per Resource via the table ResourceLock. Only the process/thread that acquires its related ResourceLock record runs the job. As to avoid permanent “lockouts”, each ResourceLock has a lifetime, namely the timespan until the next Run as configured for/for Resource. This gives all job runners a chance to obtain a lock once “time’s up” for the ResourceLock.

Additional lock-liveliness is realized by using a unique UUID per job runner. Once the lock is obtained, the UUID-field of the lock record is set and committed to the DB. If we then try to obtain the lock again (by reading from DB) but the UUID is different this means another job runner instance did the same but was just before us. The lock-lifetime (see above) guards that a particular UUID keeps the lock forever, e.g. on sudden application shutdown.

To further increase liveliness, mainly to avoid all Jobs running at the same time when scheduled to run at the same frequency, each Job is started with a random time-offset on GHC Runner startup.

The locking mechanism described above is supported for SQLite, but it is strongly advised to use PostgreSQL in production deployments, also for better robustness and performance in general.

3.6 Plugins

GHC can be extended for Resource-specific healthchecks via Plugins. GHC already comes with a set of standard plugins that may suffice most installations. However, there is no limit to detailed healthchecks one may want to perform. Hence developers can extend or even replace the GHC standard Plugins with custom implementations.

Two Plugin types exist that can be extended: the Probe and Check class. In v0.7.0 also plugins for Resource Authentication, ResourceAuth, were added.

3.6.1 Concepts

GHC versions after May 1, 2017 perform healthchecks exclusively via Plugins (see Upgrade how to upgrade from older versions). The basic concept is simple: each Resource (typically an OWS endpoint) has one or more Probes. During a GHC run (via cron or manually), GHC sequentially invokes the Probes for each Resource to determine the health (QoS) of the Resource.

A Probe typically implements a single request like a WMS GetMap. A Probe contains and applies one or more Checks (the other Plugin class). A Check implements typically a single check on the HTTP Response object of its parent Probe, for example if the HTTP response has no errors or if a WMS GetMap actually returns an image (content-type check).

Each Check will supply a CheckResult to its parent Probe. The list of CheckResults will then ultimately determine the ProbeResult. The Probe will in turn supply the ProbeResult to its parent ResourceResult. The GHC healthchecker will
then determine the final outcome of the Run (fail/success) for the Resource, adding the list of Probe/CheckResults to the historic Run-data in the DB. This data can later be used for reporting and determining which Check(s) were failing.

So in summary: a Resource has one or more Probes, each Probe one or more Checks. On a GHC run these together provide a Result.

Probes and Checks available to the GHC instance are configured in config_site.py, the GHC instance config file. Also configured there is the default Probe class to assign to a Resource-type when it is added. Assignment and configuration/parameterization of Probes and Checks is via de UI on the Resource-edit page and stored in the database (tables: probe_vars and check_vars). That way the GHC healthcheck runner can read (from the DB) the list of Probes/Checks and their config for each Resource.

### 3.6.2 Implementation

Probes and Checks plugins are implemented as Python classes derived from GeoHealthCheck.probe.Probe and GeoHealthCheck.check.Check respectively. These classes inherit from the GHC abstract base class GeoHealthCheck.plugin.Plugin. This class mainly provides default attributes (in capitals) and introspection methods needed for UI configuration. Class-attributes (in capitals) are the most important concept of GHC Plugins in general. These provide metadata for various GHC functions (internal, UI etc). General class-attributes that Plugin authors should provide for derived Probes or Checks are:

- **AUTHOR**: Plugin author or team.
- **NAME**: Short name of Plugin.
- **DESCRIPTION**: Longer description of Plugin.
- **PARAM_DEFS**: Plugin Parameter definitions (see next)

**PARAM_DEFS**, a Python *dict* defines the parameter definitions for the Probe or Check that a user can configure via the UI. Each parameter (name) is itself a *dict* entry key that with the following key/value pairs:

- **type**: the parameter type, value: ‘string’, ‘stringlist’ (comma-separated strings) or ‘bbox’ (lowerX, lowerY, upperX, upperY),
- **description**: description of the parameter,
- **default**: parameter default value,
- **required**: is parameter required?,
- **range**: range of possible parameter values (array of strings), results in UI dropdown selector

A Probe should supply these additional class-attributes:

- **RESOURCE_TYPE**: GHC Resource type this Probe applies to, e.g. OGC:WMS, *:* (any Resource Type), see enums.py for range
- **REQUEST_METHOD**: HTTP request method capitalized, ‘GET’ (default) or ‘POST’.
- **REQUEST_HEADERS**: *dict* of optional HTTP request headers
- **REQUEST_TEMPLATE**: template in standard Python *str.format(*args)* to be substituted with actual parameters from **PARAM_DEFS**
- **CHECKS_AVAIL**: available Check (classes) for this Probe.

