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Questo documento vuole essere sia un’esercitazione che un manuale. Anche se non elenca tutti i possibili casi, dovrebbe comunque fornire una buona panoramica delle funzioni principali.

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Il supporto Python è stato introdotto per la prima volta in QGIS 0.9. Ci sono diversi modi per utilizzare Python in QGIS Desktop (trattato nelle seguenti sezioni):

- Tramite i comandi nella console Python in QGIS
- Crea e usa plugin
- Esegui automaticamente il codice Python all’avvio di QGIS
- Crea algoritmi di elaborazione
- Crea funzioni per espressioni in QGIS
- Create custom applications based on the QGIS API

Python è disponibile anche per QGIS Server, inclusi i plugin Python (vedi QGIS Server and Python) e i collegamenti Python che possono essere utilizzati per incorporare il server QGIS in un’applicazione Python.

C’è un riferimento complete QGIS C++ API che documenta le classi delle librerie QGIS. The Pythonic QGIS API (pyqgis) è quasi identico all’API C++.

Un’altra buona risorsa per imparare come svolgere operazioni comuni è scaricare i plugin esistenti dal repository dei plugin <https://plugins.qgis.org/> ed esaminare il loro codice.
1.1 Scripting nel terminale python

QGIS fornisce un terminale python. Puoi aprirlo dal menu Plugins ➤ Python Console :

La schermata sopra ti mostra come puoi prendere il layer attualmente selezionato nell’elenco dei layer, mostrare il suo ID e, facoltativamente, se è un vettore, ti può mostrare il conteggio degli elementi. Per l’interazione con l’ambiente QGIS, esiste una variabile iface, che è un’istanza della :classe:`QgisInterface <qgis.gui.QgisInterface>`.

Questa interfaccia ti consente l’accesso all’area della mappa, ai menu, alle barre degli strumenti e ad altre parti di QGIS.

Per comodità, esegui le seguenti istruzioni all’avvio del terminale (in futuro sarà possibile impostare ulteriori comandi iniziali)

```
from qgis.core import *
import qgis.utils
```

Se fai spesso uso del terminale, può essere utile impostare una scorciatoia per attivarlo (con Impostazioni ➤ Scorciatoie da tastiera…)

1.2 Plugin Python

Puoi estendere i comandi di QGIS tramite plugin, che possono essere scritti in python. Il vantaggio principale rispetto ai plugin C++ è la semplicità della distribuzione (nessuna compilazione per ogni piattaforma) e uno sviluppo più semplice.

Molti plugin che coprono varie funzionalità sono stati scritti dal supporto Python. Il programma di installazione del plugin ti consente di recuperare, aggiornare e rimuovere facilmente i plugin python. Vedi la pagina Python Plugins <https://plugins.qgis.org/> per maggiori informazioni sui plugin e sullo sviluppo dei plugin.

Creare un plugin in python è semplice, vedi Sviluppo di plugin Python per avere istruzioni dettagliate.

Nota: I plugin python sono disponibili anche per il server QGIS. Per ulteriori dettagli, vedi QGIS Server and Python.
1.3 Esegui il codice Python all’avvio di QGIS

Esistono diversi metodi distinti per avviare codice Python all’avvio di QGIS.

1. Crea uno script `startup.py`
2. Configura la variabile ambientale `PYQGIS_STARTUP` per un file python esistente

1.3.1 Il file `startup.py`

Ad ogni avvio di QGIS, la cartella principale di Python

- **Linux**: `.local/share/QGIS/QGIS3`
- **Windows**: `AppData\Roaming\QGIS\QGIS3`
- **macOS**: `Library/Application Support/QGIS/QGIS3`

viene cercato un file denominato `startup.py`. Se quel file esiste, viene eseguito dall’interprete Python installato.


1.3.2 La variabile ambientale `PYQGIS_STARTUP`

Puoi eseguire il codice Python appena prima del completamento dell’inizializzazione di QGIS impostando la variabile ambiente `PYQGIS_STARTUP` sul percorso di un file Python esistente.

Questo codice verrà eseguito prima del completamento dell’inizializzazione di QGIS. Questo metodo è molto utile per pulire `sys.path`, che può avere percorsi indesiderati, o per isolare/caricare l’ambiente iniziale senza richiedere un ambiente virtuale, ad es. homebrew o MacPorts si installa su Mac.

1.4 Applicazioni Python

È spesso comodo creare degli script per automatizzare i processi. Con PyQGIS, questo è perfettamente possibile — importa il modulo `qgis.core`, inizializzalo e sei pronto per l’elaborazione.

Oppure potresti voler creare un’applicazione interattiva che usi le funzionalità GIS — eseguire misurazioni, esportare una mappa in PDF, … Il modulo `qgis.gui` fornisce vari componenti dell’interfaccia grafica, in particolare il widget dell’area grafica della mappa che può essere incorporato nell’applicazione con il supporto per lo zoom, la panoramica e/o qualsiasi altro strumento personalizzato della mappa.

Le applicazioni personalizzate PyQGIS o i singoli script autonomi devono essere configurati per individuare le risorse QGIS, come le informazioni di proiezione e gli operatori per la lettura dei vettori e dei raster. Le risorse di QGIS vengono inizializzate aggiungendo alcune righe all’inizio dell’applicazione o dello script. Il codice per inizializzare QGIS per applicazioni personalizzate e singoli script è simile. Di seguito sono riportati esempi di ciascuno.

Nota: Non usare `qgis.py` come nome per il tuo script. Python non sarà in grado di importare i collegamenti poiché il nome dello script li confonderà.
1.4.1 Usare PyQGIS in script

Per avviare un singolo script, attiva le risorse QGIS all’inizio dello script:

```python
from qgis.core import *

# Supply path to qgis install location
QgsApplication.setPrefixPath("/path/to/qgis/installation", True)

# Create a reference to the QgsApplication. Setting the # second argument to False disables the GUI.
qgs = QgsApplication([], False)

# Load providers
qgs.initQgis()

# Write your code here to load some layers, use processing # algorithms, etc.

# Finally, exitQgis() is called to remove the # provider and layer registries from memory
qgs.exitQgis()
```

Prima importiamo il modulo qgis.core e configuriamo il prefisso del percorso. Il prefisso del percorso è la posizione in cui QGIS è installato sul tuo sistema. Viene configurato nello script chiamando il metodo setPrefixPath(). Il secondo parametro di setPrefixPath() è impostato a True, specificando che i percorsi predefiniti devono essere usati.

Il percorso di installazione di QGIS varia a seconda della piattaforma; il modo più semplice per trovarlo per il tuo sistema è usare il Scripting nel terminale python dall’interno di QGIS e controllare il risultato della sua esecuzione:

```python
QgsApplication.prefixPath()
```

Dopo aver configurato il prefisso del percorso, salviamo un riferimento a QgsApplication nella variabile qgs. Il secondo parametro è impostato a False, specificando che non abbiamo intenzione di usare la GUI poiché stiamo scrivendo uno script standalone. Con QgsApplication configurato, cariciamo i fornitori di dati QGIS e il registro dei layer chiamando il metodo initQgis().

```python
qgs.initQgis()
```

Con QGIS inizializzato, siamo pronti a scrivere il resto dello script. Infine, concludiamo chiamando exitQgis() per rimuovere i data provider e il registro dei layer dalla memoria.

```python
qgs.exitQgis()
```

1.4.2 Usare PyQGIS in applicazioni personalizzate

L’unica differenza tra Usare PyQGIS in script e un’applicazione PyQGIS personalizzata è il secondo parametro quando si istanzia la QgsApplication. Imposta True invece di False per indicare che abbiamo intenzione di usare una GUI.

```python
from qgis.core import *

# Supply the path to the qgis install location
QgsApplication.setPrefixPath("/path/to/qgis/installation", True)

# Create a reference to the QgsApplication.
# Setting the second argument to True enables the GUI. We need # this since this is a custom application.
```

(continues on next page)
10 qgs = QgsApplication([], True)
11
12 # load providers
13 qgs.initQgis()
14
15 # Write your code here to load some layers, use processing
16 # algorithms, etc.
17
18 # Finally, exitQgis() is called to remove the
19 # provider and layer registries from memory
20 qgs.exitQgis()

Ora puoi lavorare con l’API QGIS: caricare i livelli ed eseguire alcune elaborazioni o avviare una GUI con un’area della mappa. Le possibilità sono infinite :-) 

1.4.3 Avviare applicazioni personalizzate

Devi dire al tuo sistema dove cercare le librerie QGIS e i moduli Python se non si trovano in una posizione già nota, altrimenti Python lo segnalerà:

```python
>>> import qgis.core
ImportError: No module named qgis.core
```

Puoi risolvere impostando la variabile ambiente PYTHONPATH. Nei seguenti comandi, <qgispath> deve essere sostituito con il percorso di installazione di QGIS:

- su Linux: `export PYTHONPATH=/<qgispath>/share/qgis/python`
- su Windows: `set PYTHONPATH=c:\<qgispath>\python`
- su macOS: `export PYTHONPATH=/<qgispath>/Contents/Resources/python`

Ora, il percorso dei moduli PyQGIS è noto, ma questi dipendono dalle librerie qgis_core e qgis_gui (i moduli Python servono solo come contenitori). Il percorso di queste librerie potrebbe essere sconosciuto al sistema operativo, quindi verrà visualizzato nuovamente un errore di importazione (il messaggio potrebbe variare in base al sistema):

```python
>>> import qgis.core
ImportError: libqgis_core.so.3.2.0: cannot open shared object file:
No such file or directory
```

Risolvi questo aggiungendo le cartelle delle librerie QGIS nel percorso di ricerca del collegamento dinamico:

- su Linux: `export LD_LIBRARY_PATH=/<qgispath>/lib`
- su Windows: `set PATH=C:\<qgispath>\bin;C:\<qgispath>\apps\<qgisrelease>\bin;%PATH%` dove `<qgisrelease>` dovrebbe essere sostituito con il tuo tipo di versione (es. qgis-ltr, qgis, qgis-dev)

Questi comandi possono essere inseriti in uno script che se ne occuperà all’avvio del programma. Quando si fa uso di applicazioni personalizzate utilizzando PyQGIS, esistono di solito due possibilità:

- richiede all’utente di installare QGIS prima di installare l’applicazione. Il programma di installazione dell’applicazione dovrebbe cercare percorsi predefiniti delle librerie QGIS e consentire all’utente di impostare il percorso se non trovato. Questo approccio ha il vantaggio di essere più semplice, tuttavia richiede all’utente di fare più passaggi.
- impacchetta QGIS insieme alla tua applicazione. Rilasciare l’applicazione può essere più impegnativo e il pacchetto sarà più grande, ma l’utente sarà risparmiato dall’onere di scaricare e installare parti addizionali del programma.

I due modelli di distribuzione possono essere combinati. È possibile fornire applicazioni indipendenti su Windows e macOS, ma per Linux lasciare l’installazione di GIS all’utente e al suo gestore dei pacchetti.

1.4. Applicazioni Python
1.5 Note tecniche su PyQt e SIP

Python è una dei linguaggi preferiti per lo scripting. I collegamenti PyQGIS in QGIS 3 dipendono da SIP e PyQt5. La ragione per usare SIP invece del SWIG più usato è che il codice QGIS dipende dalle librerie Qt. I collegamenti Python per Qt (PyQt) vengono eseguiti utilizzando SIP e ciò consente una perfetta integrazione di PyQGIS con PyQt.

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import (QgsProject,
                      QgsPathResolver)

from qgis.gui import (QgsLayerTreeMapCanvasBridge,
                      )
```
Caricamento di progetti

Ti può capitare di dovere caricare un progetto esistente da un plugin o (più spesso) quando stai sviluppando un’applicazione QGIS Python autonoma (see: Applicazioni Python).

Per caricare un progetto nell’applicazione QGIS corrente devi creare un’istanza della classe QgsProject. Questa è una classe singleton, quindi devi utilizzare il suo metodo instance() per farlo. Puoi chiamare il suo metodo read(), indicando il percorso del progetto da caricare:

```python
# If you are not inside a QGIS console you first need to import
# qgis and PyQt classes you will use in this script as shown below:
from qgis.core import QgsProject
# Get the project instance
project = QgsProject.instance()
# Print the current project file name (might be empty in case no projects have been loaded)
print(project.fileName())
# Load another project
project.read('testdata/01_project.qgs')
print(project.fileName())
```

testdata/01_project.qgs

Se vuoi modificare il progetto (ad esempio per aggiungere o rimuovere dei layer) e salvarne le modifiche, chiama il metodo write() dell’istanza del progetto. Il metodo write() accetta anche un nuovo percorso per salvare il progetto in una nuova posizione:

```python
# Save the project to the same
project.write()
# ... or to a new file
project.write('testdata/my_new_qgis_project.qgs')
```

Sia la funzione read() che quella write() restituiscono un valore booleano che puoi utilizzare per verificare se l’operazione ha avuto esito positivo.

Nota: Se stai scrivendo un’applicazione QGIS, per sincronizzare il progetto caricato con l’area di mappa, devi creare un’istanza di QgsLayerTreeMapCanvasBridge come nell’esempio seguente:
bridge = QgsLayerTreeMapCanvasBridge( \
    QgsProject.instance().layerTreeRoot(), canvas)  
# Now you can safely load your project and see it in the canvas 
project.read('testdata/my_new_qgis_project.qgs')

## 2.1 Resolving bad paths

It can happen that layers loaded in the project are moved to another location. When the project is loaded again all the layer paths are broken.

The `QgsPathResolver` class with the `setPathPreprocessor()` allows setting a custom path pre-processor function, which allows for manipulation of paths and data sources prior to resolving them to file references or layer sources.

The processor function must accept a single string argument (representing the original file path or data source) and return a processed version of this path.

The path pre-processor function is called before any bad layer handler.

Some use cases:

1. replace an outdated path:

   ```python
def my_processor(path):
       return path.replace('c:/Users/ClintBarton/Documents/Projects', 'x:/Projects/')

QgsPathResolver.setPathPreprocessor(my_processor)
```

2. replace a database host address with a new one:

   ```python
def my_processor(path):
       return path.replace('host=10.1.1.115', 'host=10.1.1.116')

QgsPathResolver.setPathPreprocessor(my_processor)
```

3. replace stored database credentials with new ones:

   ```python
def my_processor(path):
       path = path.replace("user='gis_team'", "user='team_awesome'")
       path = path.replace("password='cats'", "password='g7as!m*'")
       return path

QgsPathResolver.setPathPreprocessor(my_processor)
```
I frammenti di codice in questa pagina hanno bisogno dei seguenti import:

```python
import os # This is is needed in the pyqgis console also
from qgis.core import (QgsVectorLayer)
```

- **Vettori**
- **Raster**
- **Istanza QgsProject**

Apri alcuni layer con dati. QGIS riconosce vettori e raster. Inoltre sono disponibili tipi di layer personalizzati ma non li discuteremo qui.

### 3.1 Vettori

Per creare e aggiungere un’istanza di layer vettoriale al progetto, specificare l’identificatore della fonte di dati del layer, il nome del layer ed il nome del provider:

```python
# get the path to the shapefile e.g. /home/project/data/ports.shp
path_to_airports_layer = "testdata/airports.shp"

# The format is:
# vlayer = QgsVectorLayer(data_source, layer_name, provider_name)

vlayer = QgsVectorLayer(path_to_airports_layer, "Airports layer", "ogr")

if not vlayer.isValid():
    print("Layer failed to load!")
else:
    QgsProject.instance().addMapLayer(vlayer)
```
L’identificativo dell’origine dati è una stringa ed è specifico per ciascun fornitore di dati vettoriali. Il nome del livello viene utilizzato nell’oggetto elenco livelli. È importante verificare se il layer è stato caricato correttamente. In caso contrario, viene restituita un’istanza di livello non valida.

Per un vettore geopackage:

```python
# get the path to a geopackage e.g. /usr/share/qgis/resources/data/world_map.gpkg
path_to_gpkg = os.path.join(QgsApplication.pkgDataPath(), "resources", "data", "world_map.gpkg")

# append the layername part
gpkg_countries_layer = path_to_gpkg + "|layername=countries"

gpkg_places_layer = "|layername=places"

vlayer = QgsVectorLayer(gpkg_countries_layer, "Countries layer", "ogr")

if not vlayer.isValid():
    print("Layer failed to load!")
else:
    QgsProject.instance().addMapLayer(vlayer)
```

Il modo più rapido per aprire e visualizzare un vettore in QGIS è il metodo `addVectorLayer()` della classe `QgisInterface`:

```python
vlayer = iface.addVectorLayer(path_to_airports_layer, "Airports layer", "ogr")

if not vlayer:
    print("Layer failed to load!")
```

Questo crea un nuovo layer e lo aggiunge al progetto QGIS corrente (facendolo apparire nell’elenco dei layer) in un solo passaggio. La funzione restituisce l’istanza del layer o `None` se non è stato possibile caricare il layer.

Il seguente elenco mostra come accedere a varie fonti di dati usando i fornitori di dati vettoriali:

- **Libreria OGR** (shapefile e molti altri formati di file) — l’origine dati è il percorso del file:
  - per shapefile:
    ```python
    vlayer = QgsVectorLayer("testdata/airports.shp", "layer_name_you_like", "ogr")
    QgsProject.instance().addMapLayer(vlayer)
    ```
  - per dxf (nota le opzioni nell’origine dati uri):
    ```python
    uri = "testdata/sample.dxf|layername=entities|geometrytype=Polygon"
    vlayer = QgsVectorLayer(uri, "layer_name_you_like", "ogr")
    QgsProject.instance().addMapLayer(vlayer)
    ```

- **Database PostGIS** - data source è una stringa con tutte le informazioni necessarie per creare una connessione al database PostgreSQL.

La classe `QgsDataSourceUri` può generare questa stringa per te. Nota che QGIS deve essere stato compilato con il supporto Postgres, altrimenti questo provider non è disponibile:

```python
uri = QgsDataSourceUri()
uri.setConnection("localhost", "5432", "dbname", "johny", "xxx")
uri.setDataSource("public", "roads", "the_geom", "cityid = 2643", "primary_key", "field")

vlayer = QgsVectorLayer(uri.uri(False), "layer name you like", "postgis")
```
Nota: L’argomento `False` passato a `uri.uri(False)` previene l’espansione dei parametri di configurazione di autenticazione, se tu non usi nessuna configurazione di autenticazione questo argomento non produrrà nessun effetto.

- CSV o altri file di testo delimitati — per aprire un file con un punto e virgola come delimitatore, con il campo «x» per la coordinata X e il campo «y» per la coordinata Y si userebbe qualcosa di simile:

```python
uri = "file:///testdata/delimited_xy.csv?delimiter=/\xField=/\yField=/".
       "format(os.getcwd(), ";", "x", "y")
vlayer = QgsVectorLayer(uri, "layer name you like", "delimitedtext")
QgsProject.instance().addMapLayer(vlayer)
```

Nota: La stringa provider è strutturata come un URL, quindi il percorso deve avere il prefisso `file://`. Inoltre permette di formattare geometrie WKT (well known text) in alternativa ai campi 'x' e 'y' e permette di specificare il sistema di riferimento di coordinate. Per esempio:

```python
uri = "file:///some/path/file.csv?delimiter=/\xField=/\yField=/".
       ";"", "shape"
```

- I file GPX — il provider di dati «gpx» legge tracce, percorsi e waypoint dai file gpx. Per aprire un file, il tipo (track/route/waypoint) deve essere specificato come parte dell'url:

```python
uri = "testdata/layers.gpx?type=track"
vlayer = QgsVectorLayer(uri, "layer name you like", "gpx")
QgsProject.instance().addMapLayer(vlayer)
```

- Database SpatiaLite — Analogamente ai database PostGIS, :class:`Qgsdatasourceuri` può essere utilizzato per la generazione dell’identificatore della fonte di dati:

```python
uri = QgsDataSourceUri()
uri.setDatabase('/home/martin/test-2.3.sqlite')
schema = '
    table = 'Towns'
    geom_column = 'Geometry'
    uri.setDataSource(schema, table, geom_column)
    display_name = 'Towns'
vlayer = QgsVectorLayer(uri.uri(), display_name, 'spatialite')
QgsProject.instance().addMapLayer(vlayer)
```

- Mysql WKB-based geometries, attraverso OGR — data source è la stringa di connessione alla tabella:

```python
uri = "MySQL:dbname,host=localhost,port=3306,user=root,
    password=xxx|layername=my_table"
vlayer = QgsVectorLayer( uri, "my table", "ogr" )
QgsProject.instance().addMapLayer(vlayer)
```

- Connessione WFS: la connessione è definita con un URI e usando il ``WFS`` provider:

```python
uri = "https://demo.mapserver.org/cgi-bin/wfs?service=WFS&version=2.0.0&
    request=GetFeature&typename=ms:cities"
vlayer = QgsVectorLayer(uri, "my wfs layer", "WFS")
```

L’uri può essere creato usando la libreria standard `urllib`:

```python
import urllib
```

(continues on next page)
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(continua dalla pagina precedente)

```python
params = {
    'service': 'WFS',
    'version': '2.0.0',
    'request': 'GetFeature',
    'typename': 'ms:cities',
    'srsname': 'EPSG:4326'
}

uri2 = 'https://demo.mapserver.org/cgi-bin/wfs?' + urllib.parse.unquote(urllib.parse.urlencode(params))
```

Nota: È possibile cambiare la fonte di dati di un livello esistente chiamando `setDataSource()` su un'istanza `Qgsvectorlayer` come nell'esempio seguente:

```python
uri = "https://demo.mapserver.org/cgi-bin/wfs?service=WFS&version=2.0.0&request=GetFeature&typename=ms:cities"

provider_options = QgsDataProvider.ProviderOptions()

# Use project's transform context

provider_options.transformContext = QgsProject.instance().transformContext()

vlayer.setDataSource(uri, "layer name you like", "WFS", provider_options)

del(vlayer)
```

### 3.2 Raster

Per accedere ai file raster, viene utilizzata la libreria GDAL. Supporta una vasta gamma di formati di file. In caso di problemi con l’apertura di alcuni file, verificare se il GDAL ha il supporto per il formato particolare (non tutti i formati sono disponibili per impostazione predefinita). Per caricare un raster da un file, specificare il nome del file e il nome di visualizzazione:

```python
# get the path to a tif file e.g. /home/project/data/srtm.tif
path_to_tif = "qgis-projects/python_cookbook/data/srtm.tif"

rlayer = QgsRasterLayer(path_to_tif, "SRTM layer name")

if not rlayer.isValid():
    print("Layer failed to load!")
```

Per caricare un raster da un geopackage:

```python
# get the path to a geopackage e.g. /home/project/data/data.gpkg
path_to_gpkg = os.path.join(os.getcwd(), "testdata", "sublayers.gpkg")

# gpkg_raster_layer = "GPKG:/home/project/data/data.gpkg:srtm"
gpkg_raster_layer = "GPKG:" + path_to_gpkg + ":srtm"

rlayer = QgsRasterLayer(gpkg_raster_layer, "layer name you like", "gdal")

if not rlayer.isValid():
    print("Layer failed to load!")
```

Analogamente ai livelli vettoriali, i livelli raster possono essere caricati usando la funzione `addRasterLayer` dell’oggetto classe `QgisInterface <qgis.gui.QgisInterface>`:

```python
iface.addRasterLayer(path_to_tif, "layer name you like")
```

Questo crea un nuovo livello e lo aggiunge al progetto corrente (facendolo apparire nella lista dei livelli) in un solo passaggio.

Per caricare un raster Postgis:
I raster PostGIS, simili ai vettori PostGIS, possono essere aggiunti a un progetto usando una stringa URI. È efficiente mantenere un dizionario riutilizzabile di stringhe per i parametri di connessione al database. Questo rende facile modificare il dizionario per la connessione appropriata. Il dizionario viene poi codificato in un URI usando l’oggetto metadati del provider "postgresraster". Dopo di che il raster può essere aggiunto al progetto.