Note: **CHECKS_AVAIL** denotes all possible Checks that can be assigned, by default or via UI, to an instance of this Probe.

A Check has no additional class-attributes.

In many cases writing a Probe is a matter of just defining the above class-attributes. The GHC healthchecker GeoHealthCheck.healthcheck.run_test_resource() will call lifecycle methods of the
GeoHealthCheck.probe.Probe base class, using the class-attributes and actualized parameters (stored in `probe_vars` table) as defined in `PARAM_DEFS` plus a list of the actual and parameterized Checks (stored in `check_vars` table) for its Probe instance.

More advanced Probes can override base-class methods of `Probe` in particular `GeoHealthCheck.probe.Probe.perform_request()`. In that case the Probe-author should add one or more `GeoHealthCheck.result.Result` objects to `self.result` via `self.result.add_result(result)`

Writing a Check class requires providing the Plugin class-attributes (see above) including optional `PARAM_DEFS`. The actual check is implemented by overriding the Check base class method `GeoHealthCheck.check.Check.perform()`, setting the check-result via `GeoHealthCheck.check.Check.set_result()`.

Finally your Probes and Checks need to be made available to your GHC instance via `config_site.py` and need to be found on the Python-PATH of your app.

The above may seem daunting at first. Examples below will hopefully make things clear as writing new Probes and Checks may sometimes be a matter of minutes!

**TODO: may need VERSION variable class-attr to support upgrades**

### 3.6.3 Examples

GHC includes Probes and Checks that on first setup are made available in `config_site.py`. By studying the the GHC standard Probes and Checks under the subdir `GeoHealthCheck/plugins`, Plugin-authors may get a feel how implementation can be effected.

There are broadly two ways to write a Probe:

- using a `REQUEST_*` class-attributes, i.e. letting GHC do the Probe’s HTTP requests and checks
- overriding `GeoHealthCheck.probe.Probe.perform_request()`: making your own requests

An example for each is provided, including the Checks used.

The simplest Probe is one that does:

- an HTTP GET on a Resource URL
- checks if the HTTP Response is not errored, i.e. a 404 or 500 status
- optionally checks if the HTTP Response (not) contains expected strings

Below is the implementation of the class `GeoHealthCheck.plugins.probe.http.HttpGet`:

```python
    from GeoHealthCheck.probe import Probe

class HttpGet(Probe):
    """
    Do HTTP GET Request, to poll/ping any Resource bare url.
    """

    NAME = 'HTTP GET Resource URL'
    DESCRIPTION = 'Simple HTTP GET on Resource URL'
    RESOURCE_TYPE = '*:*'
    REQUEST_METHOD = 'GET'

    CHECKS_AVAIL = {
                       'GeoHealthCheck.plugins.check.checks.HttpStatusNoError': {
                           'default': True
                       },
    }
```

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Yes, this is the entire implementation of GeoHealthCheck.plugins.probe.http.HttpGet! Only class-attributes are needed:

- standard Plugin attributes: AUTHOR (‘GHC Team’ by default) NAME, DESCRIPTION
- RESOURCE_TYPE = ‘*::*’ denotes that any Resource may use this Probe (UI lists this Probe under “Probes Available” for Resource)
- REQUEST_METHOD = ‘GET’: GHC should use the HTTP GET request method
- CHECKS_AVAIL : all Check classes that can be applied to this Probe (UI lists these under “Checks Available” for Probe)

By setting:

```
'GeoHealthCheck.plugins.check.checks.HttpStatusNoError': {
    'default': True
},
```

that Check is automatically assigned to this Probe when created. The other Checks may be added and configured via the UI.