```python
uri_config = {
    # database parameters
    'dbname': 'gis_db',  # The PostgreSQL database to connect to.
    'host': 'localhost',  # The host IP address or localhost.
    'port': '5432',  # The port to connect on.
    'sslmode': QgsDataSourceUri.SslDisable,  # SslAllow, SslPrefer, SslRequire, -
    # user and password are not needed if stored in the authcfg or service
    'service': 'QconfigId',  # The QGIS authentication database ID holding...
    # connection details.
    # The PostgreSQL service to be used for connection to...
    # the database.
    'username': None,  # The PostgreSQL user name.
    'password': None,  # The PostgreSQL password for the user.
    # table and raster column details
    'schema': 'public',  # The database schema that the table is located in.
    'table': 'my_rasters',  # The database table to be loaded.
    'geometrycolumn': 'rast',  # raster column in PostGIS table
    'sql': None,  # An SQL WHERE clause. It should be placed at the end...
    # of the string.
    # A key column from the table.
    'key': None,
    # A string designating the SRID of the coordinate...
    # reference system.
    'estimatedmetadata': False,  # A boolean value telling if the metadata is...
    # estimated.
    'type': None,  # A WKT string designating the WKB Type.
    'selectatid': None,  # Set to True to disable selection by feature ID.
    'options': None,  # other PostgreSQL connection options not in this list.
    'enableTime': None,
    # raster column in PostGIS table
    'temporalDefaultTime': None,
    'temporalFieldIndex': None,
    # GTAL 'mode' parameter, 2 unions raster tiles, 1 adds...
    # tiles separately (may require user input)
    'mode': '2',
    # database parameters
}

uri_config = (key: val for key, val in uri_config.items() if val is not None)

md = QgsProviderRegistry.instance().providerMetadata('postgresraster')
uri = QgsDataSourceUri(md.encodeUri(uri_config))

# the raster can then be loaded into the project
layer = iface.addRasterLayer(uri.uri(False), "raster layer name", "postgresraster ...")
```

I livelli raster possono anche essere creati da un servizio WCS:

```python
layer_name = 'modis'
url = "https://demo.mapserver.org/cgi-bin/wcs?identifier=modis".format(layer_name)
layer = QgsRasterLayer(url, "my wcs layer", 'wcs')
```

Ecco una descrizione dei parametri che l’URI WCS può contenere:

L’URI WCS è composto da coppie key=value separate da &. È lo stesso formato come la stringa di interrogazione nell’URL, codificata nello stesso modo. : class:QgsDataSourceURI Qgs.core QgsDataSourceURI> dovrebbe essere usato per costruire l’URI per garantire che i caratteri speciali siano codificati correttamente.

- **url** (obbligatorio): URL del server WCS. Non usare VERSION nell’URL, perché ogni versione del WCS usa un nome di parametro diverso per la versione GetCapabilities, vedi param version.

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• **identifier** (obbligatorio): Coverage name

• **time** (opzionale): posizione temporale o periodo temporale (beginPosition/endposition[timeResolution])

• **format** (opzionale): Nome formato supportato. Il formato predefinito è il primo formato supportato con tif nel nome o il primo formato supportato.

• **crs** (facoltativo): CRS nel modulo AUTHORITY:ID, ad es. EPSG:4326. Il valore predefinito è EPSG:4326 se supportato o il primo SR supportato.

• **username** (opzionale): Nome utente per l’autenticazione di base.

• **password** (opzionale): password per l’autenticazione di base.

• **IgnoreGetMapUrl** (opzionale, hack): Se specificato (impostato a 1), ignora l’URL di GetCoverage pubblicizzato da GetCapabilities. Può essere necessario se un server non è configurato correttamente.

• **InvertAxisOrientation** (opzionale, hack): Se specificato (impostato a 1), inverte l’asse nella richiesta GetCoverage. Può essere necessario per un SR geografico se un server sta “usando un’ordine errato dell’asse.

• **IgnoreAxisOrientation** (opzionale, hack): Se specificato (impostato a 1), non invertire l’orientamento dell’asse secondo lo standard WCS per SR geografico.

• **cache** (opzionale): controllo del caricamento della cache, come descritto in QNetworkRequest::CacheLoadControl, ma la richiesta viene rinviiata come PreferCache se non riuscita con AlwaysCache. Valori ammessi: AlwaysCache, PreferCache, PreferNetwork, AlwaysNetwork. Il valore predefinito è AlwaysCache.

In alternativa è possibile caricare un livello raster dal server WMS. Tuttavia attualmente non è possibile accedere alla risposta GetCapabilities da API — devi sapere quali livelli vuoi:

```python
def urlWithParams = "crs=EPSG:4326&format=image/png&layers=continents&styles&url=https://demo.mapserver.org/cgi-bin/wms"
rlayer = QgsRasterLayer(urlWithParams, 'some layer name', 'wms')
if not rlayer.isValid():
    print("Layer failed to load!")
```

### 3.3 Istanza QgsProject

Se volete usare i livelli aperti per il rendering, non dimenticate di aggiungerli all’istanza QgsProject qgis.core.QgsProject. L’istanza QgsProject prende la proprietà di livelli e possono essere successivamente accessibili da qualsiasi parte dell’applicazione dal loro ID univoco. Quando il livello viene rimosso dal progetto, viene anche eliminato. I livelli possono essere rimossi dall’utente nell’interfaccia QGIS, o tramite Python usando il metodo removeMapLayer() qgis.core.Qgsproject.removeMapLayer().

L’aggiunta di un livello al progetto corrente viene effettuata utilizzando il metodo `addMapLayer()` :

```python
QgsProject.instance().addMapLayer(rlayer)
```

Per aggiungere un livello in una posizione assoluta:

```python
# first add the layer without showing it
QgsProject.instance().addMapLayer(rlayer, False)
# obtain the layer tree of the top-level group in the project
layerTree = iface.layerTreeCanvasBridge().rootGroup()
# the position is a number starting from 0, with -1 an alias for the end
layerTree.insertChildNode(-1, QgsLayerTreeLayer(rlayer))
```

Se si desidera eliminare il livello utilizzare il metodo `removeMapLayer()` :

```python
# QgsProject.instance().removeMapLayer(layer_id)
QgsProject.instance().removeMapLayer(rlayer.id())
```
Nel codice precedente, l'ID del livello viene passato (si può ottenere chiamando il metodo `id()` del livello), ma si può anche passare l'oggetto del livello stesso.

Per una lista di livelli caricati e ID di livello, usare il metodo `mapLayers()`:

```python
QgsProject.instance().mapLayers()
```

The code snippets on this page need the following imports if you're outside the pyqgis console:

```python
from qgis.core import (QgsProject, QgsVectorLayer,
)
```
Accessing the Table Of Contents (TOC)

- The QgsProject class
- QgsLayerTreeGroup class

You can use different classes to access all the loaded layers in the TOC and use them to retrieve information:

- QgsProject
- QgsLayerTreeGroup

### 4.1 The QgsProject class

You can use `QgsProject` to retrieve information about the TOC and all the layers loaded.

You have to create an instance of `QgsProject` and use its methods to get the loaded layers.

The main method is `mapLayers()`. It will return a dictionary of the loaded layers:

```python
layers = QgsProject.instance().mapLayers()
print(layers)
```

```
{'countries_89ae1b0f_f41b_4f42_bca4_caf55ddbe4b6': <QgsVectorLayer: 'countries'...-(ogr)>}
```

The dictionary keys are the unique layer ids while the values are the related objects.

It is now straightforward to obtain any other information about the layers:

```python
# list of layer names using list comprehension
l = [layer.name() for layer in QgsProject.instance().mapLayers().values()]
# dictionary with key = layer name and value = layer object
layers_list = {}
for l in QgsProject.instance().mapLayers().values():
    layers_list[l.name()] = l
print(layers_list)
```
You can also query the TOC using the name of the layer:

```python
country_layer = QgsProject.instance().mapLayersByName("countries")[0]
```

**Nota:** A list with all the matching layers is returned, so we index with [0] to get the first layer with this name.

### 4.2 QgsLayerTreeGroup class

The layer tree is a classical tree structure built of nodes. There are currently two types of nodes: group nodes (`QgsLayerTreeGroup`) and layer nodes (`QgsLayerTreeLayer`).

**Nota:** for more information you can read these blog posts of Martin Dobias: Part 1 Part 2 Part 3

The project layer tree can be accessed easily with the method `layerTreeRoot()` of the `QgsProject` class:

```python
root = QgsProject.instance().layerTreeRoot()
```

`root` is a group node and has children:

```python
root.children()
```

A list of direct children is returned. Sub group children should be accessed from their own direct parent.

We can retrieve one of the children:

```python
child0 = root.children()[0]
print(child0)
```

```
<qgis._core.QgsLayerTreeLayer object at 0x7f1e1ea54168>
```

Layers can also be retrieved using their (unique) id:

```python
ids = root.findLayerIds()
# access the first layer of the ids list
root.findLayer(ids[0])
```

And groups can also be searched using their names:

```python
root.findGroup('Group Name')
```

`QgsLayerTreeGroup` has many other useful methods that can be used to obtain more information about the TOC:

```python
# list of all the checked layers in the TOC
checked_layers = root.checkedLayers()
print(checked_layers)
```

```
[<QgsVectorLayer: 'countries' (ogr)>]
```

Now let’s add some layers to the project’s layer tree. There are two ways of doing that:

1. Explicit addition using the `addLayer()` or `insertLayer()` functions:
1. Implicit addition: since the project’s layer tree is connected to the layer registry it is enough to add a layer to the map layer registry:

```python
QgsProject.instance().addMapLayer(layer1)
```

You can switch between `QgsVectorLayer` and `QgsLayerTreeLayer` easily:

```python
node_layer = root.findLayer(country_layer.id())
print("Layer node:", node_layer)
print("Map layer:", node_layer.layer())
```

Layer node: `<qgis._core.QgsLayerTreeLayer object at 0x7f24423175e0>
Map layer: `<QgsVectorLayer: 'countries' (ogr)>

Groups can be added with the `addGroup()` method. In the example below, the former will add a group to the end of the TOC while for the latter you can add another group within an existing one:

```python
node_group1 = root.addGroup('Simple Group')
# add a sub-group to Simple Group
node_subgroup1 = node_group1.addGroup("I'm a sub group")
```

To moving nodes and groups there are many useful methods.

Moving an existing node is done in three steps:

1. cloning the existing node
2. moving the cloned node to the desired position
3. deleting the original node

```python
# clone the group
cloned_group1 = node_group1.clone()
# move the node (along with sub-groups and layers) to the top
root.insertChildNode(0, cloned_group1)
# remove the original node
root.removeChildNode(node_group1)
```

It is a little bit more complicated to move a layer around in the legend:

```python
# get a QgsVectorLayer
vl = QgsProject.instance().mapLayersByName("countries")[0]
# create a QgsLayerTreeLayer object from vl by its id
myvl = root.findLayer(vl.id())
# clone the myvl QgsLayerTreeLayer object
myvclone = myvl.clone()
# get the parent. If None (layer is not in group) returns ''
parent = myvl.parent()
# move the cloned layer to the top (0)
parent.insertChildNode(0, myvclone)
# remove the original myvl
root.removeChildNode(myvl)
```

or moving it to an existing group:

---

4.2. QgsLayerTreeGroup class

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```python
# get a QgsVectorLayer
vl = QgsProject.instance().mapLayersByName("countries")[0]
# create a QgsLayerTreeLayer object from vl by its id
myvl = root.findLayer(vl.id())
# clone the myvl QgsLayerTreeLayer object
myvlc = myvl.clone()
# create a new group
group1 = root.addGroup("Group1")
# get the parent. If None (layer is not in group) returns ''
p = myvl.parent()
# move the cloned layer to the top (0)
group1.insertChildNode(0, myvlc)
# remove the QgsLayerTreeLayer from its parent
myvl.parent().removeChildNode(myvl)

Some other methods that can be used to modify the groups and layers:

node_group1 = root.findGroup("Group1")
# change the name of the group
node_group1.setName("Group X")
node_layer2 = root.findLayer(country_layer.id())
# change the name of the layer
node_layer2.setName("Layer X")
# change the visibility of a layer
node_group1.setItemVisibilityChecked(True)
node_layer2.setItemVisibilityChecked(False)
# expand/collapse the group view
node_group1.setExpanded(True)
node_group1.setExpanded(False)
```

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import (QgsRasterLayer, QgsProject, QgsPointXY, QgsRaster, QgsRasterShader, QgsColorRampShader, QgsSingleBandPseudoColorRenderer, QgsSingleBandColorDataRenderer, QgsSingleBandGrayRenderer,)

from qgis.PyQt.QtGui import (QColor,
)```
5.1 Dettagli del raster

A raster layer consists of one or more raster bands — referred to as single band and multi band rasters. One band represents a matrix of values. A color image (e.g. aerial photo) is a raster consisting of red, blue and green bands. Single band rasters typically represent either continuous variables (e.g. elevation) or discrete variables (e.g. land use). In some cases, a raster layer comes with a palette and the raster values refer to the colors stored in the palette.

The following code assumes `rlayer` is a `QgsRasterLayer` object.

```python
rlayer = QgsProject.instance().mapLayersByName('srtm')[0]
# get the resolution of the raster in layer unit
print(rlayer.width(), rlayer.height())
919 619

# get the extent of the layer as QgsRectangle
print(rlayer.extent())
<QgsRectangle: 20.06856808199999875 -34.2700107699999896, 20.83945284300000012 -33.75077500700000144>

# get the extent of the layer as Strings
print(rlayer.extent().toString())
20.068568081999998, -34.270010769999999 : 20.839452843000001, -33.7507750070000014

# get the raster type: 0 = GrayOrUndefined (single band), 1 = Palette (single band), 2 = Multiband
print(rlayer.rasterType())
0

# get the total band count of the raster
print(rlayer.bandCount())
21
```
# get the first band name of the raster
print(rlayer.bandName(1))

Band 1: Height

# get all the available metadata as a QgsLayerMetadata object
print(rlayer.metadata())

5.2 Visualizzatore

When a raster layer is loaded, it gets a default renderer based on its type. It can be altered either in the layer properties or programmatically.

To query the current renderer:

print(rlayer.renderer())

<qgis._core.QgsSingleBandGrayRenderer object at 0x7f471c1da8a0>

print(rlayer.renderer().type())

singlebandgray

To set a renderer, use the setRenderer() method of QgsRasterLayer. There are a number of renderer classes (derived from QgsRasterRenderer):

- QgsHillshadeRenderer
- QgsMultiBandColorRenderer
- QgsPalettedRasterRenderer
- QgsRasterContourRenderer
- QgsSingleBandColorDataRenderer
- QgsSingleBandGrayRenderer
- QgsSingleBandPseudoColorRenderer

Single band raster layers can be drawn either in gray colors (low values = black, high values = white) or with a pseudocolor algorithm that assigns colors to the values. Single band rasters with a palette can also be drawn using the palette. Multiband layers are typically drawn by mapping the bands to RGB colors. Another possibility is to use just one band for drawing.
5.2.1 Raster a Banda Singola

Let's say we want a render single band raster layer with colors ranging from green to yellow (corresponding to pixel values from 0 to 255). In the first stage we will prepare a QgsRasterShader object and configure its shader function:

```python
fcn = QgsColorRampShader()
fcn.setColorRampType(QgsColorRampShader.Interpolated)
lst = [QgsColorRampShader.ColorRampItem(0, QColor(0, 255, 0)),
      QgsColorRampShader.ColorRampItem(255, QColor(255, 255, 0))]
fcn.setColorRampItemList(lst)
shader = QgsRasterShader()
shader.setRasterShaderFunction(fcn)
```

The shader maps the colors as specified by its color map. The color map is provided as a list of pixel values with associated colors. There are three modes of interpolation:

- **linear (Interpolated):** the color is linearly interpolated from the color map entries above and below the pixel value
- **discrete (Discrete):** the color is taken from the closest color map entry with equal or higher value
- **exact (Exact):** the color is not interpolated, only pixels with values equal to color map entries will be drawn

In the second step we will associate this shader with the raster layer:

```python
renderer = QgsSingleBandPseudoColorRenderer(rlayer.dataProvider(), 1, shader)
rlayer.setRenderer(renderer)
```

The number 1 in the code above is the band number (raster bands are indexed from one).

Finally we have to use the triggerRepaint() method to see the results:

```python
rlayer.triggerRepaint()
```

5.2.2 Raster Multi Banda

By default, QGIS maps the first three bands to red, green and blue to create a color image (this is the MultiBandColor drawing style. In some cases you might want to override these setting. The following code interchanges red band (1) and green band (2):

```python
rlayer_multi = QgsProject.instance().mapLayersByName('multiband')[0]
rlayer_multi.renderer().setGreenBand(1)
rlayer_multi.renderer().setRedBand(2)
```

In case only one band is necessary for visualization of the raster, single band drawing can be chosen, either gray levels or pseudocolor.

We have to use triggerRepaint() to update the map and see the result:

```python
rlayer_multi.triggerRepaint()
```
5.3 Valori dell’interrogazione

Raster values can be queried using the `sample()` method of the `QgsRasterDataProvider` class. You have to specify a `QgsPointXY` and the band number of the raster layer you want to query. The method returns a tuple with the value and `True` or `False` depending on the results:

```python
val, res = rlayer.dataProvider().sample(QgsPointXY(20.50, -34), 1)
```

Another method to query raster values is using the `identify()` method that returns a `QgsRasterIdentifyResult` object.

```python
ident = rlayer.dataProvider().identify(QgsPointXY(20.5, -34), QgsRaster.IdentifyFormatValue)
if ident.isValid():
    print(ident.results())
```

In this case, the `results()` method returns a dictionary, with band indices as keys, and band values as values. For instance, something like `{1: 323.0}`

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import QgsApplication, QgsDataSourceUri, QgsCategorizedSymbolRenderer, QgsClassificationRange, QgsPointXY, QgsProject, QgsExpression, QgsField, QgsFields, QgsFeature, QgsFeatureRequest, QgsFeatureRenderer, QgsGeometry, QgsGraduatedSymbolRenderer, QgsMarkerSymbol, QgsMessageLog, QgsRectangle, QgsRendererCategory, QgsRendererRange, QgsSymbol, QgsVectorDataProvider, QgsVectorLayer, QgsVectorFileWriter, QgsWkbTypes, QgsSpatialIndex, QgsVectorLayerUtils

from qgis.core.additions.edit import edit

from qgis.PyQt.QtGui import (QColor,
)
```
Usare i Vettori

• Recuperare informazioni sugli attributi
• Iterare un Vettore.
• Selezionare geometrie
  – Accedere agli attributi
  – Iterare le caratteristiche selezionate
  – Iterare un sottoinsieme di caratteristiche
• Modificare i Vettori
  – Aggiungi Elementi
  – Elimina Elementi
  – Modifica Elementi
  – Modificare i Vettori con un Buffer di Modifica
  – Aggiungere e Rimuovere Campi
• Usare l’Indice Spaziale
• The QgsVectorLayerUtils class
• Creating Vector Layers
  – From an instance of QgsVectorFileWriter
  – Directly from features
  – From an instance of QgsVectorLayer
• Apparenza (Simbologia) dei Vettori
  – Visualizzatore Simbolo Singolo
  – Categorized Symbol Renderer
  – Graduated Symbol Renderer
  – Working with Symbols
Questa sezione riassume le varie azioni che si possono eseguire con i vettori.

Most work here is based on the methods of the QgsVectorLayer class.

### 6.1 Recuperare informazioni sugli attributi

You can retrieve information about the fields associated with a vector layer by calling `fields()` on a QgsVectorLayer object:

```python
vlayer = QgsVectorLayer("testdata/airports.shp", "airports", "ogr")
for field in vlayer.fields():
    print(field.name(), field.typeName())
```

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Integer64</td>
</tr>
<tr>
<td>fk_region</td>
<td>Integer64</td>
</tr>
<tr>
<td>ELEV</td>
<td>Real</td>
</tr>
<tr>
<td>NAME</td>
<td>String</td>
</tr>
<tr>
<td>USE</td>
<td>String</td>
</tr>
</tbody>
</table>

The `displayField()` and `mapTipTemplate()` methods of the QgsVectorLayer class provide information on the field and template used in the maptips tab.

When you load a vector layer, a field is always chosen by QGIS as the Display Name, while the HTML Map Tip is empty by default. With these methods you can easily get both:

```python
vlayer = QgsVectorLayer("testdata/airports.shp", "airports", "ogr")
print(vlayer.displayField())
```

**Nota:** If you change the Display Name from a field to an expression, you have to use `displayExpression()` instead of `displayField()`.

---

### 6.2 Iterare un Vettore.

Iterating over the features in a vector layer is one of the most common tasks. Below is an example of the simple basic code to perform this task and showing some information about each feature. The `layer` variable is assumed to have a QgsVectorLayer object.

```python
# "layer" is a QgsVectorLayer instance
layer = iface.activeLayer()
features = layer.getFeatures()
for feature in features:
    # retrieve every feature with its geometry and attributes
    print("Feature ID: ", feature.id())
    # fetch geometry
```

(continues on next page)
# show some information about the feature geometry
geom = feature.geometry()
geomSingleType = QgsWkbTypes.isSingleType(geom.wkbType())
if geom.type() == QgsWkbTypes.PointGeometry:
  # the geometry type can be of single or multi type
  if geomSingleType:
    x = geom.asPoint()
    print("Point: ", x)
  else:
    x = geom.asMultiPoint()
    print("MultiPoint: ", x)
elif geom.type() == QgsWkbTypes.LineGeometry:
  if geomSingleType:
    x = geom.asPolyline()
    print("Line: ", x, "length: ", geom.length())
  else:
    x = geom.asMultiPolyline()
    print("MultiLine: ", x, "length: ", geom.length())
elif geom.type() == QgsWkbTypes.PolygonGeometry:
  if geomSingleType:
    x = geom.asPolygon()
    print("Polygon: ", x, "Area: ", geom.area())
  else:
    x = geom.asMultiPolygon()
    print("MultiPolygon: ", x, "Area: ", geom.area())
else:
  print("Unknown or invalid geometry")

# fetch attributes
attrs = feature.attributes()
# attrs is a list. It contains all the attribute values of this feature
print(attrs)
# for this test only print the first feature
break

Feature ID: 1
Point: <QgsPointXY: POINT(7 45)>
[1, 'First feature']

6.3 Selezionare geometrie

In QGIS desktop, features can be selected in different ways: the user can click on a feature, draw a rectangle on
the map canvas or use an expression filter. Selected features are normally highlighted in a different color (default is
yellow) to draw user's attention on the selection.

Sometimes it can be useful to programmatically select features or to change the default color.

To select all the features, the selectAll() method can be used:

```python
# Get the active layer (must be a vector layer)
layer = iface.activeLayer()
layer.selectAll()
```

To select using an expression, use the selectByExpression() method:

```python
# Assumes that the active layer is points.shp file from the QGIS test suite
# (Class (string) and Heading (number) are attributes in points.shp)
layer = iface.activeLayer()
layer.selectByExpression("Class='B52' and Heading > 10 and Heading <70',...
QgsVectorLayer.SetSelection)
```
To change the selection color you can use `setSelectionColor()` method of `QgsMapCanvas` as shown in the following example:

```python
iface.mapCanvas().setSelectionColor( QColor("red") )
```

To add features to the selected features list for a given layer, you can call `select()` passing to it the list of features IDs:

```python
selected_fid = []

# Get the first feature id from the layer
for feature in layer.getFeatures():
    selected_fid.append(feature.id())
    break

# Add these features to the selected list
layer.select(selected_fid)
```

To clear the selection:

```python
layer.removeSelection()
```

### 6.3.1 Accedere agli attributi

Attributes can be referred to by their name:

```python
print(feature['name'])
```

First feature

Alternatively, attributes can be referred to by index. This is a bit faster than using the name. For example, to get the second attribute:

```python
print(feature[1])
```

First feature

### 6.3.2 Iterare le caratteristiche selezionate

If you only need selected features, you can use the `selectedFeatures()` method from the vector layer:

```python
selection = layer.selectedFeatures()
for feature in selection:
    # do whatever you need with the feature
    pass
```

### 6.3.3 Iterare un sottoinsieme di caratteristiche

If you want to iterate over a given subset of features in a layer, such as those within a given area, you have to add a `QgsFeatureRequest` object to the `getFeatures()` call. Here’s an example:

```python
areaOfInterest = QgsRectangle(450290, 400520, 450750, 400780)
request = QgsFeatureRequest().setFilterRect(areaOfInterest)
for feature in layer.getFeatures(request):
```

(continues on next page)
For the sake of speed, the intersection is often done only using feature’s bounding box. There is however a flag ExactIntersect that makes sure that only intersecting features will be returned:

```python
request = QgsFeatureRequest().setFilterRect(areaOfInterest) \
    .setFlags(QgsFeatureRequest.ExactIntersect)
```

With `setLimit()` you can limit the number of requested features. Here’s an example:

```python
request = QgsFeatureRequest()
request.setLimit(2)
for feature in layer.getFeatures(request):
    print(feature)
```

If you need an attribute-based filter instead (or in addition) of a spatial one like shown in the examples above, you can build a `QgsExpression` object and pass it to the `QgsFeatureRequest` constructor. Here’s an example:

```python
# The expression will filter the features where the field "location_name"
# contains the word "Lake" (case insensitive)
exp = QgsExpression('location_name ILIKE "%Lake%"')
request = QgsFeatureRequest(exp)
```

See [Espressioni, Filtraggio e Calcolo di Valori](#) for the details about the syntax supported by `QgsExpression`.

The request can be used to define the data retrieved for each feature, so the iterator returns all features, but returns partial data for each of them.

```python
# Only return selected fields to increase the "speed" of the request
request.setSubsetOfAttributes([0, 2])

# More user friendly version
request.setSubsetOfAttributes([('name', 'id'), layer.fields()])

# Don’t return geometry objects to increase the "speed" of the request
request.setFlags(QgsFeatureRequest.NoGeometry)

# Fetch only the feature with id 45
request.setFilterFid(45)
```

# The options may be chained
request.setFilterRect(areaOfInterest).setFlags(QgsFeatureRequest.NoGeometry).\n    .setFilterFid(45).setSubsetOfAttributes([0, 2])

## 6.4 Modificare i Vettori

Most vector data providers support editing of layer data. Sometimes they support just a subset of possible editing actions. Use the `capabilities()` function to find out what set of functionality is supported.

```python
caps = layer.dataProvider().capabilities()
# Check if a particular capability is supported:
if caps & QgsVectorDataProvider.DeleteFeatures:
    print('The layer supports DeleteFeatures')
```
The layer supports DeleteFeatures

For a list of all available capabilities, please refer to the API Documentation of QgsVectorDataProvider.

To print layer’s capabilities textual description in a comma separated list you can use capabilitiesString() as in the following example:

```python
caps_string = layer.dataProvider().capabilitiesString()
```

By using any of the following methods for vector layer editing, the changes are directly committed to the underlying data store (a file, database etc). In case you would like to do only temporary changes, skip to the next section that explains how to do modifications with editing buffer.

**Nota:** If you are working inside QGIS (either from the console or from a plugin), it might be necessary to force a redraw of the map canvas in order to see the changes you’ve done to the geometry, to the style or to the attributes:

```python
# If caching is enabled, a simple canvas refresh might not be sufficient
# to trigger a redraw and you must clear the cached image for the layer
if iface.mapCanvas().isCachingEnabled():
    layer.triggerRepaint()
else:
    iface.mapCanvas().refresh()
```

### 6.4.1 Aggiungi Elementi

Create some QgsFeature instances and pass a list of them to provider’s addFeatures() method. It will return two values: result (True or False) and list of added features (their ID is set by the data store).

To set up the attributes of the feature, you can either initialize the feature passing a QgsFields object (you can obtain that from the fields() method of the vector layer) or call initAttributes() passing the number of fields you want to be added.

```python
if caps & QgsVectorDataProvider.AddFeatures:
    feat = QgsFeature(layer.fields())
    feat.setAttributes([0, 'hello'])
    # Or set a single attribute by key or by index:
    feat.setAttribute('name', 'hello')
    feat.setAttribute(0, 'hello')
    feat.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(123, 456)))
    (res, outFeats) = layer.dataProvider().addFeatures([feat])
```
6.4.2 Elimina Elementi

To delete some features, just provide a list of their feature IDs.

```
if caps & QgsVectorDataProvider.DeleteFeatures:
    res = layer.dataProvider().deleteFeatures([5, 10])
```

6.4.3 Modifica Elementi

It is possible to either change feature’s geometry or to change some attributes. The following example first changes values of attributes with index 0 and 1, then it changes the feature’s geometry.

```
fid = 100  # ID of the feature we will modify
if caps & QgsVectorDataProvider.ChangeAttributeValues:
    attrs = { 0 : "hello", 1 : 123 }
    layer.dataProvider().changeAttributeValues({ fid : attrs })
if caps & QgsVectorDataProvider.ChangeGeometries:
    geom = QgsGeometry.fromPointXY(QgsPointXY(111, 222))
    layer.dataProvider().changeGeometryValues({ fid : geom })
```

Suggerimento: Favor QgsVectorLayerEditUtils class for geometry-only edits

If you only need to change geometries, you might consider using the QgsVectorLayerEditUtils which provides some useful methods to edit geometries (translate, insert or move vertex, etc.).

6.4.4 Modificare i Vettori con un Buffer di Modifica

When editing vectors within QGIS application, you have to first start editing mode for a particular layer, then do some modifications and finally commit (or rollback) the changes. All the changes you make are not written until you commit them — they stay in layer’s in-memory editing buffer. It is possible to use this functionality also programmatically — it is just another method for vector layer editing that complements the direct usage of data providers. Use this option when providing some GUI tools for vector layer editing, since this will allow user to decide whether to commit/rollback and allows the usage of undo/redo. When changes are committed, all changes from the editing buffer are saved to data provider.

The methods are similar to the ones we have seen in the provider, but they are called on the QgsVectorLayer object instead.

For these methods to work, the layer must be in editing mode. To start the editing mode, use the startEditing() method. To stop editing, use the commitChanges() or rollBack() methods. The first one will commit all your changes to the data source, while the second one will discard them and will not modify the data source at all.

To find out whether a layer is in editing mode, use the isEditable() method.

Here you have some examples that demonstrate how to use these editing methods.

```
from qgis.PyQt.QtCore import QVariant
feat1 = feat2 = QgsFeature(layer.fields())
fid = 99
feat1.setId(fid)
# add two features (QgsFeature instances)
layer.addFeatures([feat1, feat2])
# delete a feature with specified ID
layer.deleteFeature(fid)
```

(continues on next page)
# set new geometry (QgsGeometry instance) for a feature
geometry = QgsGeometry.fromWkt("POINT(7 45)")
layers.changeGeometry(fid, geometry)

# update an attribute with given field index (int) to a given value
fieldIndex = 1
value = 'My new name'
layers.changeAttributeValue(fid, fieldIndex, value)

# add new field
layers.addAttribute(QgsField("mytext", QVariant.String))

# remove a field
layers.deleteAttribute(fieldIndex)

In order to make undo/redo work properly, the above mentioned calls have to be wrapped into undo commands. (If you do not care about undo/redo and want to have the changes stored immediately, then you will have easier work by editing with data provider.)

Here is how you can use the undo functionality:

```python
layers.beginEditCommand("Feature triangulation")

# ... call layer's editing methods ...

if problem_occurred:
    layers.destroyEditCommand()
    # ... tell the user that there was a problem
    # and return

# ... more editing ...

layers.endEditCommand()
```

The `beginEditCommand()` method will create an internal «active» command and will record subsequent changes in vector layer. With the call to `endEditCommand()` the command is pushed onto the undo stack and the user will be able to undo/redo it from GUI. In case something went wrong while doing the changes, the `destroyEditCommand()` method will remove the command and rollback all changes done while this command was active.

You can also use the `with edit(layer)`-statement to wrap commit and rollback into a more semantic code block as shown in the example below:

```python
with edit(layer):
    feat = next(layers.getFeatures())
    feat[0] = 5
    layers.updateFeature(feat)
```

This will automatically call `commitChanges()` in the end. If any exception occurs, it will `rollback()` all the changes. In case a problem is encountered within `commitChanges()` (when the method returns False) a `QgsEditError` exception will be raised.
6.4.5 Aggiungere e Rimuovere Campi

To add fields (attributes), you need to specify a list of field definitions. For deletion of fields just provide a list of field indexes.

```python
from qgis.PyQt.QtCore import QVariant

if caps & QgsVectorDataProvider.AddAttributes:
    res = layer.dataProvider().addAttributes([QgsField("mytext", QVariant.String), QgsField("myint", QVariant.Int)])

if caps & QgsVectorDataProvider.DeleteAttributes:
    res = layer.dataProvider().deleteAttributes([0])
```

After adding or removing fields in the data provider the layer's fields need to be updated because the changes are not automatically propagated.

```python
layer.updateFields()
```

**Suggerimento: Directly save changes using with based command**

Using `with edit(layer):` the changes will be committed automatically calling `commitChanges()` at the end. If any exception occurs, it will `rollBack()` all the changes. See `Modificare i Vettori con un Buffer di Modifica`.

6.5 Usare l'Indice Spaziale

Spatial indexes can dramatically improve the performance of your code if you need to do frequent queries to a vector layer. Imagine, for instance, that you are writing an interpolation algorithm, and that for a given location you need to know the 10 closest points from a points layer, in order to use those point for calculating the interpolated value. Without a spatial index, the only way for QGIS to find those 10 points is to compute the distance from each and every point to the specified location and then compare those distances. This can be a very time consuming task, especially if it needs to be repeated for several locations. If a spatial index exists for the layer, the operation is much more effective.

Think of a layer without a spatial index as a telephone book in which telephone numbers are not ordered or indexed. The only way to find the telephone number of a given person is to read from the beginning until you find it.

Spatial indexes are not created by default for a QGIS vector layer, but you can create them easily. This is what you have to do:

- create spatial index using the `QgsSpatialIndex` class:

  ```python
  index = QgsSpatialIndex()
  ```
• add features to index — index takes QgsFeature object and adds it to the internal data structure. You can create the object manually or use one from a previous call to the provider’s getFeatures() method.

```python
index.addFeature(feat)
```

• alternatively, you can load all features of a layer at once using bulk loading

```python
index = QgsSpatialIndex(layer.getFeatures())
```

• once spatial index is filled with some values, you can do some queries

```python
# returns array of feature IDs of five nearest features
nearest = index.nearestNeighbor(QgsPointXY(25.4, 12.7), 5)

# returns array of IDs of features which intersect the rectangle
intersect = index.intersects(QgsRectangle(22.5, 15.3, 23.1, 17.2))
```

You can also use the QgsSpatialIndexKDBush spatial index. This index is similar to the standard QgsSpatialIndex but:

• supports only single point features
• is static (no additional features can be added to the index after the construction)
• is much faster!
• allows direct retrieval of the original feature’s points, without requiring additional feature requests
• supports true distance based searches, i.e. return all points within a radius from a search point

### 6.6 The QgsVectorLayerUtils class

The QgsVectorLayerUtils class contains some very useful methods that you can use with vector layers.

For example the createFeature() method prepares a QgsFeature to be added to a vector layer keeping all the eventual constraints and default values of each field:

```python
vlayer = QgsVectorLayer("testdata/airports.shp", "airports", "ogr")
feat = QgsVectorLayerUtils.createFeature(vlayer)
```

The getValues() method allows you to quickly get the values of a field or expression:

```python
vlayer = QgsVectorLayer("testdata/airports.shp", "airports", "ogr")
# select only the first feature to make the output shorter
vlayer.selectByIds([1])
val = QgsVectorLayerUtils.getValues(vlayer, "NAME", selectedOnly=True)
print(val)
```

```python
[['AMBLER'], True]
```
6.7 Creating Vector Layers

There are several ways to generate a vector layer dataset:

- the `QgsVectorFileWriter` class: A convenient class for writing vector files to disk, using either a static call to `writeAsVectorFormat()` which saves the whole vector layer or creating an instance of the class and issue calls to `addFeature()`. This class supports all the vector formats that OGR supports (GeoPackage, Shapefile, GeoJSON, KML and others).

- the `QgsVectorLayer` class: instantiates a data provider that interprets the supplied path (url) of the data source to connect to and access the data. It can be used to create temporary, memory-based layers (memory) and connect to OGR datasets (ogr), databases (postgres, spatialite, mysql, mssql) and more (wfs, gpz, delimitedtext...).

### 6.7.1 From an instance of QgsVectorFileWriter

```python
# SaveVectorOptions contains many settings for the writer process
save_options = QgsVectorFileWriter.SaveVectorOptions()
transform_context = QgsProject.instance().transformContext()
# Write to a GeoPackage (default)
error = QgsVectorFileWriter.writeAsVectorFormatV2(layer,
    "testdata/my_new_file.gpkg",
    transform_context,
    save_options)
if error[0] == QgsVectorFileWriter.NoError:
    print("success!")
else:
    print(error)

# Write to an ESRI Shapefile format dataset using UTF-8 text encoding
save_options = QgsVectorFileWriter.SaveVectorOptions()
save_options.driverName = "ESRI Shapefile"
save_options.fileEncoding = "UTF-8"
transform_context = QgsProject.instance().transformContext()
error = QgsVectorFileWriter.writeAsVectorFormatV2(layer,
    "testdata/my_new_shapefile",
    transform_context,
    save_options)
if error[0] == QgsVectorFileWriter.NoError:
    print("success again!")
else:
    print(error)

# Write to an ESRI GDB file
save_options = QgsVectorFileWriter.SaveVectorOptions()
save_options.driverName = "FileGDB"
# if no geometry
save_options.overrideGeometryType = QgsWkbTypes.Unknown
save_options.actionOnExistingFile = QgsVectorFileWriter.CreateOrOverwriteLayer
save_options.layerName = "my_new_layer_name"
transform_context = QgsProject.instance().transformContext()
gdb_path = "testdata/my_example.gdb"
error = QgsVectorFileWriter.writeAsVectorFormatV2(layer,
    gdb_path,
    transform_context,
    save_options)
if error[0] == QgsVectorFileWriter.NoError:
    print("success!")
else:
    print(error)
```

6.7. Creating Vector Layers
You can also convert fields to make them compatible with different formats by using the `FieldValueConverter`. For example, to convert array variable types (e.g. in Postgres) to a text type, you can do the following:

```python
LIST_FIELD_NAME = 'xxxx'

class ESRIValueConverter(QgsVectorFileWriter.FieldValueConverter):

    def __init__(self, layer, list_field):
        QgsVectorFileWriter.FieldValueConverter.__init__(self)
        self.layer = layer
        self.list_field_idx = self.layer.fields().indexFromName(list_field)

    def convert(self, fieldIdxInLayer, value):
        if fieldIdxInLayer == self.list_field_idx:
            return QgsListFieldFormatter().representValue(layer=vlayer,
                fieldIndex=self.list_field_idx,
                config={},
                cache=None,
                value=value)
        else:
            return value

    def fieldDefinition(self, field):
        idx = self.layer.fields().indexFromName(field.name())
        if idx == self.list_field_idx:
            return QgsField(LIST_FIELD_NAME, QVariant.String)
        else:
            return self.layer.fields()[idx]

converter = ESRIValueConverter(vlayer, LIST_FIELD_NAME)
opts = QgsVectorFileWriter.SaveVectorOptions()
opts.fieldValueConverter = converter
```

A destination CRS may also be specified — if a valid instance of `QgsCoordinateReferenceSystem` is passed as the fourth parameter, the layer is transformed to that CRS.

For valid driver names please call the `supportedFiltersAndFormats()` method or consult the supported formats by OGR — you should pass the value in the «Code» column as the driver name.

Optionally you can set whether to export only selected features, pass further driver-specific options for creation or tell the writer not to create attributes... There are a number of other (optional) parameters; see the `QgsVectorFileWriter` documentation for details.

### 6.7.2 Directly from features

```python
from qgis.PyQt.QtCore import QVariant

# define fields for feature attributes. A QgsFields object is needed
fields = QgsFields()
fields.append(QgsField("first", QVariant.Int))
fields.append(QgsField("second", QVariant.String))

""" create an instance of vector file writer, which will create the vector file.
Arguments:
1. path to new file (will fail if exists already)
2. field map
3. geometry type - from WKBTYPE enum
4. layer's spatial reference (instance of QgsCoordinateReferenceSystem)
5. coordinate transform context
6. save options (driver name for the output file, encoding etc.)
```

(continues on next page)
6.7.3 From an instance of QgsVectorLayer

Among all the data providers supported by the QgsVectorLayer class, let’s focus on the memory-based layers. Memory provider is intended to be used mainly by plugin or 3rd party app developers. It does not store data on disk, allowing developers to use it as a fast backend for some temporary layers.

The memory provider also supports spatial indexing, which is enabled by calling the provider’s createSpatialIndex() function. Once the spatial index is created you will be able to iterate over features within smaller regions faster (since it’s not necessary to traverse all the features, only those in specified rectangle).

A memory provider is created by passing "memory" as the provider string to the QgsVectorLayer constructor. The constructor also takes a URI defining the geometry type of the layer, one of: "Point", "LineString", "Polygon", "MultiPoint", "MultiLineString", "MultiPolygon" or "None".

L’URI può anche specificare il sistema di riferimento delle coordinate, i campi e l’indicizzazione del provider in memoria nell’URI. La sintassi è:

- **crs=definizione** Specifies the coordinate reference system, where definition may be any of the forms accepted by QgsCoordinateReferenceSystem.createFromString()
- **index=yes** Specifica che il provider userà un indice spaziale
- **field=nome:tipo(lunghezza, precisione)** Specifica un attributo del vettore. L’attributo ha un nome, e facoltativamente un tipo (intero, double, o string), lunghezza, e precisione. Ci sono possono essere definizioni di campo multiple

The following example of a URI incorporates all these options
The following example code illustrates creating and populating a memory provider

```python
from qgis.QgsPyQt.QtCore import QVariant

# create layer
vl = QgsVectorLayer("Point", "temporary_points", "memory")
pr = vl.dataProvider()

# add fields
pr.addAttributes([QgsField("name", QVariant.String),
                  QgsField("age", QVariant.Int),
                  QgsField("size", QVariant.Double)])
vl.updateFields()  # tell the vector layer to fetch changes from the provider

# add a feature
fet = QgsFeature()
fet.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(10, 10)))
fet.setAttributes(['Johny', 2, 0.3])
pr.addFeatures([fet])

# update layer's extent when new features have been added
# because change of extent in provider is not propagated to the layer
vl.updateExtents()

# show some stats
print("fields:", len(pr.fields()))
print("features:", pr.featureCount())
print("extent:", e.xMinimum(), e.yMinimum(), e.xMaximum(), e.yMaximum())

# iterate over features
for fet in features:
    print("F: ", fet.id(), fet.attributes(), fet.geometry().asPoint())
```

Finally, let's check whether everything went well

```python
# show some stats
print("fields:", len(pr.fields()))
print("features:", pr.featureCount())
e = vl.extent()
print("extent:", e.xMinimum(), e.yMinimum(), e.xMaximum(), e.yMaximum())

# iterate over features
for fet in features:
    print("F: ", fet.id(), fet.attributes(), fet.geometry().asPoint())
```

fields: 3
features: 1
extent: 10.0 10.0 10.0 10.0
F: 1 ['Johny', 2, 0.3] <QgsPointXY: POINT(10 10)>

### 6.8 Apparenza (Simbologia) dei Vettori

Quando un vettore deve essere visualizzato, l'aspetto dei dati è dato dal visualizzatore e dai simboli associati al vettore. I simboli sono classi che si occupano del disegno di rappresentazione visiva delle geometrie, mentre i visualizzatori determinano quale simbolo sarà usato per una particolare geometria. The renderer for a given layer can be obtained as shown below:

```python
renderer = layer.renderer()
```

And with that reference, let us explore it a bit

```python
print("Type:", renderer.type())
```
There are several known render types available in the QGIS core library:

<table>
<thead>
<tr>
<th>Tipo</th>
<th>Classe</th>
<th>Descrizione</th>
</tr>
</thead>
<tbody>
<tr>
<td>singleSymbol</td>
<td>QgsSingleSymbolRenderer</td>
<td>Visualizza tutte le geometrie con lo stesso simbolo</td>
</tr>
<tr>
<td>categorizedSymbol</td>
<td>QgsCategorizedSymbolRenderer</td>
<td>Visualizza le geometrie usando un simbolo diverso per ogni categoria</td>
</tr>
<tr>
<td>graduatedSymbol</td>
<td>QgsGraduatedSymbolRenderer</td>
<td>Visualizza le geometrie usando un simbolo diverso per ogni intervallo di valori</td>
</tr>
</tbody>
</table>

There might be also some custom renderer types, so never make an assumption there are just these types. You can query the application’s QgsRendererRegistry to find out currently available renderers:

```python
print(QgsApplication.rendererRegistry().renderersList())
```

```python
['nullSymbol', 'singleSymbol', 'categorizedSymbol', 'graduatedSymbol',
 'RuleRenderer', 'pointDisplacement', 'pointCluster', 'invertedPolygonRenderer',
 'heatmapRenderer', '25dRenderer']
```

It is possible to obtain a dump of a renderer contents in text form — can be useful for debugging

```python
renderer.dump()
```

**6.8.1 Visualizzatore Simbolo Singolo**

You can get the symbol used for rendering by calling `symbol()` method and change it with `setSymbol()` method (note for C++ devs: the renderer takes ownership of the symbol.)

You can change the symbol used by a particular vector layer by calling `setSymbol()` passing an instance of the appropriate symbol instance. Symbols for `point`, `line` and `polygon` layers can be created by calling the `createSimple()` function of the corresponding classes `QgsMarkerSymbol`, `QgsLineSymbol` and `QgsFillSymbol`.

The dictionary passed to `createSimple()` sets the style properties of the symbol.

For example you can replace the symbol used by a particular `point` layer by calling `setSymbol()` passing an instance of a `QgsMarkerSymbol`, as in the following code example:

```python
symbol = QgsMarkerSymbol.createSimple({'name': 'square', 'color': 'red'})
layer.renderer().setSymbol(symbol)
# show the change
layer.triggerRepaint()
```

`name` indicates the shape of the marker, and can be any of the following:

- circle
- square
- cross
- rectangle
- diamond
- pentagon
- triangle
To get the full list of properties for the first symbol layer of a symbol instance you can follow the example code:

```python
print(layer.renderer().symbol().symbolLayers()[0].properties())
```

This can be useful if you want to alter some properties:

```python
# You can alter a single property...
layer.renderer().symbol().symbolLayer(0).setSize(3)
# ... but not all properties are accessible from methods,
# you can also replace the symbol completely:
props = layer.renderer().symbol().symbolLayer(0).properties()
props['color'] = 'yellow'
props['name'] = 'square'
layer.renderer().setSymbol(QgsMarkerSymbol.createSimple(props))
# show the changes
layer.triggerRepaint()
```

### 6.8.2 Categorized Symbol Renderer

When using a categorized renderer, you can query and set the attribute that is used for classification: use the `classAttribute()` and `setClassAttribute()` methods.

To get a list of categories

```python
categorized_renderer = QgsCategorizedSymbolRenderer()
# Add a few categories
cat1 = QgsRendererCategory('1', QgsMarkerSymbol(), 'category 1')
cat2 = QgsRendererCategory('2', QgsMarkerSymbol(), 'category 2')
categorized_renderer.addCategory(cat1)
categorized_renderer.addCategory(cat2)
for cat in categorized_renderer.categories():
    print("{}: {} :: {}".format(cat.value(), cat.label(), cat.symbol()))
```

Where `value()` is the value used for discrimination between categories, `label()` is a text used for category description and `symbol()` method returns the assigned symbol.

The renderer usually stores also original symbol and color ramp which were used for the classification: `sourceColorRamp()` and `sourceSymbol()` methods.
6.8.3 Graduated Symbol Renderer

Questo visualizzatore è molto simile al visualizzatore simbolo categorizzato descritto sopra, ma invece di un valore di attributo per classe esso lavora con intervalli di valori e quindi può essere usato solo con attributi di tipo numerico.

To find out more about ranges used in the renderer

```python
graduated_renderer = QgsGraduatedSymbolRenderer()
# Add a few categories
graduated_renderer.addClassRange(QgsRendererRange(QgsClassificationRange('class 0-100', 0, 100), QgsMarkerSymbol()))
graduated_renderer.addClassRange(QgsRendererRange(QgsClassificationRange('class 101-200', 101, 200), QgsMarkerSymbol()))

for ran in graduated_renderer.ranges():
    print("{} - {}: {}", format(
        ran.lowerValue(),
        ran.upperValue(),
        ran.label(),
        ran.symbol()
    ))
```

you can again use the `classAttribute()` (to find the classification attribute name), `sourceSymbol()` and `sourceColorRamp()` methods. Additionally there is the `mode()` method which determines how the ranges were created: using equal intervals, quantiles or some other method.

If you wish to create your own graduated symbol renderer you can do so as illustrated in the example snippet below (which creates a simple two class arrangement)

```python
from qgis.PyQt.Qt import QtGui

myVectorLayer = QgsVectorLayer("testdata/airports.shp", "airports", "ogr")
myTargetField = 'ELEV'
myRangeList = []
myOpacity = 1

# Make our first symbol and range...
myMin = 0.0
myMax = 50.0
myLabel = 'Group 1'
myColour = QtGui.QColor('#ffee00')
mySymbol1 = QgsSymbol.defaultSymbol(myVectorLayer.geometryType())
mySymbol1.setColor(myColour)
mySymbol1.setOpacity(myOpacity)
myRange1 = QgsRendererRange(myMin, myMax, mySymbol1, myLabel)
myRangeList.append(myRange1)

# Now make another symbol and range...
myMin = 50.1
myMax = 100
myLabel = 'Group 2'
myColour = QtGui.QColor('#00eeff')
mySymbol2 = QgsSymbol.defaultSymbol(
    myVectorLayer.geometryType())
mySymbol2.setColor(myColour)
mySymbol2.setOpacity(myOpacity)
myRange2 = QgsRendererRange(myMin, myMax, mySymbol2, myLabel)
myRangeList.append(myRange2)
myRenderer = QgsGraduatedSymbolRenderer('', myRangeList)
myClassificationMethod = QgsApplication.classificationMethodRegistry().method("EqualInterval")
```

(continues on next page)
myRenderer.setClassificationMethod(myClassificationMethod)
myRenderer.setClassAttribute(myTargetField)
myVectorLayer.setRenderer(myRenderer)

6.8.4 Working with Symbols

For representation of symbols, there is QgsSymbol base class with three derived classes:

- QgsMarkerSymbol — for point features
- QgsLineSymbol — for line features
- QgsFillSymbol — for polygon features

Every symbol consists of one or more symbol layers (classes derived from QgsSymbolLayer). The symbol layers do the actual rendering, the symbol class itself serves only as a container for the symbol layers.

Having an instance of a symbol (e.g. from a renderer), it is possible to explore it: the type() method says whether it is a marker, line or fill symbol. There is a dump() method which returns a brief description of the symbol. To get a list of symbol layers:

```python
marker_symbol = QgsMarkerSymbol()
for i in range(marker_symbol.symbolLayerCount()):
    lyr = marker_symbol.symbolLayer(i)
    print("{}/ {}".format(i, lyr.layerType()))
```

0: SimpleMarker

To find out symbol's color use color() method and setColor() to change its color. With marker symbols additionally you can query for the symbol size and rotation with the size() and angle() methods. For line symbols the width() method returns the line width.

La dimensione e la larghezza sono in millimetri per impostazione predefinita, gli angoli sono in gradi.

Working with Symbol Layers

As said before, symbol layers (subclasses of QgsSymbolLayer) determine the appearance of the features. There are several basic symbol layer classes for general use. It is possible to implement new symbol layer types and thus arbitrarily customize how features will be rendered. The layerType() method uniquely identifies the symbol layer class — the basic and default ones are SimpleMarker, SimpleLine and SimpleFill symbol layers types.

You can get a complete list of the types of symbol layers you can create for a given symbol layer class with the following code:

```python
from qgis.core import QgsSymbolLayerRegistry
myRegistry = QgsApplication.symbolLayerRegistry()
myMetadata = myRegistry.symbolLayerMetadata("SimpleFill")
for item in myRegistry.symbolLayersForType(QgsSymbol.Marker):
    print(item)
```

- EllipseMarker
- FilledMarker
- FontMarker
- GeometryGenerator
- MaskMarker
- RasterMarker
- SimpleMarker
- SvgMarker
- VectorField
The `QgsSymbolLayerRegistry` class manages a database of all available symbol layer types.

To access symbol layer data, use its `properties()` method that returns a key-value dictionary of properties which determine the appearance. Each symbol layer type has a specific set of properties that it uses. Additionally, there are the generic methods `color()`, `size()`, `angle()` and `width()`, with their setter counterparts. Of course size and angle are available only for marker symbol layers and width for line symbol layers.

### Creating Custom Symbol Layer Types

Imagine you would like to customize the way how the data gets rendered. You can create your own symbol layer class that will draw the features exactly as you wish. Here is an example of a marker that draws red circles with specified radius.

```python
from qgis.core import QgsMarkerSymbolLayer
from qgis.PyQt.QtGui import QColor

class FooSymbolLayer(QgsMarkerSymbolLayer):
    def __init__(self, radius=4.0):
        QgsMarkerSymbolLayer.__init__(self)
        self.radius = radius
        self.color = QColor(255, 0, 0)

    def layerType(self):
        return "FooMarker"

    def properties(self):
        return {"radius": str(self.radius) }

    def startRender(self, context):
        pass

    def stopRender(self, context):
        pass

    def renderPoint(self, self, point, context):
        # Rendering depends on whether the symbol is selected (QGIS >= 1.5)
        color = context.selectionColor() if context.selected() else self.color
        p = context.renderContext().painter()
        p.setPen(color)
        p.drawEllipse(point, self.radius, self.radius)

    def clone(self):
        return FooSymbolLayer(self.radius)
```

The `layerType()` method determines the name of the symbol layer; it has to be unique among all symbol layers. The `properties()` method is used for persistence of attributes. The `clone()` method must return a copy of the symbol layer with all attributes being exactly the same. Finally there are rendering methods: `startRender()` is called before rendering the first feature, `stopRender()` when the rendering is done, and `renderPoint()` is called to do the rendering. The coordinates of the point(s) are already transformed to the output coordinates.

For polylines and polygons the only difference would be in the rendering method: you would use `renderPolyline()` which receives a list of lines, while `renderPolygon()` receives a list of points on the outer ring as the first parameter and a list of inner rings (or None) as a second parameter.

Usually it is convenient to add a GUI for setting attributes of the symbol layer type to allow users to customize the appearance: in case of our example above we can let user set circle radius. The following code implements such widget.

```python
from qgis.gui import QgsSymbolLayerWidget
```

(continues on next page)
This widget can be embedded into the symbol properties dialog. When the symbol layer type is selected in symbol properties dialog, it creates an instance of the symbol layer and an instance of the symbol layer widget. Then it calls the `setSymbolLayer()` method to assign the symbol layer to the widget. In that method the widget should update the UI to reflect the attributes of the symbol layer. The `symbolLayer()` method is used to retrieve the symbol layer again by the properties dialog to use it for the symbol.

On every change of attributes, the widget should emit the `changed()` signal to let the properties dialog update the symbol preview.

Now we are missing only the final glue: to make QGIS aware of these new classes. This is done by adding the symbol layer to registry. It is possible to use the symbol layer also without adding it to the registry, but some functionality will not work: e.g. loading of project files with the custom symbol layers or inability to edit the layer’s attributes in GUI.

We will have to create metadata for the symbol layer.

```python
class FooSymbolLayerWidget(QgsSymbolLayerWidget):
    def __init__(self, parent=None):
        QgsSymbolLayerWidget.__init__(self, parent)
        self.layer = None

        # setup a simple UI
        self.label = QLabel("Radius:")
        self.spinRadius = QDoubleSpinBox()
        self.hbox = QHBoxLayout()
        self.hbox.addWidget(self.label)
        self.hbox.addWidget(self.spinRadius)
        self.setLayout(self.hbox)
        self.connect(self.spinRadius, SIGNAL("valueChanged(double)"), \\
                     self.radiusChanged)

    def setSymbolLayer(self, layer):
        if layer.layerType() != "FooMarker":
            return
        self.layer = layer
        self.spinRadius.setValue(layer.radius)

    def symbolLayer(self):
        return self.layer

    def radiusChanged(self, value):
        self.layer.radius = value
        self.emit(SIGNAL("changed()"))
```

```
from qgis.core import QgsSymbol, QgsSymbolLayerAbstractMetadata, QgsSymbolLayerRegistry

class FooSymbolLayerMetadata(QgsSymbolLayerAbstractMetadata):
    def __init__(self):
        super().__init__("FooMarker", "My new Foo marker", QgsSymbol.Marker)

    def createSymbolLayer(self, self, props):
        radius = float(props["radius"]) if "radius" in props else 4.0
        return FooSymbolLayer(radius)

fslmetadata = FooSymbolLayerMetadata()
QgsApplication.symbolLayerRegistry().addSymbolLayerType(fslmetadata)
```

You should pass layer type (the same as returned by the layer) and symbol type (marker/line/fill) to the constructor of the parent class. The `createSymbolLayer()` method takes care of creating an instance of symbol layer with attributes specified in the `props` dictionary. And there is the `createSymbolLayerWidget()` method which returns the settings widget for this symbol layer type.

The last step is to add this symbol layer to the registry — and we are done.

### 6.8.5 Creating Custom Renderers

It might be useful to create a new renderer implementation if you would like to customize the rules how to select symbols for rendering of features. Some use cases where you would want to do it: symbol is determined from a combination of fields, size of symbols changes depending on current scale etc.

The following code shows a simple custom renderer that creates two marker symbols and chooses randomly one of them for every feature

```python
import random
from qgis import core
import QgsWkbTypes, QgsSymbol, QgsFeatureRenderer

class RandomRenderer(QgsFeatureRenderer):
    def __init__(self, syms=None):
        super().__init__('RandomRenderer')
        self.syms = syms if syms else [
            QgsSymbol.defaultSymbol(QgsWkbTypes.geometryType(QgsWkbTypes.Point)),
            QgsSymbol.defaultSymbol(QgsWkbTypes.geometryType(QgsWkbTypes.Point))
        ]

    def symbolForFeature(self, feature, context):
        return random.choice(self.syms)

    def startRender(self, context, fields):
        super().startRender(context, fields)
        for s in self.syms:
            s.startRender(context, fields)

    def stopRender(self, context):
        super().stopRender(context)
        for s in self.syms:
            s.stopRender(context)

    def usedAttributes(self, context):
        return []

    def clone(self):
        return RandomRenderer(self.syms)
```

The constructor of the parent `QgsFeatureRenderer` class needs a renderer name (which has to be unique among renderers). The `symbolForFeature()` method is the one that decides what symbol will be used for a particular feature. `startRender()` and `stopRender()` take care of initialization/finalization of symbol rendering. The `usedAttributes()` method can return a list of field names that the renderer expects to be present. Finally, the `clone()` method should return a copy of the renderer.

Like with symbol layers, it is possible to attach a GUI for configuration of the renderer. It has to be derived from `QgsRendererWidget`. The following sample code creates a button that allows the user to set the first symbol

```python
from qgis.gui import QgsRendererWidget, QgsColorButton

class RandomRendererWidget(QgsRendererWidget):
    def __init__(self, layer, style, renderer):
(continues on next page)
```

6.8. Apparenza (Simbologia) dei Vettori 45
The constructor receives instances of the active layer (QgsVectorLayer), the global style (QgsStyle) and the current renderer. If there is no renderer or the renderer has different type, it will be replaced with our new renderer, otherwise we will use the current renderer (which has already the type we need). The widget contents should be updated to show current state of the renderer. When the renderer dialog is accepted, the widget’s renderer() method is called to get the current renderer — it will be assigned to the layer.

The last missing bit is the renderer metadata and registration in registry, otherwise loading of layers with the renderer will not work and user will not be able to select it from the list of renderers. Let us finish our RandomRenderer example

```python
from qgis.core import 
    QgsRendererAbstractMetadata,
    QgsRendererRegistry,
    QgsApplication

class RandomRendererMetadata(QgsRendererAbstractMetadata):
    def __init__(self):
        super().__init__("RandomRenderer", "Random renderer")

    def createRenderer(self, element):
        return RandomRenderer()

    def createRendererWidget(self, layer, style, renderer):
        return RandomRendererWidget(layer, style, renderer)

rrmetadata = RandomRendererMetadata()
QgsApplication.rendererRegistry().addRenderer(rrmetadata)
```

Similarly as with symbol layers, abstract metadata constructor awaits renderer name, name visible for users and optionally name of renderer’s icon. The createRenderer() method passes a QDomElement instance that can be used to restore the renderer’s state from the DOM tree. The createRendererWidget() method creates the configuration widget. It does not have to be present or can return None if the renderer does not come with GUI.

To associate an icon with the renderer you can assign it in the QgsRendererAbstractMetadata constructor as a third (optional) argument — the base class constructor in the RandomRendererMetadata __init__() function becomes

```python
QgsApplication.rendererRegistry().addRenderer(rrmetadata)
```
QgsRendererAbstractMetadata.__init__(self,
   "RandomRenderer",
   "Random renderer",
   QIcon(QPixmap("RandomRendererIcon.png", "png")))

The icon can also be associated at any later time using the `setIcon()` method of the metadata class. The icon can be loaded from a file (as shown above) or can be loaded from a Qt resource (PyQt5 includes .qrc compiler for Python).

### 6.9 Further Topics

TODO:

- creating/modifying symbols
- working with style (`QgsStyle`)
- working with color ramps (`QgsColorRamp`)
- exploring symbol layer and renderer registries

The code snippets on this page need the following imports if you're outside the `pyqgis` console:

```python
from qgis.core import (QgsGeometry,
QgsPoint,
QgsPointXY,
QgsWkbTypes,
QgsProject,
QgsFeatureRequest,
QgsVectorLayer,
QgsDistanceArea,
QgsUnitTypes,
QgsCoordinateTransform,
QgsCoordinateReferenceSystem)
```
Punti, linee e poligoni che rappresentano un elemento spaziale sono comunemente indicati come geometrie. In QGIS sono rappresentati con la QgsGeometry class.

Alcune volte una geometria è effettivamente una collezione di geometrie (parti singole) più semplici. Se contiene un tipo di geometria semplice, la chiameremo punti multipli, string multi linea o poligoni multipli. Ad esempio, un Paese formato da più isole può essere rappresentato come un poligono multiplo.

Le coordinate delle geometrie possono essere in qualsiasi sistema di riferimento delle coordinate (CRS). Quando si estraggono delle caratteristiche da un vettore, le geometrie associate avranno le coordinate nel CRS del vettore.

Description and specifications of all possible geometries construction and relationships are available in the OGC Simple Feature Access Standards for advanced details.

### 7.1 Costruzione della Geometria

PyQGIS provides several options for creating a geometry:

- dalle coordinate

```python
import qgis.core as QgsGeometry
from qgis.core import QgsPointXY

# punto
pnt = QgsGeometry.fromPointXY(QgsPointXY(1, 1))
print(pnt)

# linea
line = QgsGeometry.fromPolyline([QgsPoint(1, 1), QgsPoint(2, 2)])
print(line)

# poligono
polygon = QgsGeometry.fromPolygonXY([[QgsPointXY(1, 1),
                                      QgsPointXY(2, 2),
                                      QgsPointXY(2, 1)]])
print(polygon)
```

Coordinates are given using QgsPoint class or QgsPointXY class. The difference between these classes is that QgsPoint supports M and Z dimensions.

A Polyline (Linestring) is represented by a list of points.
A Polygon is represented by a list of linear rings (i.e. closed linestrings). The first ring is the outer ring (boundary), optional subsequent rings are holes in the polygon. Note that unlike some programs, QGIS will close the ring for you so there is no need to duplicate the first point as the last.

Le geometrie a parti multiple vanno ad un livello successivo: punti multipli è una lista di punti, una stringa multi linea è una linea di linee ed un poligono multiplo è una lista di poligoni.

• da well-known text (WKT)

```python
geom = QgsGeometry.fromWkt("POINT(3 4)"
print(geom)
```

• da well-known binary (WKB)

```python
g = QgsGeometry()
wkb = bytes.fromhex("010100000000000000000000000000000000001440")
g.fromWkb(wkb)

# print WKT representation of the geometry
print(g.asWkt())
```

## 7.2 Accedere alla Geometria

First, you should find out the geometry type. The `wkbType()` method is the one to use. It returns a value from the `QgsWkbTypes.Type` enumeration.

```python
if gPnt.wkbType() == QgsWkbTypes.Point:
    print(gPnt.wkbType())
    # output: 1 for Point
if gLine.wkbType() == QgsWkbTypes.LineString:
    print(gLine.wkbType())
    # output: 2 for LineString
if gPolygon.wkbType() == QgsWkbTypes.Polygon:
    print(gPolygon.wkbType())
    # output: 3 for Polygon
```

As an alternative, one can use the `type()` method which returns a value from the `QgsWkbTypes.GeometryType` enumeration.

You can use the `displayString()` function to get a human readable geometry type.

```python
print(QgsWkbTypes.displayString(gPnt.wkbType()))
# output: 'Point'
print(QgsWkbTypes.displayString(gLine.wkbType()))
# output: 'LineString'
print(QgsWkbTypes.displayString(gPolygon.wkbType()))
# output: 'Polygon'
```

There is also a helper function `isMultipart()` to find out whether a geometry is multipart or not.

To extract information from a geometry there are accessor functions for every vector type. Here’s an example on how to use these accessor:

```python
print(gPnt.asPoint())
# output: QgsPointXY: POINT(1 1)
print(gLine.asPolyline())
```

(continues on next page)
# output: [{<QgsPointXY: POINT(1 1)>, <QgsPointXY: POINT(2 2)>}, ...
print(gPolygon.asPolygon())
# output: [{<QgsPointXY: POINT(1 1)>, <QgsPointXY: POINT(2 2)>}, ...

Nota: The tuples (x,y) are not real tuples, they are QgsPoint objects, the values are accessible with x() and y() methods.

For multipart geometries there are similar accessor functions: asMultiPoint(), asMultiPolyline() and asMultiPolygon().

It is possible to iterate over all the parts of a geometry, regardless of the geometry’s type. E.g.

```python
geom = QgsGeometry.fromWkt('MultiPoint( 0 0, 1 1, 2 2)')
for part in geom.parts():
    print(part.asWkt())
```

Point (0 0)
Point (1 1)
Point (2 2)

```python
geom = QgsGeometry.fromWkt('LineString( 0 0, 10 10 )')
for part in geom.parts():
    print(part.asWkt())
```

LineString (0 0, 10 10)

It’s also possible to modify each part of the geometry using QgsGeometry.parts() method.

```python
geom = QgsGeometry.fromWkt('MultiPoint( 0 0, 1 1, 2 2)')
for part in geom.parts():
    part.transform(QgsCoordinateTransform(  
        QgsCoordinateReferenceSystem("EPSG:4326"),  
        QgsCoordinateReferenceSystem("EPSG:3111"),  
        QgsProject.instance())  
)
print(geom.asWkt())
```

MultiPoint ((-10334726.79314761981368065 -5360105.10101188533008099),(-10462133.82917750626802444 -5217484.34365727473050356),(-10589398.5134685110099316 -5072020.358805269934237))

### 7.3 Predicati ed Operazioni delle Geometrie

QGIS uses GEOS library for advanced geometry operations such as geometry predicates (contains(), intersects(), ...) and set operations (combine(), difference(), ...). It can also compute geometric properties of geometries, such as area (in the case of polygons) or lengths (for polygons and lines).

Let’s see an example that combines iterating over the features in a given layer and performing some geometric computations based on their geometries. The below code will compute and print the area and perimeter of each country in the countries layer within our tutorial QGIS project.

The following code assumes layer is a QgsVectorLayer object that has Polygon feature type.
# let's access the 'countries' layer
layer = QgsProject.instance().mapLayersByName('countries')[0]

# let's filter for countries that begin with Z, then get their features
query = "name" LIKE '\Z\'
features = layer.getFeatures(QgsFeatureRequest().setFilterExpression(query))

# now loop through the features, perform geometry computation and print the results
for f in features:
    geom = f.geometry()
    name = f.attribute('NAME')
    print('Area: ', geom.area())
    print('Perimeter: ', geom.length())

Zambia
Area: 62.822790653431205
Perimeter: 50.65232014052552
Zimbabwe
Area: 33.41113559136521
Perimeter: 26.608288555013935

Now you have calculated and printed the areas and perimeters of the geometries. You may however quickly notice that the values are strange. That is because areas and perimeters don’t take CRS into account when computed using the area() and length() methods from the QgsGeometry class. For a more powerful area and distance calculation, the QgsDistanceArea class can be used, which can perform ellipsoid based calculations:

The following code assumes layer is a QgsVectorLayer object that has Polygon feature type.

d = QgsDistanceArea()
d.setEllipsoid('WGS84')
layer = QgsProject.instance().mapLayersByName('countries')[0]

# let's filter for countries that begin with Z, then get their features
query = "name" LIKE '\Z\'
features = layer.getFeatures(QgsFeatureRequest().setFilterExpression(query))

for f in features:
    geom = f.geometry()
    name = f.attribute('NAME')
    print('Perimeter (m):', d.measurePerimeter(geom))
    print('Area (m2):', d.measureArea(geom))
    print('Perimeter (km):', d.convertAreaMeasurement(d.measureArea(geom), QgsUnitTypes.AreaSquareKilometers))

Zambia
Perimeter (m): 5539361.250080013
Area (m2): 752000605894.2937
Area (km2): 752000.6058942936
Zimbabwe
Perimeter (m): 2865021.3323912495
Area (m2): 389250992553.95465
Area (km2): 389250.99255395465

Alternatively, you may want to know the distance and bearing between two points.
```
from qgis.core import (QgsCoordinateReferenceSystem, 
QgsCoordinateTransform, 
QgsProject, 
QgsPointXY, 
)
```

É possibile trovare molti esempi di algoritmi che sono inclusi in QGIS ed utilizzare questi metodi per analizzare e trasformare i dati vettoriali. Di seguito i link al codice di alcuni di questi.

- **Distance and area using the** `QgsDistanceArea` **class**: Distance matrix algorithm
- **Lines to polygons algorithm**

The code snippets on this page need the following imports if you’re outside the pyqgis console:
8.1 Sistemi di riferimento delle coordinate

I sistemi di riferimento delle coordinate (SR) sono incapsulati dalla classe `QgsCoordinateReferenceSystem`. Le istanze di questa classe possono essere create in diversi modi:

- Specifica SR con il suo ID

```python
# EPSG 4326 is allocated for WGS84
 CRS = QgsCoordinateReferenceSystem("EPSG:4326")
print(CRS.isValid())
```

QGIS supporta diversi identificatori SR con i seguenti formati:

- EPSG:<code> — ID assigned by the EPSG organization - handled with `createFromOgcWms()`
- POSTGIS:<srid>— ID used in PostGIS databases - handled with `createFromSrid()`
- INTERNAL:<srsid> — ID used in the internal QGIS database - handled with `createFromSrsId()`
- PROJ:<proj> - handled with `createFromProj()`
- WKT:<wkt> - handled with `createFromWkt()`

Se non viene specificato alcun prefisso, viene assunta la definizione WKT.

- specificare il SR con il suo well-known text (WKT)

```python
wkt = 'GEOGCS["WGS 84", DATUM["WGS 84", SPHEROID["WGS 84", 6378137.0, 298.2572155]],' \n   'PRIMEM["Greenwich", 0.0], UNIT["degree", 0.017453292519943295],'' \n   'AXIS["Longitude", EAST], AXIS["Latitude", NORTH]]'

CRS = QgsCoordinateReferenceSystem(wkt)
print(CRS.isValid())
```

True
• create an invalid CRS and then use one of the create* functions to initialize it. In the following example we use a Proj string to initialize the projection.