Next look at the Checks, the class GeoHealthCheck.plugins.check.checks.HttpStatusNoError:

```
import sys
from owslib.etree import etree
from GeoHealthCheck.plugin import Plugin
from GeoHealthCheck.check import Check
from html import escape

""" Contains basic Check classes for a Probe object."""

class HttpStatusNoError(Check):
    """ Checks if HTTP status code is not in the 400- or 500-range. """

    NAME = 'HTTP status should not be errored'
    DESCRIPTION = 'Response should not contain a HTTP 400 or 500 range Error'

    def __init__(self):
        Check.__init__(self)

    def perform(self):
        """Default check: Resource should at least give no error""
        status = self.probe.response.status_code
        overall_status = status // 100
        if overall_status in [4, 5]:
            self.set_result(False, 'HTTP Error status=%d' % status)
```

(continues on next page)
class HttpHasHeaderValue(Check):
    
    Checks if header exists and has given header value.
    See http://docs.python-requests.org/en/master/user/quickstart
    
Also this class is quite simple: providing class-attributes NAME, DESCRIPTION and implementing the base-class method GeoHealthCheck.check.Check.perform(). Via self.probe a Check always has a reference to its parent Probe instance and the HTTP Response object via self.probe.response. The check itself is a test if the HTTP status code is in the 400 or 500-range. The CheckResult is implicitly created by setting: self.set_result(False, 'HTTP Error status=%d' % status) in case of errors. self.set_result() only needs to be called when a Check fails. By default the Result is succes (True).

According to this pattern more advanced Probes are implemented for OWS Get Capabilities, the most basic test for OWS-es like WMS and WFS. Below the implementation of the class GeoHealthCheck.plugins.probe.owsgetcaps.OwsGetCaps and its derived classes for specific OWS-es:
CHECKS_AVAIL = {
    'GeoHealthCheck.plugins.check.checks.HttpStatusNoError': {
        'default': True
    },
    'GeoHealthCheck.plugins.check.checks.XmlParse': {
        'default': True
    },
    'GeoHealthCheck.plugins.check.checks.NotContainsOwsException': {
        'default': True
    },
    'GeoHealthCheck.plugins.check.checks.ContainsStrings': {
        'set_params': {
            'strings': {
                'name': 'Contains Title Element',
                'value': ['Title>']
            }
        },
        'default': True
    }
}

""" Checks avail for all specific Caps checks. Optionally override Check PARAM DEFS using set_params e.g. with specific 'value'. """

class WmsGetCaps(OwsGetCaps):
    """Fetch WMS capabilities doc"""
    NAME = 'WMS GetCapabilities'
    RESOURCE_TYPE = 'OGC:WMS'

    PARAM_DEFS = Plugin.merge(OwsGetCaps.PARAM_DEFS, {
        'service': {
            'value': 'WMS'
        },
        'version': {
            'default': '1.3.0',
            'range': ['1.1.1', '1.3.0']
        }
    })
    """Param defs"""

class WfsGetCaps(OwsGetCaps):
    """WFS GetCapabilities Probe"""
    NAME = 'WFS GetCapabilities'
    RESOURCE_TYPE = 'OGC:WFS'

    def __init__(self):
        OwsGetCaps.__init__(self)

        PARAM_DEFS = Plugin.merge(OwsGetCaps.PARAM_DEFS, {
            'service': {
            }""" (continues on next page)
More elaborate but still only class-attributes are used! Compared to GeoHealthCheck.plugins.probe.http.HttpGet, two additional class-attributes are used in GeoHealthCheck.plugins.probe.owsgetcaps.OwsGetCaps:

- `REQUEST_TEMPLATE = '?SERVICE={service}&VERSION={version}&REQUEST=GetCapabilities'
- `PARAM_DEFS` for the `REQUEST_TEMPLATE`

GHC will recognize a `REQUEST_TEMPLATE` (for GET or POST) and use `PARAM_DEFS` to substitute configured or default values, here defined in subclasses. This string is then appended to the Resource URL.