```python
crs = QgsCoordinateReferenceSystem()
crs.createFromProj("+proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs")
print(crs.isValid())
```

True

It's wise to check whether creation (i.e. lookup in the database) of the CRS has been successful: `isValid()` must return True.

Note that for initialization of spatial reference systems QGIS needs to look up appropriate values in its internal database `srs.db`. Thus in case you create an independent application you need to set paths correctly with `QgsApplication.setPrefixPath()`, otherwise it will fail to find the database. If you are running the commands from the QGIS Python console or developing a plugin you do not care: everything is already set up for you.

Accessing spatial reference system information:

```python
crs = QgsCoordinateReferenceSystem("EPSG:4326")
print("QGIS CRS ID:", crs.srsid())
print("PostGIS SRID:", crs.postgisSrid())
print("Description:", crs.description())
print("Projection Acronym:", crs.projectionAcronym())
print("Ellipsoid Acronym:", crs.ellipsoidAcronym())
print("Proj String:", crs.toProj())

# check whether it's geographic or projected coordinate system
print("Is geographic:", crs.isGeographic())

# check type of map units in this CRS (values defined in QGis::units enum)
print("Map units:", crs.mapUnits())
```

In uscita:

```
QGIS CRS ID: 3452
PostGIS SRID: 4326
Description: WGS 84
Projection Acronym: longlat
Ellipsoid Acronym: EPSG:7030
Proj String: +proj=longlat +datum=WGS84 +no_defs
Is geographic: True
Map units: 6
```

### 8.2 Trasformazione SR

You can do transformation between different spatial reference systems by using the `QgsCoordinateTransform` class. The easiest way to use it is to create a source and destination CRS and construct a `QgsCoordinateTransform` instance with them and the current project. Then just repeatedly call `transform()` function to do the transformation. By default it does forward transformation, but it is capable to do also inverse transformation.

```python
crsSrc = QgsCoordinateReferenceSystem("EPSG:4326")  # WGS 84
crsDest = QgsCoordinateReferenceSystem("EPSG:32633")  # WGS 84 / UTM zone 33N
transformContext = QgsProject.instance().transformContext()
xform = QgsCoordinateTransform(crsSrc, crsDest, transformContext)

# forward transformation: src -> dest
pt1 = xform.transform(QgsPointXY(18,5))
```

(continues on next page)
print("Transformed point:", pt1)

# inverse transformation: dest -> src
pt2 = xform.transform(pt1, QgsCoordinateTransform.ReverseTransform)
print("Transformed back:", pt2)

In uscita:

Transformed point: <QgsPointXY: POINT(832713.7987384437583869 553423.98688333143945783)>
Transformed back: <QgsPointXY: POINT(18 5)>

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.PyQt.QtGui import (QColor,
 Qt, QRectF)
from qgis.PyQt.QtCore import Qt, QRectF
from qgis.core import (QgsVectorLayer, QgsPoint,
 QgsPointXY, QgsProject, QgsGeometry,
 QgsMapRendererJob,)
from qgis.gui import (QgsMapCanvas,
 QgsVertexMarker, QgsMapCanvasItem,
 QgsRubberBand,)
```

8.2. Trasformazione SR
The Map canvas widget is probably the most important widget within QGIS because it shows the map composed from overlaid map layers and allows interaction with the map and layers. The canvas always shows a part of the map defined by the current canvas extent. The interaction is done through the use of map tools: there are tools for panning, zooming, identifying layers, measuring, vector editing and others. Similar to other graphics programs, there is always one tool active and the user can switch between the available tools.

The map canvas is implemented with the QgsMapCanvas class in the qgis.gui module. The implementation is based on the Qt Graphics View framework. This framework generally provides a surface and a view where custom graphics items are placed and user can interact with them. We will assume that you are familiar enough with Qt to understand the concepts of the graphics scene, view and items. If not, please read the overview of the framework.

Whenever the map has been panned, zoomed in/out (or some other action that triggers a refresh), the map is rendered again within the current extent. The layers are rendered to an image (using the QgsMapRendererJob class) and that image is displayed on the canvas. The QgsMapCanvas class also controls refreshing of the rendered map. Besides this item which acts as a background, there may be more map canvas items.

Typical map canvas items are rubber bands (used for measuring, vector editing etc.) or vertex markers. The canvas items are usually used to give visual feedback for map tools, for example, when creating a new polygon, the map tool creates a rubber band canvas item that shows the current shape of the polygon. All map canvas items are subclasses of QgsMapCanvasItem which adds some more functionality to the basic QGraphicsItem objects.

To summarize, the map canvas architecture consists of three concepts:

- map canvas — for viewing of the map
- map canvas items — additional items that can be displayed on the map canvas
- map tools — for interaction with the map canvas
9.1 Embedding Map Canvas

Map canvas is a widget like any other Qt widget, so using it is as simple as creating and showing it.

```python
canvas = QgsMapCanvas()
canvas.show()
```

This produces a standalone window with map canvas. It can be also embedded into an existing widget or window. When using .ui files and Qt Designer, place a QWidget on the form and promote it to a new class: set QgsMapCanvas as class name and set qgis.lib as header file. The pyuic5 utility will take care of it. This is a very convenient way of embedding the canvas. The other possibility is to manually write the code to construct map canvas and other widgets (as children of a main window or dialog) and create a layout.

By default, map canvas has black background and does not use anti-aliasing. To set white background and enable anti-aliasing for smooth rendering:

```python
canvas.setCanvasColor(Qt.white)
canvas.enableAntiAliasing(True)
```

(In case you are wondering, Qt comes from PyQt.QtCore module and Qt.white is one of the predefined QColor instances.)

Now it is time to add some map layers. We will first open a layer and add it to the current project. Then we will set the canvas extent and set the list of layers for the canvas.

```python
vlayer = QgsVectorLayer('testdata/airports.shp', "Airports layer", "ogr")
if not vlayer.isValid():
    print("Layer failed to load!")
QgsProject.instance().addMapLayer(vlayer)
# set extent to the extent of our layer
canvas.setExtent(vlayer.extent())
# set the map canvas layer set
canvas.setLayers([vlayer])
```

After executing these commands, the canvas should show the layer you have loaded.

9.2 Rubber Bands and Vertex Markers

To show some additional data on top of the map in canvas, use map canvas items. It is possible to create custom canvas item classes (covered below), however there are two useful canvas item classes for convenience: QgsRubberBand for drawing polylines or polygons, and QgsVertexMarker for drawing points. They both work with map coordinates, so the shape is moved/scaled automatically when the canvas is being panned or zoomed.

Per mostrare una polilinea:

```python
r = QgsRubberBand(canvas, False)  # False = not a polygon
points = [QgsPoint(-100, 45), QgsPoint(10, 60), QgsPoint(120, 45)]
r.setToGeometry(QgsGeometry.fromPolyline(points), None)
```

Per mostrare un poligono

```python
r = QgsRubberBand(canvas, True)  # True = a polygon
points = [[QgsPointXY(-100, 35), QgsPointXY(10, 50), QgsPointXY(120, 35)]]
r.setToGeometry(QgsGeometry.fromPolygonXY(points), None)
```
Note that points for polygon is not a plain list: in fact, it is a list of rings containing linear rings of the polygon: first ring is the outer border; further (optional) rings correspond to holes in the polygon.

Rubber bands allow some customization, namely to change their color and line width:

```python
r.setColor(QColor(0, 0, 255))
r.setWidth(3)
```

The canvas items are bound to the canvas scene. To temporarily hide them (and show them again), use the `hide()` and `show()` combo. To completely remove the item, you have to remove it from the scene of the canvas:

```python
canvas.scene().removeItem(r)
```

(in C++ it’s possible to just delete the item, however in Python `del r` would just delete the reference and the object will still exist as it is owned by the canvas)

Rubber band can be also used for drawing points, but the `QgsVertexMarker` class is better suited for this (`QgsRubberBand` would only draw a rectangle around the desired point).

You can use the vertex marker like this:

```python
m = QgsVertexMarker(canvas)
m.setCenter(QgsPointXY(10, 40))
```

This will draw a red cross on position [10, 45]. It is possible to customize the icon type, size, color and pen width:

```python
m.setColor(QColor(0, 255, 0))
m.setIconSize(5)
m.setIconType(QgsVertexMarker.ICON_BOX)  # or ICON_CROSS, ICON_X
m.setPenWidth(3)
```

For temporary hiding of vertex markers and removing them from canvas, use the same methods as for rubber bands.

### 9.3 Using Map Tools with Canvas

The following example constructs a window that contains a map canvas and basic map tools for map panning and zooming. Actions are created for activation of each tool: panning is done with `QgsMapToolPan`, zooming in/out with a pair of `QgsMapToolZoom` instances. The actions are set as checkable and later assigned to the tools to allow automatic handling of checked/unchecked state of the actions – when a map tool gets activated, its action is marked as selected and the action of the previous map tool is deselected. The map tools are activated using `setMapTool()` method.

```python
from qgis.gui import *
from qgis.PyQt.QtWidgets import QAction, QMainWindow
from qgis.PyQt.QtCore import Qt

class MyWnd(QMainWindow):
    def __init__(self, layer):
        QMainWindow.__init__(self)

        self.canvas = QgsMapCanvas()
        self.canvas.setCanvasColor(Qt.white)

        self.canvas.setExtent(layer.extent())
        self.canvas.setLayers([layer])

        self.setCentralWidget(self.canvas)

        self.actionZoomIn = QAction("Zoom in", self)
        self.actionZoomOut = QAction("Zoom out", self)
```

(continues on next page)
self.actionPan = QAction("Pan", self)

self.actionZoomIn.setCheckable(True)
self.actionZoomOut.setCheckable(True)
self.actionPan.setCheckable(True)

self.actionZoomIn.triggers.connect(self.zoomIn)
self.actionZoomOut.triggers.connect(self.zoomOut)
self.actionPan.triggers.connect(self.pan)

self.toolbar = self.addToolBar("Canvas actions")
self.toolbar.addAction(self.actionZoomIn)
self.toolbar.addAction(self.actionZoomOut)
self.toolbar.addAction(self.actionPan)

# create the map tools
self.toolPan = QgsMapToolPan(self.canvas)
self.toolPan.setAction(self.actionPan)
self.toolZoomIn = QgsMapToolZoom(self.canvas, False)  # false = in
self.toolZoomIn.setAction(self.actionZoomIn)
self.toolZoomOut = QgsMapToolZoom(self.canvas, True)  # true = out
self.toolZoomOut.setAction(self.actionZoomOut)

self.pan()

def zoomIn(self):
    self.canvas.setMapTool(self.toolZoomIn)

def zoomOut(self):
    self.canvas.setMapTool(self.toolZoomOut)

def pan(self):
    self.canvas.setMapTool(self.toolPan)

You can try the above code in the Python console editor. To invoke the canvas window, add the following lines to instantiate the MyWnd class. They will render the currently selected layer on the newly created canvas.

```python
w = MyWnd(iface.activeLayer())
w.show()
```

### 9.3.1 Select a feature using QgsMapToolIdentifyFeature

You can use the map tool QgsMapToolIdentifyFeature for asking to the user to select a feature that will be sent to a callback function.

```python
def callback(feature):
    """Code called when the feature is selected by the user"
    ""
    print("You clicked on feature {}".format(feature.id()))

canvas = iface.mapCanvas()
feature_identifier = QgsMapToolIdentifyFeature(canvas)

# indicates the layer on which the selection will be done
feature_identifier.setLayer(vlayer)

# use the callback as a slot triggered when the user identifies a feature
feature_identifier.featureIdentified.connect(callback)

# activation of the map tool
canvas.setMapTool(feature_identifier)
```
9.4 Writing Custom Map Tools

You can write your custom tools, to implement a custom behavior to actions performed by users on the canvas.

Map tools should inherit from the QgsMapTool class or any derived class, and selected as active tools in the canvas using the setMapTool() method as we have already seen.

Here is an example of a map tool that allows to define a rectangular extent by clicking and dragging on the canvas. When the rectangle is defined, it prints its boundary coordinates in the console. It uses the rubber band elements described before to show the selected rectangle as it is being defined.

```python
class RectangleMapTool(QgsMapToolEmitPoint):
    def __init__(self, canvas):
        self.canvas = canvas
        QgsMapToolEmitPoint.__init__(self, self.canvas)
        self.rubberBand = QgsRubberBand(self.canvas, True)
        self.rubberBand.setColor(Qt.red)
        self.rubberBand.setWidth(1)
        self.reset()

    def reset(self):
        self startPoint = self endPoint = None
        self.isEmittingPoint = False
        self.rubberBand.reset(True)

    def canvasPressEvent(self, e):
        self startPoint = self.toMapCoordinates(e.pos())
        self endPoint = self startPoint
        self.isEmittingPoint = True
        self.showRect(self startPoint, self endPoint)

    def canvasReleaseEvent(self, e):
        self.isEmittingPoint = False
        r = self.rectangle()
        if r is not None:
            print("Rectangle:", r.xMinimum(),
                  r.yMinimum(), r.xMaximum(), r.yMaximum())

    def canvasMoveEvent(self, e):
        if not self.isEmittingPoint:
            return
        self endPoint = self.toMapCoordinates(e.pos())
        self.showRect(self startPoint, self endPoint)

    def showRect(self, startPoint, endPoint):
        self.rubberBand.reset(QGis.Polygon)
        if startPoint.x() == endPoint.x() or startPoint.y() == endPoint.y():
            return

        point1 = QgsPoint(startPoint.x(), startPoint.y())
        point2 = QgsPoint(startPoint.x(), endPoint.y())
        point3 = QgsPoint(endPoint.x(), endPoint.y())
        point4 = QgsPoint(endPoint.x(), startPoint.y())

        self.rubberBand.addPoint(point1, False)
        self.rubberBand.addPoint(point2, False)
        self.rubberBand.addPoint(point3, False)
        self.rubberBand.addPoint(point4, True)  # true to update canvas
        self.rubberBand.show()
```

(continues on next page)
def rectangle(self):
    if self startPoint is None or self endPoint is None:
        return None
    elif (self startPoint.x() == self endPoint.x() or
          self startPoint.y() == self endPoint.y()):
        return None
        return QgsRectangle(self startPoint, self endPoint)

def deactivate(self):
    QgsMapTool.deactivate(self)
    self deactivated.emit()

9.5 Writing Custom Map Canvas Items

Here is an example of a custom canvas item that draws a circle:

class CircleCanvasItem(QgsMapCanvasItem):
    def __init__(self, canvas):
        super().__init__(canvas)
        self.center = QgsPoint(0, 0)
        self.size = 100
    def setCenter(self, center):
        self.center = center
    def center(self):
        return self.center
    def setSize(self, size):
        self.size = size
    def size(self):
        return self.size
    def boundingRect(self):
        return QRectF(self.center.x() - self.size/2,
                      self.center.y() - self.size/2,
                      self.center.x() + self.size/2,
                      self.center.y() + self.size/2)
    def paint(self, painter, option, widget):
        path = QPainterPath()
        path.moveTo(self.center.x(), self.center.y());
        path.arcTo(self.boundingRect(), 0.0, 360.0)
        painter.fillPath(path, QColor("red"))

# Using the custom item:
item = CircleCanvasItem(iface.mapCanvas())
item.setCenter(QgsPointXY(200, 200))
item.setSize(80)

I frammenti di codice in questa pagina hanno bisogno dei seguenti import:

import os
from qgis.core import (continues on next page)
9.5. Writing Custom Map Canvas Items

```python
QgsGeometry,
QgsMapSettings,
QgsPrintLayout,
QgsMapRendererParallelJob,
QgsLayoutItemLabel,
QgsLayoutItemLegend,
QgsLayoutItemMap,
QgsLayoutItemPolygon,
QgsLayoutItemScaleBar,
QgsLayoutExporter,
QgsLayoutItem,
QgsLayoutPoint,
QgsLayoutSize,
QgsUnitTypes,
QgsProject,
QgsFillSymbol,

from qgis.PyQt.QtGui import (QPolygonF,
QColor,
)

from qgis.PyQt.QtCore import (QPointF,
QRectF,
QSize,
)
Visualizzazione e Stampa di una Mappa

10.1 Visualizzazione Semplice

The rendering is done creating a QgsMapSettings object to define the rendering settings, and then constructing a QgsMapRendererJob with those settings. The latter is then used to create the resulting image.

Ecco un esempio:

```python
image_location = os.path.join(QgsProject.instance().homePath(), "render.png")
vlayer = iface.activeLayer()
settings = QgsMapSettings()
settings.setLayers([vlayer])
settings.setBackgroundColor(QColor(255, 255, 255))
settings.setOutputSize(QSize(800, 600))
settings.setExtent(vlayer.extent())
render = QgsMapRendererParallelJob(settings)
def finished():
    img = render.renderedImage()
    # save the image; e.g. img.save("/Users/myuser/render.png", "png")
    img.save(image_location, "png")
```

(continues on next page)
# Start the rendering
def start():
    # The following loop is not normally required, we are using it here because this is a standalone example.
    from qgis.PyQt.QtCore import QEventLoop
    loop = QEventLoop()
    render.finished.connect(loop.quit)
    loop.exec_()

10.2 Visualizzare layer con diversi SR

If you have more than one layer and they have a different CRS, the simple example above will probably not work: to get the right values from the extent calculations you have to explicitly set the destination CRS.

```python
layers = [iface.activeLayer()]
settings.setLayers(layers)
settings.setDestinationCrs(layers[0].crs())
```

10.3 Output using print layout

Print layout is a very handy tool if you would like to do a more sophisticated output than the simple rendering shown above. It is possible to create complex map layouts consisting of map views, labels, legend, tables and other elements that are usually present on paper maps. The layouts can be then exported to PDF, raster images or directly printed on a printer.

The layout consists of a bunch of classes. They all belong to the core library. QGIS application has a convenient GUI for placement of the elements, though it is not available in the GUI library. If you are not familiar with Qt Graphics View framework, then you are encouraged to check the documentation now, because the layout is based on it.

The central class of the layout is the QgsLayout class, which is derived from the Qt QGraphicsScene class. Let us create an instance of it:

```python
project = QgsProject.instance()
layout = QgsPrintLayout(project)
layout.initializeDefaults()
```

This initializes the layout with some default settings, specifically by adding an empty A4 page to the layout. You can create layouts without calling the `initializeDefaults()` method, but you'll need to take care of adding pages to the layout yourself.

The previous code creates a «temporary» layout that is not visible in the GUI. It can be handy to e.g. quickly add some items and export without modifying the project itself nor expose these changes to the user. If you want the layout to be saved/restored along with the project and available in the layout manager, then add:

```python
layout.setName("MyLayout")
project.layoutManager().addLayout(layout)
```

Now we can add various elements (map, label, …) to the layout. All these objects are represented by classes that inherit from the base QgsLayoutItem class.

Here's a description of some of the main layout items that can be added to a layout.

- map — Here we create a map of a custom size and render the current map canvas
```python
map = QgsLayoutItemMap(layout)
# Set map item position and size (by default, it is a 0 width/0 height item placed at 0,0)
map.attemptMove(QgsLayoutPoint(5, 5, QgsUnitTypes.LayoutMillimeters))
map.attemptResize(QgsLayoutSize(200, 200, QgsUnitTypes.LayoutMillimeters))
# Provide an extent to render
map.zoomToExtent(iface.mapCanvas().extent())
layout.addLayoutItem(map)
```

• **etichetta** — permetta la visualizzazione di etichette. È possibile modificarne il carattere, colore, allineamento e margine.

```python
label = QgsLayoutItemLabel(layout)
label.setText("Hello world")
label.adjustSizeToText()
layout.addLayoutItem(label)
```

• **legenda**

```python
legend = QgsLayoutItemLegend(layout)
legend.setLinkedMap(map)  # map is an instance of QgsLayoutItemMap
layout.addLayoutItem(legend)
```

• **barra di scala**

```python
item = QgsLayoutItemScaleBar(layout)
item.setStyle('Numeric')  # optionally modify the style
item.setLinkedMap(map)  # map is an instance of QgsLayoutItemMap
item.applyDefaultSize()
layout.addLayoutItem(item)
```

• **freccia**

• **immagine**

• **basic shape**

• **nodes based shape**

```python
polygon = QPolygonF()
polygon.append(QPointF(0.0, 0.0))
polygon.append(QPointF(100.0, 0.0))
polygon.append(QPointF(200.0, 100.0))
polygon.append(QPointF(100.0, 200.0))
polygonItem = QgsLayoutItemPolygon(polygon, layout)
layout.addLayoutItem(polygonItem)
```

```python
props = {}
props["color"] = "green"
props["style"] = "solid"
props["style_border"] = "solid"
props["color_border"] = "black"
props["width_border"] = "10.0"
props["joinstyle"] = "miter"
symbol = QgsFillSymbol.createSimple(props)
polygonItem.setSymbol(symbol)
```

• **tabella**

Once an item is added to the layout, it can be moved and resized.
A frame is drawn around each item by default. You can remove it as follows:

```python
# for a composer label
label.setFrameEnabled(False)
```

Besides creating the layout items by hand, QGIS has support for layout templates which are essentially compositions with all their items saved to a .qpt file (with XML syntax).

Once the composition is ready (the layout items have been created and added to the composition), we can proceed to produce a raster and/or vector output.

### 10.3.1 Exporting the layout

To export a layout, the `QgsLayoutExporter` class must be used.

```python
base_path = os.path.join(QgsProject.instance().homePath())
pdf_path = os.path.join(base_path, "output.pdf")
exporter = QgsLayoutExporter(layout)
exporter.exportToPdf(pdf_path, QgsLayoutExporter.PdfExportSettings())
```

Use the `exportToImage()` in case you want to export to an image instead of a PDF file.

### 10.3.2 Exporting a layout atlas

If you want to export all pages from a layout that has the atlas option configured and enabled, you need to use the `atlas()` method in the exporter (`QgsLayoutExporter`) with small adjustments. In the following example, the pages are exported to PNG images:

```python
exporter.exportToImage(layout.atlas(), base_path, 'png', QgsLayoutExporter.ImageExportSettings())
```

Notice that the outputs will be saved in the base path folder, using the output filename expression configured on atlas.

The code snippets on this page need the following imports if you’re outside the `pyqgis` console:

```python
from qgis.core import (edit, QgsExpression, QgsExpressionContext, QgsFeature, QgsFeatureRequest, QgsField, QgsFields, QgsVectorLayer, QgsPointXY, QgsGeometry, QgsProject, QgsExpressionContextUtils)
```
Espressioni, Filtraggio e Calcolo di Valori

- Analisi di Espressioni
- Valutazione di Espressioni
  - Espressioni Base
  - Espressioni con geometrie
  - Filtering a layer with expressions
- Handling expression errors

QGIS has some support for parsing of SQL-like expressions. Only a small subset of SQL syntax is supported. The expressions can be evaluated either as boolean predicates (returning True or False) or as functions (returning a scalar value). See vector_expressions in the User Manual for a complete list of available functions.

Sono supportati tre tipi base:
- numero – sia numeri interi che decimali, e.g. 123, 3.14
- stringa – devono essere racchiusi tra apici: 'hello world'
- riferimento a colonna – durante la valutazione, il riferimento è sostituito con il valore del campo. I nomi non sono racchiusi tra apici.

Sono disponibili le seguenti operazioni:
- operatori aritmetici: +, -, *, /, ^
- parentesi: per forzare la precedenza tra operatori: (1 + 1) * 3
- somma e sottrazione unari: -12, +5
- funzioni matematiche: sqrt, sin, cos, tan, asin, acos, atan
- funzioni di conversione: to_int, to_real, to_string, to_date
- funzioni sulla geometria: $area, $length
- funzioni di manipolazione della geometria: $x, $y, $geometry, num_geometries, centroid

Sono supportati i seguenti predicati:
- comparazione: =, !=, >, >=, <, <=
• pattern matching: LIKE (usando % e _), ~ (espressioni regolari)
• predicati logici: AND, OR, NOT
• controllo di valori NULL: IS NULL, IS NOT NULL

Esempi di predicati:
• \(1 + 2 = 3\)
• \(\sin(\text{angolo}) > 0\)
• 'Hello' LIKE 'He\%'
• \((x > 10 \text{ AND } y > 10) \text{ OR } z = 0\)

Esempi di espressioni scalari:
• \(2 \wedge 10\)
• \(\sqrt{\text{val}}\)
• \($\text{length} + 1$\)

### 11.1 Analisi di Espressioni

The following example shows how to check if a given expression can be parsed correctly:

```python
1 exp = QgsExpression('1 + 1 = 2')
2 assert(not exp.hasParserError())
3 exp = QgsExpression('1 + 1 = '
4 assert(exp.hasParserError())
5 assert(exp.parserErrorString() == '\nsyntax error, unexpected $end')
```

### 11.2 Valutazione di Espressioni

Expressions can be used in different contexts, for example to filter features or to compute new field values. In any case, the expression has to be evaluated. That means that its value is computed by performing the specified computational steps, which can range from simple arithmetic to aggregate expressions.

#### 11.2.1 Espressioni Base

This basic expression evaluates a simple arithmetic operation:

```python
exp = QgsExpression('2 * 3')
print(exp)
print(exp.evaluate())
```

```
<QgsExpression: '2 * 3'>
6
```

Expression can also be used for comparison, evaluating to 1 (True) or 0 (False)

```python
exp = QgsExpression('1 + 1 = 2')
exp.evaluate()  # 1
```
11.2.2 Espressioni con geometrie

Per valutare un'espressione su un'entità, è necessario creare un obiettivo and passarlo alla funzione evaluate per consentire all'espressione di accedere ai valori dei campi dell'entità.

Il seguente esempio mostra come creare un'entità con un campo chiamato «Column» e come aggiungerla all'ambiente espressionistico.

```python
fields = QgsFields()
field = QgsField('Column')
fields.append(field)
feature = QgsFeature()
feature.setFields(fields)
feature.setAttribute(0, 99)
exp = QgsExpression('Column')
context = QgsExpressionContext()
context.setFeature(feature)
exp.evaluate(context)
# 99
```

Il seguente è un esempio più completo di come utilizzare le espressioni nel contesto di un layer vettoriale, per calcolare nuovi valori dei campi:

```python
from qgis.PyQt.QtCore import QVariant

# creare un layer vettoriale
vl = QgsVectorLayer("Point", "Companies", "memory")
pr = vl.dataProvider()
pr.addAttributes([QgsField("Name", QVariant.String),
QgsField("Employees", QVariant.Int),
QgsField("Revenue", QVariant.Double),
QgsField("Rev. per employee", QVariant.Double),
QgsField("Sum", QVariant.Double),
QgsField("Fun", QVariant.Double)])
vl.updateFields()

# aggiungi dati ai primi tre campi
my_data = [
(x: 0, y: 0, name: 'ABC', emp: 10, rev: 100.1),
(x: 1, y: 1, name: 'DEF', emp: 2, rev: 50.5),
(x: 5, y: 5, name: 'GHI', emp: 100, rev: 725.9)]
for rec in my_data:
f = QgsFeature()
pt = QgsPointXY(rec['x'], rec['y'])
f.setGeometry(QgsGeometry.fromPointXY(pt))
f.setAttributes([rec['name'], rec['emp'], rec['rev']])
pr.addFeature(f)
vl.updateExtents()
QgsProject.instance().addMapLayer(vl)

# La prima espressione calcola il reddito per dipendente.
# La seconda calcola la somma di tutti i redditi nel layer.
# La terza espressione non ha senso ma illustra
# il fatto che possiamo usare un ampio range di funzioni espressione, come
# area e buffer nelle nostre espressioni:
expression1 = QgsExpression("Revenue/"Employees")
expression2 = QgsExpression("sum(Revenue")
expression3 = QgsExpression("area(buffer($geometry,"Employees")")
```

(Continua alla prossima pagina)
# QgsExpressionContextUtils.globalProjectLayerScopes() is a convenience function that adds the global, project, and layer scopes all at once. Alternatively, those scopes can also be added manually. In any case, it is important to always go from “most generic” to “most specific” scope, i.e. from global to project to layer.

```python
context = QgsExpressionContext()
context.appendScopes(QgsExpressionContextUtils.globalProjectLayerScopes(vl))

with edit(vl):
    for f in vl.getFeatures():
        context.setFeature(f)
        f['Rev. per employee'] = expression1.evaluate(context)
        f['Sum'] = expression2.evaluate(context)
        f['Fun'] = expression3.evaluate(context)
        vl.updateFeature(f)

print(f['Sum'])
```

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## 11.2.3 Filtering a layer with expressions

L’esempio seguente può essere usato per filtrare un layer e restituire qualsiasi geometria che soddisfi il predicato.

```python
layer = QgsVectorLayer("Point?field=Test:integer",
                      "addfeat", "memory")
layer.startEditing()

for i in range(10):
    feature = QgsFeature()
    feature.setAttributes([i])
    assert layer.addFeature(feature)
layer.commitChanges()

expression = 'Test >= 3'
request = QgsFeatureRequest().setFilterExpression(expression)
matches = 0
for f in layer.getFeatures(request):
    matches += 1

print(matches)
```

## 11.3 Handling expression errors

Expression-related errors can occur during expression parsing or evaluation:

```python
exp = QgsExpression("1 + 1 = 2")
if exp.hasParserError():
    raise Exception(exp.parserErrorString())
value = exp.evaluate()
```
The code snippets on this page need the following imports if you're outside the pyqgis console:

```python
from qgis.core import (QgsProject,
                       QgsSettings,
                       QgsVectorLayer)
```

11.3. Handling expression errors
Molte volte è utile per un plugin salvare alcune variabili in modo tale che l’utente non debba inserirle o selezionarle di nuovo la volta successiva che il plugin è eseguito.

Queste variabili possono essere salvate e recuperate con l’aiuto delle API di Qt e QGIS. Per ogni variabile, dovresti scegliere una chiave che sarà usata per accedere alla variabile — per il colore preferito dell’utente potresti usare la chiave «favourite_color» o una qualunque altra stringa significativa. È raccomandabile dare una qualche struttura alla denominazione delle chiavi.

We can differentiate between several types of settings:

- **global settings** — they are bound to the user at a particular machine. QGIS itself stores a lot of global settings, for example, main window size or default snapping tolerance. Settings are handled using the QgsSettings class, through for example the setValue() and value() methods.

Here you can see an example of how these methods are used.

```python
def store():
    s = QgsSettings()
    s.setValue("myplugin/mytext", "hello world")
    s.setValue("myplugin/myint", 10)
    s.setValue("myplugin/myreal", 3.14)

def read():
    s = QgsSettings()
    mytext = s.value("myplugin/mytext", "default text")
    myint = s.value("myplugin/myint", 123)
    myreal = s.value("myplugin/myreal", 2.71)
    nonexistent = s.value("myplugin/nonexistent", None)
    print(mytext)
    print(myint)
    print(myreal)
    print(nonexistent)
```

The second parameter of the value() method is optional and specifies the default value that is returned if there is no previous value set for the passed setting name.

For a method to pre-configure the default values of the global settings through the global_settings.ini file, see deploying_organization for further details.

- **project settings** — vary between different projects and therefore they are connected with a project file. Map canvas background color or destination coordinate reference system (CRS) are examples — white background
and WGS84 might be suitable for one project, while yellow background and UTM projection are better for another one.

An example of usage follows.

```python
proj = QgsProject.instance()
# store values
proj.writeEntry("myplugin", "mytext", "hello world")
proj.writeEntry("myplugin", "myint", 10)
proj.writeEntryDouble("myplugin", "mydouble", 0.01)
proj.writeEntryBool("myplugin", "mybool", True)

# read values (returns a tuple with the value, and a status boolean
# which communicates whether the value retrieved could be converted to
# its type, in these cases a string, an integer, a double and a boolean
# respectively)
mytext, type_conversion_ok = proj.readEntry("myplugin",
                                       "mytext",
                                       "default text")
myint, type_conversion_ok = proj.readNumEntry("myplugin",
                                          "myint",
                                          123)
mydouble, type_conversion_ok = proj.readDoubleEntry("myplugin",
                                         "mydouble",
                                         123)
mybool, type_conversion_ok = proj.readBoolEntry("myplugin",
                                          "mybool",
                                          123)
```

As you can see, the `writeEntry()` method is used for many data types (integer, string, list), but several methods exist for reading the setting value back, and the corresponding one has to be selected for each data type.

- **map layer settings** — these settings are related to a particular instance of a map layer with a project. They are not connected with underlying data source of a layer, so if you create two map layer instances of one shapefile, they will not share the settings. The settings are stored inside the project file, so if the user opens the project again, the layer-related settings will be there again. The value for a given setting is retrieved using the `customProperty()` method, and can be set using the `setCustomProperty()` one.

```python
vlayer = QgsVectorLayer()
# save a value
vlayer.setCustomProperty("mytext", "hello world")

# read the value again (returning "default text" if not found)
mytext = vlayer.customProperty("mytext", "default text")
```

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import 
                      QgsMessageLog,
                      QgsGeometry,
) 

from qgis.gui import 
                      QgsMessageBar,
) 

from qgis.PyQt.QtWidgets import 
                      QSizePolicy,
                      QPushButton,
                      QDialog,
) 
```
QGridLayout,
QDialogButtonBox,
}
CAPITOLO 13

Comunicare con l'utente

• Showing messages. The QgsMessageBar class
• Mostrare l'avanzamento
• Logging
  – QgsMessageLog
  – The python built in logging module

Questa sezione mostra alcuni metodi ed elementi che dovrebbero essere usati per comunicare con l'utente, in modo da mantenere la consistenza nell'interfaccia utente.

13.1 Showing messages. The QgsMessageBar class

Utilizzare il box dei messaggi potrebbe essere una cattiva idea dal punto di vista dell’esperienza utente. Solitamente, per mostrare un messaggio di informazione o di errore/avvertimento, la barra dei messaggi di QGIS é l’opzione migliore.

Utilizzando il riferimento all’oggetto interfaccia di QGIS, é possibile mostrare un messaggio nell’barra dei messaggi utilizzando il seguente codice

```
from qgis.core import Qgis
iface.messageBar().pushMessage("Error", "I'm sorry Dave, I'm afraid I can't do that 
...", level=Qgis.Critical)
```

Messages(2): Error : I'm sorry Dave, I'm afraid I can't do that

Fig. 13.1: Barra dei messaggi di QGIS
É possibile impostare una durata per mostrarlo per un tempo limitato

```python
iface.messageBar().pushMessage("Ooops", "The plugin is not working as it should", level=Qgis.Critical, duration=3)
```

Messages(2): Ooops : The plugin is not working as it should

Fig. 13.2: Barra dei messaggi di QGIS con timer

The examples above show an error bar, but the level parameter can be used to creating warning messages or info messages, using the Qgis.MessageLevel enumeration. You can use up to 4 different levels:

0. Info
1. Warning
2. Critical
3. Success

Fig. 13.3: Barra dei messaggi di QGIS (informazioni)

I widget possono essere aggiunti alla barra dei messaggi, ad esempio il pulsante per mostrare più informazioni

```python
def showError():
    pass

widget = iface.messageBar().createMessage("Missing Layers", "Show Me")
button = QPushButton(widget)
button.setText("Show Me")
button.pressed.connect(showError)
widget.layout().addWidget(button)
iface.messageBar().pushWidget(widget, Qgis.Warning)
```

Messages(1): Missing Layers : Show Me

Fig. 13.4: Barra dei messaggi di QGIS con un pulsante
É possibile usare una barra dei messaggi nella propria finestra di dialogo senza dover mostrare una finestra di messaggi, o nel caso in cui non abbia senso mostrarla nella finestra principale di QGIS.

```python
class MyDialog(QDialog):
    def __init__(self):
        QDialog.__init__(self)
        self.bar = QgsMessageBar()
        self.bar.setSizePolicy(QSizePolicy.Minimum, QSizePolicy.Fixed)
        self.setLayout(QGridLayout())
        self.buttonbox = QDialogButtonBox(QDialogButtonBox.Ok)
        self.buttonbox.accepted.connect(self.run)

    def run(self):
        self.bar.pushMessage("Hello", "World", level=Qgis.Info)

myDlg = MyDialog()
myDlg.show()
```

Fig. 13.5: Barra dei messaggi di QGIS in una finestra di dialogo personalizzata
13.2 Mostrare l’avanzamento

Le barre di avanzamento si possono mettere anche nella barra dei messaggi di QGIS, dato che, come abbiamo visto, accetta i widget. Di seguito un esempio che potrete provare nella console.

```python
import time
from qgis.PyQt.QtWidgets import QProgressBar
from qgis.PyQt.QtCore import *
progressMessageBar = iface.messageBar().createMessage("Doing something boring...")
progress = QProgressBar()
progress.setMaximum(10)
progress.setAlignment(Qt.AlignLeft | Qt.AlignVCenter)
progressMessageBar.layout().addWidget(progress)
iface.messageBar().pushWidget(progressMessageBar, Qgis.Info)
for i in range(10):
    time.sleep(1)
    progress.setValue(i + 1)
iface.messageBar().clearWidgets()
```

Messages(0): Doing something boring...

Also, you can use the built-in status bar to report progress, as in the next example:

```python
vlayer = iface.activeLayer()
count = vlayer.featureCount()
features = vlayer.getFeatures()
for i, feature in enumerate(features):
    # do something time-consuming here
    print('.', end='') # printing should give enough time to present the progress
    percent = i / float(count) * 100
    iface.statusBarIface().showMessage("Processed {} %").format(int(percent))
iface.statusBarIface().clearMessage()
```

13.3 Logging

There are three different types of logging available in QGIS to log and save all the information about the execution of your code. Each has its specific output location. Please consider to use the correct way of logging for your purpose:

- **QgsMessageLog** is for messages to communicate issues to the user. The output of the QgsMessageLog is shown in the Log Messages Panel.
- The python built in **logging** module is for debugging on the level of the QGIS Python API (PyQGIS). It is recommended for Python script developers that need to debug their python code, e.g. feature ids or geometries
- **QgsLogger** is for messages for QGIS internal debugging / developers (i.e. you suspect something is triggered by some broken code). Messages are only visible with developer versions of QGIS.

Examples for the different logging types are shown in the following sections below.
Avvertimento: Use of the Python print statement is unsafe to do in any code which may be multithreaded and extremely slows down the algorithm. This includes expression functions, renderers, symbol layers and Processing algorithms (amongst others). In these cases you should always use the python logging module or thread safe classes (QgsLogger or QgsMessageLog) instead.

13.3.1 QgsMessageLog

```python
# You can optionally pass a 'tag' and a 'level' parameters
QgsMessageLog.logMessage("Your plugin code has been executed correctly", 'MyPlugin', level=Qgis.Info)
QgsMessageLog.logMessage("Your plugin code might have some problems", level=Qgis.Warning)
QgsMessageLog.logMessage("Your plugin code has crashed!", level=Qgis.Critical)
```

MyPlugin(0): Your plugin code has been executed correctly
(1): Your plugin code might have some problems
(2): Your plugin code has crashed!

Nota: You can see the output of the QgsMessageLog in the log_message_panel

13.3.2 The python built in logging module

```python
import logging
formatter = '%(asctime)s - %(name)s - %(levelname)s - %(message)s'
logfilename=r'c:\temp\example.log'
logging.basicConfig(filename=logfilename, level=logging.DEBUG, format=formatter)
logging.info("This logging info text goes into the file")
logging.debug("This logging debug text goes into the file as well")
```

The basicConfig method configuresthe basic setup of the logging. In the above code the filename, logging level and the format are defined. The filename refers to where to write the logfile to, the logging level defines what levels to output and the format defines the format in which each message is output.

```
2020-10-08 13:14:42,998 - root - INFO - This logging text goes into the file
2020-10-08 13:14:42,998 - root - DEBUG - This logging debug text goes into the file as well
```

If you want to erase the log file every time you execute your script you can do something like:

```python
if os.path.isfile(logfilename):
    with open(logfilename, 'w') as file:
        pass
```

Further resources on how to use the python logging facility are available at:

- https://docs.python.org/3/library/logging.html
- https://docs.python.org/3/howto/logging.html
- https://docs.python.org/3/howto/logging-cookbook.html

Avvertimento: Please note that without logging to a file by setting a filename the logging may be multithreaded which heavily slows down the output.
The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import (QgsApplication, 
QgsRasterLayer, 
QgsAuthMethodConfig, 
QgsDataSourceUri, 
QgsPkiBundle, 
QgsMessageLog,)

from qgis.gui import (QgsAuthAuthoritiesEditor, 
QgsAuthConfigEditor, 
QgsAuthConfigSelect, 
QgsAuthSettingsWidget,)

from qgis.PyQt.QtWidgets import (QWidget, 
QTabWidget,)

from qgis.PyQt.QtNetwork import QSslCertificate
```
Authentication infrastructure

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  – *Init the manager and set the master password*
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  – *Leave authcfg expansion to QgsAuthManager*
    • *PKI examples with other data providers*
• **Adapt plugins to use Authentication infrastructure**
• **Authentication GUIs**
  – *GUI to select credentials*
  – *Authentication Editor GUI*
  – *Authorities Editor GUI*
14.1 Introduzione

User reference of the Authentication infrastructure can be read in the User Manual in the authentication_overview paragraph.

This chapter describes the best practices to use the Authentication system from a developer perspective.

The authentication system is widely used in QGIS Desktop by data providers whenever credentials are required to access a particular resource, for example when a layer establishes a connection to a Postgres database.

There are also a few widgets in the QGIS GUI library that plugin developers can use to easily integrate the authentication infrastructure into their code:

- QgsAuthConfigEditor
- QgsAuthConfigSelect
- QgsAuthSettingsWidget

A good code reference can be read from the authentication infrastructure tests code.

**Avvertimento:** Due to the security constraints that were taken into account during the authentication infrastructure design, only a selected subset of the internal methods are exposed to Python.

14.2 Glossary

Here are some definition of the most common objects treated in this chapter.

- **Master Password**  
  Password to allow access and decrypt credential stored in the QGIS Authentication DB

- **Authentication Database**  
  A *Master Password* encrypted sqlite db `qgis-auth.db` where *Authentication Configuration* are stored. e.g. user/password, personal certificates and keys, Certificate Authorities

- **Authentication DB**  
  Authentication Database

- **Authentication Configuration**  
  A set of authentication data depending on *Authentication Method*. e.g. Basic authentication method stores the couple of user/password.

- **Authentication Config**  
  Authentication Configuration

- **Authentication Method**  
  A specific method used to get authenticated. Each method has its own protocol used to gain the authenticated level. Each method is implemented as shared library loaded dynamically during QGIS authentication infrastructure init.

14.3 QgsAuthManager the entry point

The QgsAuthManager singleton is the entry point to use the credentials stored in the QGIS encrypted Authentication DB, i.e. the `qgis-auth.db` file under the active user profile folder.

This class takes care of the user interaction: by asking to set a master password or by transparently using it to access encrypted stored information.
14.3.1 Init the manager and set the master password

The following snippet gives an example to set master password to open the access to the authentication settings. Code comments are important to understand the snippet.