Three `Checks` are available, all included by default. Also see the construct:

```python
'GeoHealthCheck.plugins.check.checks.ContainsStrings': {
    'set_params': {
        'strings': {
            'name': 'Contains Title Element',
            'value': ['Title>']
        }
    },
    'default': True
},
```

This not only assigns this Check automatically on creation, but also provides it with parameters, in this case a `Capabilities` response document should always contain a `<Title>` XML element. The class GeoHealthCheck.plugins.check.checks.ContainsStrings checks if a response doc contains all of a list (array) of configured strings. So the full checklist on the response doc is:

- is it XML-parsable: GeoHealthCheck.plugins.check.checks.XmlParse
- does not contain an Exception: GeoHealthCheck.plugins.check.checks.NotContainsOwsException
- does it have a `<Title>` element: GeoHealthCheck.plugins.check.checks.ContainsStrings

These Checks are performed in that order. If any fails, the Probe Run is in error.

We can now look at classes derived from GeoHealthCheck.plugins.probe.owsgetcaps.OwsGetCaps, in particular GeoHealthCheck.plugins.probe.owsgetcaps.WmsGetCaps and GeoHealthCheck.plugins.probe.owsgetcaps.WfsGetCaps. These only need to set their `RESOURCE_TYPE` e.g. `OGC:WMS` and override/merge `PARAM_DEFS`. For example for WMS:

```python
PARAM_DEFS = Plugin.merge(OwsGetCaps.PARAM_DEFS, {
```

(continues on next page)
This sets a fixed value for service, later becoming service=WMS in the URL request string. For version it sets both a range of values a user can choose from, plus a default value 1.1.1. Plugin.merge needs to be used to merge-in new values. Alternatively PARAM DEFS can be completely redefined, but in this case we only need to make per-OWS specific settings.

Also new in this example is parameterization of Checks for the class GeoHealthCheck.plugins.check.checks.ContainsStrings. This is a generic HTTP response checker for a list of strings that each need to be present in the response. Alternatively GeoHealthCheck.plugins.check.checks.NotContainsStrings has the reverse test. Both are extremely useful and for example available to our first example GeoHealthCheck.plugins.probe.http.HttpGet. The concept of PARAM DEFS is the same for Probes and Checks.

In fact a Probe for any REST API could be defined in the above matter. For example, later in the project a Probe was added for the SensorThings API (STA), a recent OGC-standard for managing Sensor data via a JSON REST API. See the listing below:

```python
from GeoHealthCheck.probe import Probe

class StaCaps(Probe):
    '''Probe for SensorThings API main endpoint url'''

    NAME = 'STA Capabilities'
    DESCRIPTION = 'Perform STA Capabilities Operation and check validity'
    RESOURCE_TYPE = 'OGC:STA'

    REQUEST_METHOD = 'GET'

    def __init__(self):
        Probe.__init__(self)

    CHECKS_AVAIL = {
        'GeoHealthCheck.plugins.check.checks.HttpStatusNoError': {
            'default': True,
        },
        'GeoHealthCheck.plugins.check.checks.JsonParse': {
            'default': True
        },
        'GeoHealthCheck.plugins.check.checks.ContainsStrings': {
            'default': True,
            'set_params': {
                'strings': {
                    'name': 'Must contain STA Entity names',
                    'value': ['Things', 'Datastreams', 'Observations',
                              'FeaturesOfInterest', 'Locations']
                }
            }
        }
    }
```

(continues on next page)
Checks avail for all specific Caps checks. Optionally override Check.PARAM_DEFS using set_params e.g. with specific 'value' or even 'name'.

```
class StaGetEntities(Probe):
    """Fetch STA entities of type and check result""

    NAME = 'STA GetEntities'
    DESCRIPTION = 'Fetch all STA Entities of given type'
    RESOURCE_TYPE = 'OGC:STA'

    REQUEST_METHOD = 'GET'

    # e.g. http://52.26.56.239:8080/OGCSensorThings/v1.0/Things
    REQUEST_TEMPLATE = '/{entities}'

    def __init__(self):
        Probe.__init__(self)

        PARAM_DEFS = {
            'entities': {
                'type': 'string',
                'description': 'The STA Entity collection type',
                'required': True,
                'range': ['Things', 'DataStreams', 'Observations', 'Locations', 'Sensors', 'FeaturesOfInterest', 'ObservedProperties', 'HistoricalLocations']
            }
        }

        """Param defs""

        CHECKS_AVAIIL = {
            'GeoHealthCheck.plugins.check.checks.HttpStatusNoError': {
                'default': True
            },
            'GeoHealthCheck.plugins.check.checks.JsonParse': {
                'default': True
            }
        }

        """Check for STA Get entity Collection""
```

Up to now all Probes were defined using and overriding class-attributes. Next is a more elaborate example where the Probe overrides the Probe baseclass method GeoHealthCheck.probe.Probe.perform_request(). The example is more of a showcase: GeoHealthCheck.plugins.probe.wmsdrilldown.WmsDrilldown literally drills-down through WMS-entities: starting with the GetCapabilities doc it fetches the list of Layers and does a GetMap on random layers etc. It uses OWSLib.WebMapService.