```python
authmgr = QgsApplication.authManager()

# check if QgsAuthManager has already been initialized... a side effect
# of the QgsAuthManager.init() is that AuthDbPath is set.
# QgsAuthManager.init() is executed during QGIS application init and hence
# you do not normally need to call it directly.
if authmgr.authenticationDatabasePath():
    # already initialized => we are inside a QGIS app.
    if authmgr.masterPasswordIsSet():
        msg = 'Authentication master password not recognized'
        assert authmgr.masterPasswordSame("your master password"), msg
    else:
        msg = 'Master password could not be set'
        # The verify parameter checks if the hash of the password was
        # already saved in the authentication db
        assert authmgr.setMasterPassword("your master password", verify=True), msg
else:
    # outside qgis, e.g. in a testing environment => setup env var before
    # db init
    os.environ['QGIS_AUTH_DB_DIR_PATH'] = "/path/where/located/qgis-auth.db"
    msg = 'Master password could not be set'
    assert authmgr.setMasterPassword("your master password", True), msg
    authmgr.init("/path/where/located/qgis-auth.db")
```

14.3.2 Populate authdb with a new Authentication Configuration entry

Any stored credential is a Authentication Configuration instance of the QgsAuthMethodConfig class accessed using a unique string like the following one:

```python
authcfg = 'fm1s770'
```

that string is generated automatically when creating an entry using the QGIS API or GUI, but it might be useful to manually set it to a known value in case the configuration must be shared (with different credentials) between multiple users within an organization.

QgsAuthMethodConfig is the base class for any Authentication Method. Any Authentication Method sets a configuration hash map where authentication information will be stored. Hereafter a useful snippet to store PKI-path credentials for a hypothetical alice user:

```python
authmgr = QgsApplication.authManager()

# set alice PKI data
config = QgsAuthMethodConfig()
config.setName("alice")
config.setMethod("PKI-Paths")
config.setUrl("https://example.com")
config.setConfig("certpath", "path/to/alice-cert.pem")
config.setConfig("keypath", "path/to/alice-key.pem")
# check if method parameters are correctly set
assert config.isValid()

# register alice data in authdb returning the ``authcfg`` of the stored
# configuration
authmgr.storeAuthenticationConfig(config)
newAuthCfgId = config.id()
assert newAuthCfgId
```

14.3. QgsAuthManager the entry point

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Available Authentication methods

**Authentication Method** libraries are loaded dynamically during authentication manager init. Available authentication methods are:

1. **Basic** User and password authentication
2. **Esri-Token** ESRI token based authentication
3. **Identity-Cert** Identity certificate authentication
4. **OAuth2** OAuth2 authentication
5. **PKI-Paths** PKI paths authentication
6. **PKI-PKCS#12** PKI PKCS#12 authentication

**Populate Authorities**

```python
authMgr = QgsApplication.authManager()
# add authorities
cacerts = QSslCertificate.fromPath("/path/to/ca_chains.pem")
assert cacerts is not None
# store CA
authMgr.storeCertAuthorities(cacerts)
# and rebuild CA caches
authMgr.rebuildCaCertsCache()
authMgr.rebuildTrustedCaCertsCache()
```

**Manage PKI bundles with QgsPkiBundle**

A convenience class to pack PKI bundles composed on SslCert, SslKey and CA chain is the **QgsPkiBundle** class. Hereafter a snippet to get password protected:

```python
# add alice cert in case of key with pwd
cabundlesList = [] # List of CA bundles
bundle = QgsPkiBundle.fromPemPaths("/path/to/alice-cert.pem",
                                     "/path/to/alice-key_w-pass.pem",
                                     "unlock_pwd",
                                     cabundlesList )
assert bundle is not None
# You can check bundle validity by calling:
# bundle.isValid()
```

Refer to **QgsPkiBundle** class documentation to extract cert/key/CAs from the bundle.

### 14.3.3 Remove an entry from authdb

We can remove an entry from **Authentication Database** using it’s `authcfg` identifier with the following snippet:

```python
authMgr = QgsApplication.authManager()
authMgr.removeAuthenticationConfig("authCfg_Id_to_remove")
```
14.3.4 Leave authcfg expansion to QgsAuthManager

The best way to use an Authentication Config stored in the Authentication DB is referring it with the unique identifier authcfg. Expanding, means convert it from an identifier to a complete set of credentials. The best practice to use stored Authentication Configs, is to leave it managed automatically by the Authentication manager. The common use of a stored configuration is to connect to an authentication enabled service like a WMS or WFS or to a DB connection.

Nota: Take into account that not all QGIS data providers are integrated with the Authentication infrastructure. Each authentication method, derived from the base class QgsAuthMethod and support a different set of Providers. For example the certIdentity() method supports the following list of providers:

```python
authM = QgsApplication.authManager()
print(authM.authMethod("Identity-Cert").supportedDataProviders())
```

Sample output:

```
['ows', 'wfs', 'wcs', 'wms', 'postgres']
```

For example, to access a WMS service using stored credentials identified with authcfg = 'fm1s770', we just have to use the authcfg in the data source URL like in the following snippet:

```python
authCfg = 'fm1s770'
quri = QgsDataSourceUri()
quri.setParam("layers", 'usa:states')
quri.setParam("styles", '')
quri.setParam("format", 'image/png')
quri.setParam("crs", 'EPSG:4326')
quri.setParam("dpiMode", '7')
quri.setParam("featureCount", '10')
quri.setParam("authcfg", authCfg)  # <---- here my authCfg url parameter
quri.setParam("contextualWMSLegend", '0')
quri.setParam("url", 'https://my_auth_enabled_server_ip/wms')
rlayer = QgsRasterLayer(quri.uri(False), 'states', 'wms')
```

In the upper case, the wms provider will take care to expand authcfg URI parameter with credential just before setting the HTTP connection.

Avvertimento: The developer would have to leave authcfg expansion to the QgsAuthManager, in this way he will be sure that expansion is not done too early.

Usually an URI string, built using the QgsDataSourceUri class, is used to set a data source in the following way:

```python
authCfg = 'fm1s770'
quri = QgsDataSourceUri("my WMS uri here")
quri.setParam("authcfg", authCfg)
rlayer = QgsRasterLayer( quri.uri(False), 'states', 'wms')
```

Nota: The False parameter is important to avoid URI complete expansion of the authcfg id present in the URI.
PKI examples with other data providers

Other example can be read directly in the QGIS tests upstream as in `test_authmanager_pki_ows` or `test_authmanager_pki_postgres`.

14.4 Adapt plugins to use Authentication infrastructure

Many third party plugins are using `httplib2` or other Python networking libraries to manage HTTP connections instead of integrating with `QgsNetworkAccessManager` and its related Authentication Infrastructure integration.

To facilitate this integration a helper Python function has been created called `NetworkAccessManager`. Its code can be found here.

This helper class can be used as in the following snippet:

```python
http = NetworkAccessManager(authid="my_authCfg", exception_class=My_
→FailedRequestError)
try:
    response, content = http.request( "my_rest_url" )
except My_FailedRequestError, e:
    # Handle exception
    pass
```

14.5 Authentication GUIs

In this paragraph are listed the available GUIs useful to integrate authentication infrastructure in custom interfaces.

14.5.1 GUI to select credentials

If it’s necessary to select a Authentication Configuration from the set stored in the Authentication DB it is available in the GUI class `QgsAuthConfigSelect`.

and can be used as in the following snippet:

```python
# create the instance of the QgsAuthConfigSelect GUI hierarchically linked to
# the widget referred with 'parent'
parent = QWidget()  # Your GUI parent widget
gui = QgsAuthConfigSelect( parent, "postgres" )
# add the above created gui in a new tab of the interface where the
# GUI has to be integrated
tabGui = QTabWidget()
tabGui.insertTab( i, gui, "Configurations" )
```
The above example is taken from the QGIS source code. The second parameter of the GUI constructor refers to data provider type. The parameter is used to restrict the compatible Authentication Methods with the specified provider.

### 14.5.2 Authentication Editor GUI

The complete GUI used to manage credentials, authorities and to access to Authentication utilities is managed by the QgsAuthEditorWidgets class.

```python
# create the instance of the QgsAuthEditorWidgets GUI hierarchically linked to
# the widget referred with 'parent'
parent = QWidget()  # Your GUI parent widget
gui = QgsAuthConfigSelect(parent)
gui.show()
```

An integrated example can be found in the related test.
14.5.3 Authorities Editor GUI

A GUI used to manage only authorities is managed by the QgsAuthAuthoritiesEditor class.

```python
# create the instance of the QgsAuthAuthoritiesEditor GUI hierarchically
# linked to the widget referred with 'parent'
parent = QWidget()  # Your GUI parent widget
gui = QgsAuthAuthoritiesEditor( parent )
gui.show()
```

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import (QgsProcessingContext,
QgsTaskManager,
QgsTask,
QgsProcessingAlgRunnerTask,
Qgis,
QgsProcessingFeedback,
QgsApplication,
QgsMessageLog,
)
```
15.1 Introduzione

Background processing using threads is a way to maintain a responsive user interface when heavy processing is going on. Tasks can be used to achieve threading in QGIS.

A task (QgsTask) is a container for the code to be performed in the background, and the task manager (QgsTaskManager) is used to control the running of the tasks. These classes simplify background processing in QGIS by providing mechanisms for signaling, progress reporting and access to the status for background processes. Tasks can be grouped using subtasks.

The global task manager (found with QgsApplication.taskManager()) is normally used. This means that your tasks may not be the only tasks that are controlled by the task manager.

There are several ways to create a QGIS task:

- Create your own task by extending QgsTask

```python
class SpecialisedTask(QgsTask):
    pass
```

- Create a task from a function

```python
def heavyFunction():
    # Some CPU intensive processing ...
    pass

def workdone():
    # ... do something useful with the results
    pass

task = QgsTask.fromFunction('heavy function', heavyFunction, onfinished=workdone)
```

- Create a task from a processing algorithm

```python
params = dict()
context = QgsProcessingContext()
feedback = QgsProcessingFeedback()
```

(continues on next page)
Dependencies between tasks can be described using the `addSubTask()` function of `QgsTask`. When a dependency is stated, the task manager will automatically determine how these dependencies will be executed. Wherever possible dependencies will be executed in parallel in order to satisfy them as quickly as possible. If a task on which another task depends is canceled, the dependent task will also be canceled. Circular dependencies can make deadlocks possible, so be careful.

If a task depends on a layer being available, this can be stated using the `setDependentLayers()` function of `QgsTask`. If a layer on which a task depends is not available, the task will be canceled.

Once the task has been created it can be scheduled for running using the `addTask()` function of the task manager. Adding a task to the manager automatically transfers ownership of that task to the manager, and the manager will cleanup and delete tasks after they have executed. The scheduling of the tasks is influenced by the task priority, which is set in `addTask()`.

The status of tasks can be monitored using `QgsTask` and `QgsTaskManager` signals and functions.

### 15.2 Esempi

#### 15.2.1 Extending QgsTask

In this example `RandomIntegerSumTask` extends `QgsTask` and will generate 100 random integers between 0 and 500 during a specified period of time. If the random number is 42, the task is aborted and an exception is raised. Several instances of `RandomIntegerSumTask` (with subtasks) are generated and added to the task manager, demonstrating two types of dependencies.

```python
import random
from time import sleep

from qgis.core import 
    QgsApplication, QgsTask, QgsMessageLog,
)

MESSAGECATEGORY = 'RandomIntegerSumTask'

class RandomIntegerSumTask(QgsTask):
    '''This shows how to subclass QgsTask'''

    def __init__(self, description, duration):
        super().__init__(description, QgsTask.CanCancel)
        self.duration = duration
        self.total = 0
        self.iterations = 0
        self.exception = None

    def run(self):
        self.messageLog().info('Starting random number generation...')
        sum = 0
        for _ in range(self.iterations):
            number = random.randint(0, 500)
            if number == 42:
                self.exception = f'Error: Random number {number} encountered!'
                return
            sum += number
        self.messageLog().info(f'Generated total: {sum}')
        self.messageLog().info('Task completed successfully.')

    def isCompleted(self):
        return self.exception is not None

    def __del__(self):
        selfngle
```

(continues on next page)
```python
import random

def run(self):
    """Here you implement your heavy lifting.
    Should periodically test for isCanceled() to gracefully abort.
    This method MUST return True or False.
    Raising exceptions will crash QGIS, so we handle them internally and raise them in self.finished"
    QgsMessageLog.logMessage('Started task """{}\""""'.format(self.description()),
                              MESSAGE_CATEGORY, Qgis.Info)

    wait_time = self.duration / 100
    for i in range(100):
        sleep(wait_time)
        self.setProgress(i)
        arandominteger = random.randint(0, 500)
        self.total += arandominteger
        self.iterations += 1
        # check isCanceled() to handle cancellation
        if self.isCanceled():
            return False

        # simulate exceptions to show how to abort task
        if arandominteger == 42:
            # DO NOT raise Exception('bad value!')
            # this would crash QGIS
            self.exception = Exception('bad value!')
            return False

    return True

def finished(self, result):
    """
    This function is automatically called when the task has completed (successfully or not).
    You implement finished() to do whatever follow-up stuff should happen after the task is complete.
    finished is always called from the main thread, so it's safe to do GUI operations and raise Python exceptions here.
    result is the return value from self.run.
    """
    if result:
        QgsMessageLog.logMessage(
            'RandomTask """{}"""" completed\n' \n            'RandomTotal: {} (with {} iterations) \n            """iterations""""'.format(
                name=self.description(),
                total=self.total,
                iterations=self.iterations),
                MESSAGE_CATEGORY, Qgis.Success)
    else:
        if self.exception is None:
            QgsMessageLog.logMessage(
                'RandomTask """{}"""" not successful but without \n                "{} canceled by the user\"""'.format(
                    name=self.description()),
                    MESSAGE_CATEGORY, Qgis.Warning)
        else:
            QgsMessageLog.logMessage(
                'RandomTask """{}"""" Exception: {}'.format(
                    name=self.description()),
                    MESSAGE_CATEGORY, Qgis.Exception)
```

(continues on next page)
exception = self.exception, 
MESSAGE_CATEGORY, Qgis.Critical) 
raise self.exception

def cancel(self):
    QgsMessageLog.logMessage(
        'RandomTask "{name}" was canceled'.format(
        name=self.description()),
        MESSAGE_CATEGORY, Qgis.Info)
    super().cancel()

longtask = RandomIntegerSumTask('waste cpu long', 20)
shorttask = RandomIntegerSumTask('waste cpu short', 10)
minitask = RandomIntegerSumTask('waste cpu mini', 5)
shortsubtask = RandomIntegerSumTask('waste cpu subtask short', 5)
longsubtask = RandomIntegerSumTask('waste cpu subtask long', 10)
shortestsubtask = RandomIntegerSumTask('waste cpu subtask shortest', 4)

# Add a subtask (shortsubtask) to shorttask that must run after
# minitask and longtask has finished
shorttask.addSubTask(shortsubtask, [minitask, longtask])
# Add a subtask (longsubtask) to longtask that must be run
# before the parent task
longtask.addSubTask(longsubtask, [], QgsTask.ParentDependsOnSubTask)
# Add a subtask (shortestsubtask) to longtask
longtask.addSubTask(shortestsubtask)
QgsApplication.taskManager().addTask(longtask)
QgsApplication.taskManager().addTask(shorttask)
QgsApplication.taskManager().addTask(minitask)

RandomIntegerSumTask(0): Started task "waste cpu subtask shortest"
RandomIntegerSumTask(0): Started task "waste cpu short"
RandomIntegerSumTask(0): Started task "waste cpu mini"
RandomIntegerSumTask(0): Started task "waste cpu subtask long"
RandomIntegerSumTask(0): Started task "waste cpu subtask shortest" completed
RandomTotal: 25452 (with 100 iterations)
RandomIntegerSumTask(3): Task "waste cpu subtask shortest" completed
RandomTotal: 23810 (with 100 iterations)
RandomIntegerSumTask(3): Task "waste cpu mini" completed
RandomTotal: 23810 (with 100 iterations)
RandomIntegerSumTask(3): Task "waste cpu subtask long" completed
RandomTotal: 26308 (with 100 iterations)
RandomIntegerSumTask(3): Task "waste cpu long" completed
RandomTotal: 22534 (with 100 iterations)

15.2.2 Task from function

Create a task from a function (doSomething in this example). The first parameter of the function will hold the QgsTask for the function. An important (named) parameter is on_finished, that specifies a function that will be called when the task has completed. The doSomething function in this example has an additional named parameter wait_time.

import random
from time import sleep
MESSAGE_CATEGORY = 'TaskFromFunction'

def doSomething(task, wait_time):

(continues on next page)
'###
'Raisas an exception to abort the task.
'Returns a result if success.
The result will be passed, together with the exception (None in
the case of success), to the on_finished method.
If there is an exception, there will be no result.'
'###
QgsMessageLog.logMessage('Started task {}', task.description()),
MESSAGE_CATEGORY, Qgis.Info
wait_time = wait_time / 100
for i in range(100):
  # use task.setProgress to report progress
  sleep(wait_time)
  task.setProgress(i)
  arandominteger = random.randint(0, 500)
  total += arandominteger
  iterations += 1
  # check task.isCanceled() to handle cancellation
  if task.isCanceled():
    stopped(task)
    return None
  # raise an exception to abort the task
  if arandominteger == 42:
    raise Exception('bad value!')
  # raise an exception to abort the task
  result = arandominteger
  return {'total': total, 'iterations': iterations,
          'task': task.description()}

def stopped(task):
  QgsMessageLog.logMessage('Task "{name}" was canceled'.format(name=task.description()),
MESSAGE_CATEGORY, Qgis.Info)

def completed(exception, result=None):
  """This is called when doSomething is finished.
Exception is not None if doSomething raises an exception.
result is the return value of doSomething.""
  if exception is None:
    if result is None:
      QgsMessageLog.logMessage('Completed with no exception and no result '
       '(probably manually canceled by the user)',
MESSAGE_CATEGORY, Qgis.Warning)
    else:
      QgsMessageLog.logMessage('Task {name} completed

"Total: {total} ( with {iterations} iterations)"'.format(name=task, total=total, iterations=iterations),
MESSAGE_CATEGORY, Qgis.Info)
  else:
    QgsMessageLog.logMessage("Exception: {}", exception, 
MESSAGE_CATEGORY, Qgis.Critical)
    raise exception

# Create a few tasks
task1 = QgsTask.fromFunction('Waste cpu 1', doSomething,
...
15.2.3 Task from a processing algorithm

Create a task that uses the algorithm qgis:randompointsinextent to generate 50000 random points inside a specified extent. The result is added to the project in a safe way.

```python
from functools import partial
from qgis.core import (QgsTaskManager, QgsMessageLog,
                       QgsProcessingAlgRunnerTask, QgsApplication,
                       QgsProcessingContext, QgsProcessingFeedback,
                       QgsProject)

MESSAGE_CATEGORY = 'AlgRunnerTask'

def task_finished(context, successful, results):
    if not successful:
        QgsMessageLog.logMessage('Task finished unsuccessfully',
                                  MESSAGE_CATEGORY, Qgis.Warning)

        output_layer = context.getMapLayer(results['OUTPUT'])
        # because getMapLayer doesn't transfer ownership, the layer will
        # be deleted when context goes out of scope and you'll get a
        # crash.
        # takeMapLayer transfers ownership so it's then safe to add it
        # to the project and give the project ownership.

        if output_layer and output_layer.isValid():
            QgsProject.instance().addMapLayer(
                context.takeResultLayer(output_layer.id()))

    alg = QgsApplication.processingRegistry().algorithmById('qgis:randompointsinextent')
    context = QgsProcessingContext()
    feedback = QgsProcessingFeedback()

    params = {
        'EXTENT': '0.0,10.0,40,50 [EPSG:4326]',
        'MIN_DISTANCE': 0.0,
        'POINTS_NUMBER': 50000,
        'TARGET_CRS': 'EPSG:4326',
        'OUTPUT': 'memory:My random points'
    }

    task = QgsProcessingAlgRunnerTask(alg, params, context, feedback)
    task.executed.connect(partial(task_finished, context))
    QgsApplication.taskManager().addTask(task)
```

See also: https://opengis.ch/2018/06/22/threads-in-pyqgis3/.
16.1 Structuring Python Plugins

- Writing a plugin
  - Plugin files
- Plugin content
  - Plugin metadata
  - __init__.py
  - mainPlugin.py
  - Resource File
- Documentation
- Translation
  - Software requirements
  - Files and directory
    - .pro file
    - .ts file
    - .qm file
  - Translate using Makefile
  - Load the plugin
- Tips and Tricks
  - Plugin Reloader
  - Accessing Plugins
  - Log Messages
  - Share your plugin
In order to create a plugin, here are some steps to follow:

1. **Idea**: Have an idea about what you want to do with your new QGIS plugin. Why do you do it? What problem do you want to solve? Is there already another plugin for that problem?

2. **Create files**: some are essentials (see **Plugin files**)

3. **Write code**: Write the code in appropriate files

4. **Test**: **Reload your plugin** to check if everything is OK

5. **Publish**: Publish your plugin in QGIS repository or make your own repository as an «arsenal» of personal «GIS weapons».

### 16.1.1 Writing a plugin

Since the introduction of Python plugins in QGIS, a number of plugins have appeared. The QGIS team maintains an **Official Python plugin repository**. You can use their source to learn more about programming with PyQGIS or find out whether you are duplicating development effort.

**Plugin files**

Here’s the directory structure of our example plugin

```plaintext
PYTHON_PLUGINS_PATH/
MyPlugin/
   __init__.py   --> *required*
   mainPlugin.py --> *core code*
   metadata.txt  --> *required*
   resources.qrc --> *likely useful*
   resources.py  --> *compiled version, likely useful*
   form.ui       --> *likely useful*
   form.py       --> *compiled version, likely useful*
```

What is the meaning of the files:

- **__init__.py** = The starting point of the plugin. It has to have the `classFactory()` method and may have any other initialisation code.
- **mainPlugin.py** = The main working code of the plugin. Contains all the information about the actions of the plugin and the main code.
- **resources.qrc** = The .xml document created by Qt Designer. Contains relative paths to resources of the forms.
- **resources.py** = The translation of the .qrc file described above to Python.
- **form.ui** = The GUI created by Qt Designer.
- **form.py** = The translation of the form.ui described above to Python.
- **metadata.txt** = Contains general info, version, name and some other metadata used by plugins website and plugin infrastructure.

Here is a way of creating the basic files (skeleton) of a typical QGIS Python plugin.

There is a QGIS plugin called **Plugin Builder 3** that creates a plugin template for QGIS. This is the recommended option, as it produces 3.x compatible sources.

**Avvertimento**: If you plan to upload the plugin to the **Official Python plugin repository** you must check that your plugin follows some additional rules, required for plugin **Validation**
16.1.2 Plugin content

Here you can find information and examples about what to add in each of the files in the file structure described above.

Plugin metadata

First, the plugin manager needs to retrieve some basic information about the plugin such as its name, description etc. File `metadata.txt` is the right place to put this information.

Nota: All metadata must be in UTF-8 encoding.

<table>
<thead>
<tr>
<th>Metadata name</th>
<th>Required</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>name</code></td>
<td>True</td>
<td>a short string containing the name of the plugin</td>
</tr>
<tr>
<td><code>qgisMinimumVersion</code></td>
<td>True</td>
<td>dotted notation of minimum QGIS version</td>
</tr>
<tr>
<td><code>qgisMaximumVersion</code></td>
<td>False</td>
<td>dotted notation of maximum QGIS version</td>
</tr>
<tr>
<td><code>Descrizione</code></td>
<td>True</td>
<td>short text which describes the plugin, no HTML allowed</td>
</tr>
<tr>
<td><code>about</code></td>
<td>True</td>
<td>longer text which describes the plugin in details, no HTML allowed</td>
</tr>
<tr>
<td><code>version</code></td>
<td>True</td>
<td>short string with the version dotted notation</td>
</tr>
<tr>
<td><code>author</code></td>
<td>True</td>
<td>author name</td>
</tr>
<tr>
<td><code>email</code></td>
<td>True</td>
<td>email of the author, only shown on the website to logged in users, but visible in the Plugin Manager after the plugin is installed</td>
</tr>
<tr>
<td><code>changelog</code></td>
<td>False</td>
<td>string, can be multiline, no HTML allowed</td>
</tr>
<tr>
<td><code>experimental</code></td>
<td>False</td>
<td>boolean flag, True or False, if this version is experimental</td>
</tr>
<tr>
<td><code>deprecated</code></td>
<td>False</td>
<td>boolean flag, True or False, applies to the whole plugin and not just to the uploaded version</td>
</tr>
<tr>
<td><code>etichette</code></td>
<td>False</td>
<td>comma separated list, spaces are allowed inside individual tags</td>
</tr>
<tr>
<td><code>homepage</code></td>
<td>False</td>
<td>a valid URL pointing to the homepage of your plugin</td>
</tr>
<tr>
<td><code>repository</code></td>
<td>True</td>
<td>a valid URL for the source code repository</td>
</tr>
<tr>
<td><code>tracker</code></td>
<td>False</td>
<td>a valid URL for tickets and bug reports</td>
</tr>
<tr>
<td><code>icon</code></td>
<td>False</td>
<td>a file name or a relative path (relative to the base folder of the plugin's compressed package) of a web friendly image (PNG, JPEG)</td>
</tr>
<tr>
<td><code>category</code></td>
<td>False</td>
<td>one of Raster, Vector, Database and Web</td>
</tr>
<tr>
<td><code>plugin_dependencies</code></td>
<td>False</td>
<td>PIP-like comma separated list of other plugins to install</td>
</tr>
<tr>
<td><code>server</code></td>
<td>False</td>
<td>boolean flag, True or False, determines if the plugin has a server interface</td>
</tr>
<tr>
<td><code>hasProcessingProvider</code></td>
<td>False</td>
<td>boolean flag, True or False, determines if the plugin provides processing algorithms</td>
</tr>
</tbody>
</table>

By default, plugins are placed in the Plugins menu (we will see in the next section how to add a menu entry for your plugin) but they can also be placed into Raster, Vector, Database and Web menus.