We show the first 70 lines here.

```python
import random
```
from GeoHealthCheck.probe import Probe
from GeoHealthCheck.result import Result
from owslib.wms import WebMapService

class WmsDrilldown(Probe):
    """
    Probe for WMS endpoint "drilldown": starting
    with GetCapabilities doc: get Layers and do
    GetMap on them etc. Using OWSLib.WebMapService.
    
    TODO: needs finalization.
    """
    NAME = 'WMS Drilldown'
    DESCRIPTION = 'Traverses a WMS endpoint by drilling down from Capabilities'
    RESOURCE_TYPE = 'OGC:WMS'
    REQUEST_METHOD = 'GET'
    PARAM_DEFS = {
        'drilldown_level': {
            'type': 'string',
            'description': 'How heavy the drilldown should be.',
            'default': 'minor',
            'required': True,
            'range': ['minor', 'moderate', 'full']
        }
    }
    """Param defs"

    def __init__(self):
        Probe.__init__(self)

    def perform_request(self):
        """
        Perform the drilldown.
        See https://github.com/geopython/OWSLib/blob/
        master/tests/doctests/wms_GeoServerCapabilities.txt
        """
        wms = None

        # 1. Test capabilities doc, parses
        result = Result(True, 'Test Capabilities')
        result.start()
        try:
            wms = WebMapService(self._resource.url,
                                 headers=self.get_request_headers())
            title = wms.identification.title
            self.log('response: title=%s' % title)
        except Exception as err:
            result.set(False, str(err))
        result.stop()
        self.result.add_result(result)

        # 2. Test layers
This shows that any kind of simple or elaborate healthchecks can be implemented using single or multiple HTTP requests. As long as Result objects are set via `self.result.add_result(result)`. It is optional to also define Checks in this case. In the example `GeoHealthCheck.plugins.probe.wmsdrilldown.WmsDrilldown` example no Checks are used.

One can imagine custom Probes for many use-cases:

- drill-downs for OWS-es
- checking both the service and its metadata (CSW links in Capabilities doc e.g.)
- gaps in timeseries data (SOS, STA)
- even checking resources like a remote GHC itself!

Writing custom Probes is only limited by your imagination!

### 3.6.4 Configuration

Plugins available to a GHC installation are configured via `config_main.py` and overridden in `config_site.py`. By default all built-in Plugins are available.

- **GHC_PLUGINS**: list of built-in/core Plugin classes and/or modules available on installation
- **GHC_PROBE_DEFAULTS**: Default Probe class to assign on “add” per Resource-type
- **GHC_USER_PLUGINS**: list of your Plugin classes and/or modules available on installation

To add your Plugins, you need to configure **GHC_USER_PLUGINS**. In most cases you don’t need to bother with **GHC_PLUGINS** and **GHC_PROBE_DEFAULTS**.

See an example for both below from `config_main.py` for **GHC_PLUGINS** and **GHC_PROBE_DEFAULTS**:

```python
GHC_PLUGINS = [
    # Probes
    'GeoHealthCheck.plugins.probe.owsgetcaps',
    'GeoHealthCheck.plugins.probe.wms',
    'GeoHealthCheck.plugins.probe.wfs.WfsGetFeatureBbox',
    'GeoHealthCheck.plugins.probe.wmsdrilldown',
    'GeoHealthCheck.plugins.probe.sta',
    'GeoHealthCheck.plugins.probe.wfs3',
    'GeoHealthCheck.plugins.probe.http',
    'GeoHealthCheck.plugins.probe.wmsdrilldown',
    'GeoHealthCheck.plugins.probe.wfs3',

    # Checks
    'GeoHealthCheck.plugins.check.checks',
]```
# Default Probe to assign on "add" per Resource-type

GHC_PROBE_DEFAULTS = {
    'OGC:WMS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.WmsGetCaps'
    },
    'OGC:WMTS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.WmtsGetCaps'
    },
    'OSGeo:TMS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.tms.TmsCaps'
    },
    'OGC:WFS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.WfsGetCaps'
    },
    'OGC:WCS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.WcsGetCaps'
    },
    'OGC:WPS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.WpsGetCaps'
    },
    'OGC:CSW': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.CswGetCaps'
    },
    'OGC:SOS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.owsgetcaps.SosGetCaps'
    },
    'OGC:STA': {
        'probe_class': 'GeoHealthCheck.plugins.probe.sta.StaCaps'
    },
    'OGC:WFS3': {
        'probe_class': 'GeoHealthCheck.plugins.probe.wfs3.WFS3Drilldown'
    },
    'ESRI:FS': {
        'probe_class': 'GeoHealthCheck.plugins.probe.esrifs.ESRIFSDrilldown'
    },
    'urn:geoss:waf': {
        'probe_class': 'GeoHealthCheck.plugins.probe.http.HttpGet'
    },
    'WWW:LINK': {
        'probe_class': 'GeoHealthCheck.plugins.probe.http.HttpGet'
    },
    'FTP': {
        'probe_class': None
    }
}

To add your User Plugins these steps are needed:

- place your Plugin in any directory
- specify your Plugin in config_site.py in GHC_USER_PLUGINS var
- your Plugin module needs to be available in the PYTHONPATH of the GHC app

Let's say your Plugin is in file /plugins/ext/myplugin.py. Example config_site.py

GHC_USER_PLUGINS='ext.myplugin'

3.6. Plugins
Then you need to add the path /plugins to the PYTHONPATH such that your Plugin is found.

### 3.6.5 User Plugins via Docker

The easiest way to add your Plugins (and running GHC in general!) is by using GHC Docker. See more info in the GHC Docker Plugins README.

### 3.6.6 Plugin API Docs

For GHC extension via Plugins the following classes apply.

Most Plugins have `PARAM_DEFS` parameter definitions. These are variables that should be filled in by the user in the GUI unless a fixed value applies.

**Plugins - Base Classes**

These are the base classes for GHC Plugins. Developers will mainly extend `Probe` and `Check`.

*Results* are helper-classes whose intances are generated by both `Probe` and `Check` classes. They form the ultimate outcome when running a `Probe`. A `ResourceResult` contains `ProbeResults`, the latter contains `CheckResults`.

```python
class GeoHealthCheck.result.CheckResult(check, check_vars, success=True, message='OK')
    Bases: GeoHealthCheck.result.Result
    Holds result data from a single Check.

class GeoHealthCheck.result.ProbeResult(probe, probe_vars)
    Bases: GeoHealthCheck.result.Result
    Holds result data from a single Probe: one Probe, N Checks.

class GeoHealthCheck.result.ResourceResult(resource)
    Bases: GeoHealthCheck.result.Result
    Holds result data from a single Resource: one Resource, N Probe(Results). Provides Run data.

class GeoHealthCheck.result.Result(success=True, message='OK')
    Bases: object
    Base class for results for Resource or Probe.
```

**Plugins - Probes**

*Probes* apply to a single `Resource` instance. They are responsible for running requests against the Resource URL endpoint. Most *Probes* are implemented mainly via configuring class variables in particular `PARAM_DEFS` and `CHECKS_AVAIL`, but one is free to override any of the `Probe` baseclass methods.

**Plugins - Checks**

*Checks* apply to a single `Probe` instance. They are responsible for checking request results from their `Probe`.

**Plugins - Resource Auth**

*ResourceAuth* apply to optional authentication for a `Resource` instance. They are responsible for handling any (UI) configuration, encoding and execution of specific HTTP authentication methods for the `Resource` endpoint.
3.7 License

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3.8 Contact

The website geohealthcheck.org is the main entry point.

All development is done via GitHub: see https://github.com/geopython/geohealthcheck.

3.8.1 Links

- website: http://geohealthcheck.org
- GitHub: https://github.com/geopython/geohealthcheck
- Demo: https://demo.geohealthcheck.org
- Presentation: http://geohealthcheck.org/presentation
- Gitter Chat: https://gitter.im/geopython/GeoHealthCheck
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