A corresponding «category» metadata entry exists to specify that, so the plugin can be classified accordingly. This metadata entry is used as tip for users and tells them where (in which menu) the plugin can be found. Allowed values for «category» are: Vector, Raster, Database or Web. For example, if your plugin will be available from Raster menu, add this to metadata.txt

```
category=Raster
```

Nota: If `qgisMaximumVersion` is empty, it will be automatically set to the major version plus .99 when uploaded to the Official Python plugin repository.

An example for this metadata.txt
Capitolo 16. Sviluppo di plugin Python

; the next section is mandatory

[general]
name=HelloWorld
email=me@example.com
author=Just Me
qgisMinimumVersion=3.0
description=This is an example plugin for greeting the world.
   Multiline is allowed:
   lines starting with spaces belong to the same field, in this case to the "description" field.
   HTML formatting is not allowed.
about=This paragraph can contain a detailed description of the plugin. Multiline is allowed, HTML is not.
version=version 1.2
tracker=http://bugs.itopen.it
repository=http://www.itopen.it/repo

; start of optional metadata
category=Raster
changelog=The changelog lists the plugin versions and their changes as in the example below:
   1.0 - First stable release
   0.9 - All features implemented
   0.8 - First testing release

tags=wkt,raster,hello world

; experimental flag (applies to the single version)
experimental=True

; deprecated flag (applies to the whole plugin and not only to the uploaded... version)
deprecated=False

; if empty, it will be automatically set to major version + .99
qgisMaximumVersion=3.99

; Since QGIS 3.8, a comma separated list of plugins to be installed (or upgraded) can be specified.
; The example below will try to install (or upgrade) "MyOtherPlugin" version 1.12
; and any version of "YetAnotherPlugin"
plugin_dependencies=MyOtherPlugin==1.12,YetAnotherPlugin
This file is required by Python's import system. Also, QGIS requires that this file contains a `classFactory()` function, which is called when the plugin gets loaded into QGIS. It receives a reference to the instance of `QgisInterface` and must return an object of your plugin's class from the `mainplugin.py` — in our case it's called `TestPlugin` (see below). This is how `__init__.py` should look like:

```python
def classFactory(iface):
    from .mainPlugin import TestPlugin
    return TestPlugin(iface)
# any other initialisation needed
```

This is where the magic happens and this is how magic looks like: (e.g. `mainPlugin.py`)

```python
from qgis.PyQt.QtGui import *
from qgis.PyQt.QtWidgets import *

# initialize Qt resources from file resources.py
from . import resources

class TestPlugin:
    def __init__(self, iface):
        # save reference to the QGIS interface
        self.iface = iface

    def initGui(self):
        # create action that will start plugin configuration
        self.action = QAction(QIcon(":/plugins/testplug/icon.png"), "Test plugin",
                               self.iface.mainWindow())
        self.action.setObjectName("testAction")
        self.action.setWhatsThis("Configuration for test plugin")
        self.action.setStatusTip("This is status tip")
        self.action.triggered.connect(self.run)

        # add toolbar button and menu item
        self.iface.addToolBarIcon(self.action)
        self.iface.addPluginToMenu("&Test plugins", self.action)

        # connect to signal renderComplete which is emitted when canvas
        # rendering is done
        self.iface.mapCanvas().renderComplete.connect(self.renderTest)

    def unload(self):
        # remove the plugin menu item and icon
        self.iface.removePluginMenu("&Test plugins", self.action)
        self.iface.removeToolBarIcon(self.action)

        # disconnect form signal of the canvas
        self.iface.mapCanvas().renderComplete.disconnect(self.renderTest)

    def run(self):
        # create and show a configuration dialog or something similar
        print("TestPlugin: run called!")

    def renderTest(self, self, painter):
```

(continues on next page)
The only plugin functions that must exist in the main plugin source file (e.g. mainPlugin.py) are:

- __init__ which gives access to QGIS interface
- initGui() called when the plugin is loaded
- unload() called when the plugin is unloaded

In the above example, addPluginToMenu() is used. This will add the corresponding menu action to the Plugins menu. Alternative methods exist to add the action to a different menu. Here is a list of those methods:

- addPluginToRasterMenu()
- addPluginToVectorMenu()
- addPluginToDatabaseMenu()
- addPluginToWebMenu()

All of them have the same syntax as the addPluginToMenu() method.

Adding your plugin menu to one of those predefined method is recommended to keep consistency in how plugin entries are organized. However, you can add your custom menu group directly to the menu bar, as the next example demonstrates:

```python
def initGui(self):
    self.menu = QMenu(self.iface.mainWindow())
    self.menu.setObjectName("testMenu")
    self.menu.setTitle("MyMenu")

    self.action = QAction(QIcon(":/plugins/testplug/icon.png"),
                          "Test plugin",
                          self.iface.mainWindow())
    self.action.setObjectName("testAction")
    self.action.setWhatsThis("Configuration for test plugin")
    self.action.setStatusTip("This is status tip")
    self.action.triggered.connect(self.run)
    self.menu.addAction(self.action)

    menuBar = self.iface.mainWindow().menuBar()
    menuBar.insertMenu(self.iface.firstRightStandardMenu().menuAction(),
                       self.menu)

def unload(self):
    self.menu.deleteLater()
```

Don’t forget to set QAction and QMenu objectName to a name specific to your plugin so that it can be customized.

**Resource File**

You can see that in initGui() we’ve used an icon from the resource file (called resources.qrc in our case)

```
<RCC>
  <qresource prefix="/plugins/testplug" >
    <file>icon.png</file>
  </qresource>
</RCC>
```
It is good to use a prefix that will not collide with other plugins or any parts of QGIS, otherwise you might get resources you did not want. Now you just need to generate a Python file that will contain the resources. It’s done with pyrcc5 command:

```
pyrcc5 -o resources.py resources.qrc
```

**Nota:** In Windows environments, attempting to run the pyrcc5 from Command Prompt or Powershell will probably result in the error «Windows cannot access the specified device, path, or file [...]». The easiest solution is probably to use the OSGeo4W Shell but if you are comfortable modifying the PATH environment variable or specifying the path to the executable explicitly you should be able to find it at `<Your QGIS Install Directory>\bin\pyrcc5.exe`.

And that’s all… nothing complicated :)

If you’ve done everything correctly you should be able to find and load your plugin in the plugin manager and see a message in console when toolbar icon or appropriate menu item is selected.

When working on a real plugin it’s wise to write the plugin in another (working) directory and create a makefile which will generate UI + resource files and install the plugin into your QGIS installation.

### 16.1.3 Documentation

The documentation for the plugin can be written as HTML help files. The qgis.utils module provides a function, `showPluginHelp()` which will open the help file browser, in the same way as other QGIS help.

The `showPluginHelp()` function looks for help files in the same directory as the calling module. It will look for, in turn, `index-ll_cc.html`, `index-ll.html`, `index-en.html`, `index-en_us.html` and `index.html`, displaying whichever it finds first. Here `ll_cc` is the QGIS locale. This allows multiple translations of the documentation to be included with the plugin.

The `showPluginHelp()` function can also take parameters `packageName`, which identifies a specific plugin for which the help will be displayed, `filename`, which can replace «index» in the names of files being searched, and `section`, which is the name of an html anchor tag in the document on which the browser will be positioned.

### 16.1.4 Translation

With a few steps you can set up the environment for the plugin localization so that depending on the locale settings of your computer the plugin will be loaded in different languages.

#### Software requirements

The easiest way to create and manage all the translation files is to install Qt Linguist. In a Debian-based GNU/Linux environment you can install it typing:

```
sudo apt install qttools5-dev-tools
```
Files and directory

When you create the plugin you will find the i18n folder within the main plugin directory.

All the translation files have to be within this directory.

.pro file

First you should create a .pro file, that is a project file that can be managed by Qt Linguist.

In this .pro file you have to specify all the files and forms you want to translate. This file is used to set up the localization files and variables. A possible project file, matching the structure of our example plugin:

```
FORMS = ../form.ui
SOURCES = ../your_plugin.py
TRANSLATIONS = your_plugin_it.ts
```

Your plugin might follow a more complex structure, and it might be distributed across several files. If this is the case, keep in mind that pylupdate5, the program we use to read the .pro file and update the translatable string, does not expand wild card characters, so you need to place every file explicitly in the .pro file. Your project file might then look like something like this:

```
FORMS = ../ui/about.ui ../ui/feedback.ui \
       ../ui/main_dialog.ui
SOURCES = ../your_plugin.py ../computation.py \
          ../utils.py
```

Furthermore, the your_plugin.py file is the file that calls all the menu and sub-menus of your plugin in the QGIS toolbar and you want to translate them all.

Finally with the TRANSLATIONS variable you can specify the translation languages you want.

### Avvertimento:
Be sure to name the ts file like your_plugin+_language+.ts otherwise the language loading will fail! Use the 2 letter shortcut for the language (it for Italian, de for German, etc...)

.ts file

Once you have created the .pro you are ready to generate the .ts file(s) for the language(s) of your plugin.

Open a terminal, go to your_plugin/i18n directory and type:

```
pylupdate5 your_plugin.pro
```

you should see the your_plugin_language.ts file(s).

Open the .ts file with Qt Linguist and start to translate.

.qm file

When you finish to translate your plugin (if some strings are not completed the source language for those strings will be used) you have to create the .qm file (the compiled .ts file that will be used by QGIS).

Just open a terminal cd in your_plugin/i18n directory and type:

```
lrelease your_plugin.ts
```

now, in the i18n directory you will see the your_plugin.qm file(s).
Translate using Makefile

Alternatively you can use the makefile to extract messages from python code and Qt dialogs, if you created your plugin with Plugin Builder. At the beginning of the Makefile there is a LOCALES variable:

```
LOCALES = en
```

Add the abbreviation of the language to this variable, for example for Hungarian language:

```
LOCALES = en hu
```

Now you can generate or update the hu.ts file (and the en.ts too) from the sources by:

```
make transup
```

After this, you have updated .ts file for all languages set in the LOCALES variable. Use Qt Linguist to translate the program messages. Finishing the translation the .qm files can be created by the transcompile:

```
make transcompile
```

You have to distribute .ts files with your plugin.

Load the plugin

In order to see the translation of your plugin, open QGIS, change the language (Settings ► Options ► General) and restart QGIS.

You should see your plugin in the correct language.

Avvertimento: If you change something in your plugin (new UIs, new menu, etc..) you have to generate again the update version of both .ts and .qm file, so run again the command of above.

16.1.5 Tips and Tricks

Plugin Reloader

During development of your plugin you will frequently need to reload it in QGIS for testing. This is very easy using the Plugin Reloader plugin. You can find it with the Plugin Manager.

Accessing Plugins

You can access all the classes of installed plugins from within QGIS using python, which can be handy for debugging purposes.

```
my_plugin = qgis.utils.plugins['My Plugin']
```
Log Messages
Plugins have their own tab within the log_message_panel.

Share your plugin
QGIS is hosting hundreds of plugins in the plugin repository. Consider sharing yours! It will extend the possibilities of QGIS and people will be able to learn from your code. All hosted plugins can be found and installed from within QGIS with the Plugin Manager.
Information and requirements are here: plugins.qgis.org.

16.2 Code Snippets

- How to call a method by a key shortcut
- How to toggle Layers
- How to access attribute table of selected features
- Interface for plugin in the options dialog

This section features code snippets to facilitate plugin development.

16.2.1 How to call a method by a key shortcut

In the plug-in add to the initGui()

```python
self.key_action = QAction("Test Plugin", self.iface.mainWindow())
self.iface.registerMainWindowAction(self.key_action, "Ctrl+I") # action triggered by Ctrl+I
self.iface.addPluginToMenu("Test plugins", self.key_action)
self.key_action.triggered.connect(self.key_action_triggered)
```

To unload() add

```python
self.iface.unregisterMainWindowAction(self.key_action)
```

The method that is called when CTRL+I is pressed

```python
def key_action_triggered(self):
    QMessageBox.information(self.iface.mainWindow(),"Ok", "You pressed Ctrl+I")
```

16.2.2 How to toggle Layers

There is an API to access layers in the legend. Here is an example that toggles the visibility of the active layer

```python
root = QgsProject.instance().layerTreeRoot()
node = root.findLayer(iface.activeLayer().id())
new_state = Qt.Checked if node.isVisible() -- Qt.Unchecked else Qt.Unchecked
node.setItemVisibilityChecked(new_state)
```
16.2.3 How to access attribute table of selected features

```python
def change_value(value):
    """Change the value in the second column for all selected features.
    """
    :param value: The new value.
    
    layer = iface.activeLayer()
    if layer:
        count_selected = layer.selectedFeatureCount()
        if count_selected > 0:
            layer.startEditing()
            id_features = layer.selectedFeatureIds()
            for i in id_features:
                layer.changeAttributeValue(i, 1, value)  # 1 being the second column
                layer.commitChanges()
        else:
            iface.messageBar().pushCritical("Error", "Please select at least one feature from current layer")
    else:
        iface.messageBar().pushCritical("Error", "Please select a layer")

# The method requires one parameter (the new value for the second
# field of the selected feature(s)) and can be called by
change_value(50)
```

16.2.4 Interface for plugin in the options dialog

You can add a custom plugin options tab to Settings ▶ Options. This is preferable over adding a specific main menu entry for your plugin’s options, as it keeps all of the QGIS application settings and plugin settings in a single place which is easy for users to discover and navigate.

The following snippet will just add a new blank tab for the plugin’s settings, ready for you to populate with all the options and settings specific to your plugin. You can split the following classes into different files. In this example, we are adding two classes into the main mainPlugin.py file.

```python
class MyPluginOptionsFactory(QgsOptionsWidgetFactory):
    def __init__(self):
        super().__init__()

    def icon(self):
        return QIcon('icons/my_plugin_icon.svg')

    def createWidget(self, parent):
        return ConfigOptionsPage(parent)

class ConfigOptionsPage(QgsOptionsPageWidget):
    def __init__(self, parent):
        super().__init__(parent)
        layout = QHBoxLayout()
        layout.setContentsMargins(0, 0, 0, 0)
        self.setLayout(layout)
```

Finally we are adding the imports and modifying the __init__ function:

```python
from qgis.PyQt.QtWidgets import QHBoxLayout
from qgis.gui import QgsOptionsWidgetFactory, QgsOptionsPageWidget
```

(continues on next page)
class MyPlugin:
    # """QGIS Plugin Implementation."""
    def __init__(self, iface):
        # """Constructor.
        :param iface: An interface instance that will be passed to this class
        which provides the hook by which you can manipulate the QGIS
        application at run time.
        :type iface: QgsInterface
        """
        # Save reference to the QGIS interface
        self.iface = iface

    def initGui(self):
        self.options_factory = MyPluginOptionsFactory()
        self.options_factory.setTitle(self.tr('My Plugin'))
        iface.registerOptionsWidgetFactory(self.options_factory)

    def unload(self):
        iface.unregisterOptionsWidgetFactory(self.options_factory)

Suggerimento: Add custom tabs to a vector layer properties dialog

You can apply a similar logic to add the plugin custom option to the layer properties dialog using the classes
QgsMapLayerConfigWidgetFactory and QgsMapLayerConfigWidget.

16.3 Usare Plugin Layer

Se il tuo plugin usa i propri metodi per visualizzare un layer mappa, scrivere il proprio tipo di layer basato su
QgsPluginLayer potrebbe essere il modo migliore per implementarlo.

16.3.1 Sottoclasse QgsPluginLayer

Di seguito è riportato un esempio di implementazione minima di QgsPluginLayer. È basato sul codice originale del
plugin d’esempio Watermark.

Il visualizzatore personalizzato è il componente dell’implementazione che definisce la rappresentazione grafica sulla
mappa.

class WatermarkLayerRenderer(QgsMapLayerRenderer):
    def __init__(self, layerId, rendererContext):
        super().__init__(layerId, rendererContext)

    def render(self, self):
        image = QImage("/usr/share/icons/hicolor/128x128/apps/qgis.png")
        painter = self.renderContext().painter()
        painter.save()
        painter.drawImage(10, 10, image)
        painter.restore()
        return True

(continues on next page)
```python
class WatermarkPluginLayer(QgsPluginLayer):
    LAYER_TYPE = "watermark"

    def __init__(self):
        super().__init__(WatermarkPluginLayer.LAYER_TYPE, "Watermark plugin layer")
        self.setValid(True)

    def createMapRenderer(self, rendererContext):
        return WatermarkLayerRenderer(self.id(), rendererContext)

    def setTransformContext(self, ct):
        pass

    # Methods for reading and writing specific information to the project file can
    # also be added:

    def readXml(self, node, context):
        pass

    def writeXml(self, node, doc, context):
        pass
```

Il layer plugin può essere aggiunto al progetto e al mappa come qualsiasi altro layer della mappa:

```python
plugin_layer = WatermarkPluginLayer()
QgsProject.instance().addMapLayer(plugin_layer)
```

Quando si carica un progetto contenente un layer di questo tipo, è necessaria una classe factory:

```python
class WatermarkPluginLayerType(QgsPluginLayerType):
    def __init__(self):
        super().__init__(WatermarkPluginLayer.LAYER_TYPE)

    def createLayer(self):
        return WatermarkPluginLayer()

    # You can also add GUI code for displaying custom information
    # in the layer properties
    def showLayerProperties(self, layer):
        pass

    # Keep a reference to the instance in Python so it won’t
    # be garbage collected
    plt = WatermarkPluginLayerType()

    assert QgsApplication.pluginLayerRegistry().addPluginLayerType(plt)
```

16.3. Usare Plugin Layer
16.4 IDE settings for writing and debugging plugins

- Useful plugins for writing Python plugins
- A note on configuring your IDE on Linux and Windows
- Debugging using Pyscripter IDE (Windows)
- Debugging using Eclipse and PyDev
  - Installazione
  - Setting up Eclipse
  - Configuring the debugger
  - Making eclipse understand the API
- Debugging with PyCharm on Ubuntu with a compiled QGIS
- Debugging using PDB

Although each programmer has his preferred IDE/Text editor, here are some recommendations for setting up popular IDE’s for writing and debugging QGIS Python plugins.

16.4.1 Useful plugins for writing Python plugins

Some plugins are convenient when writing Python plugins. From Plugins ➤ Manage and Install plugins…. install:

- Plugin reloader: This will let you reload a plugin and pull new changes without restarting QGIS.
- First Aid: This will add a Python console and local debugger to inspect variables when an exception is raised from a plugin.

**Avvertimento:** Despite our constant efforts, information beyond this line may not be updated for QGIS 3. Refer to https://qgis.org/pyqgis/master for the python API documentation or, give a hand to update the chapters you know about. Thanks.

16.4.2 A note on configuring your IDE on Linux and Windows

On Linux, all that usually needs to be done is to add the QGIS library locations to the user’s PYTHONPATH environment variable. Under most distributions, this can be done by editing ~/.bashrc or ~/.bash-profile with the following line (tested on OpenSUSE Tumbleweed):

```
export PYTHONPATH="$PYTHONPATH:/usr/share/qgis/python/plugins:/usr/share/qgis/…-python"
```

Save the file and implement the environment settings by using the following shell command:

```
source ~/.bashrc
```

On Windows, you need to make sure that you have the same environment settings and use the same libraries and interpreter as QGIS. The fastest way to do this is to modify the startup batch file of QGIS.

If you used the OSGeo4W Installer, you can find this under the bin folder of your OSGeo4W install. Look for something like C:\OSGeo4W\bin\qgis-unstable.bat.
16.4.3 Debugging using Pyscripter IDE (Windows)

For using Pyscripter IDE, here’s what you have to do:

1. Make a copy of qgis-unstable.bat and rename it pyscripter.bat.
2. Open it in an editor. And remove the last line, the one that starts GIS.
3. Add a line that points to your Pyscripter executable and add the command line argument that sets the version of Python to be used.
4. Also add the argument that points to the folder where Pyscripter can find the Python dll used by QGIS, you can find this under the bin folder of your OSGeoW install.

```bash
@echo off
SET OSGEO4W_ROOT=C:\OSGeo4W
call "%OSGEO4W_ROOT%\bin\o4w_env.bat
call "%OSGEO4W_ROOT%\bin\gdal16.bat
@echo off
path %PATH%;%GISBASE%\bin
Start C:\pyscripter\pyscripter.exe --python25 --pythondllpath=C:\OSGeo4W\bin
```

5. Now when you double click this batch file it will start Pyscripter, with the correct path.

More popular than Pyscripter, Eclipse is a common choice among developers. In the following section, we will be explaining how to configure it for developing and testing plugins.

16.4.4 Debugging using Eclipse and PyDev

Installazione

To use Eclipse, make sure you have installed the following:

- Eclipse
- Aptana Studio 3 Plugin or PyDev
- QGIS 2.x
- You may also want to install Remote Debug, a QGIS plugin. At the moment it’s still experimental so enable Experimental plugins under Plugins ➤ Manage and Install plugins… ➤ Options beforehand.

To prepare your environment for using Eclipse in Windows, you should also create a batch file and use it to start Eclipse:

1. Locate the folder where qgis_core.dll resides in. Normally this is C:\OSGeo4W\apps\qgis\bin, but if you compiled your own QGIS application this is in your build folder in output/bin/RelWithDebInfo
2. Locate your eclipse.exe executable.
3. Create the following script and use this to start eclipse when developing QGIS plugins.

```bash
call "C:\OSGeo4W\bin\o4w_env.bat"
set PATH=%PATH%;C:\path\to\your\qgis_core.dll\parent\folder
C:\path\to\your\eclipse.exe
```
Setting up Eclipse

1. In Eclipse, create a new project. You can select General Project and link your real sources later on, so it does not really matter where you place this project.

2. Right-click your new project and choose New ➤ Folder.

3. Click Advanced and choose Link to alternate location (Linked Folder). In case you already have sources you want to debug, choose these. In case you don’t, create a folder as it was already explained.

Now in the view Project Explorer, your source tree pops up and you can start working with the code. You already have syntax highlighting and all the other powerful IDE tools available.
Configuring the debugger

To get the debugger working:

1. Switch to the Debug perspective in Eclipse (Window ► Open Perspective ► Other ► Debug).
2. start the PyDev debug server by choosing PyDev ► Start Debug Server.
3. Eclipse is now waiting for a connection from QGIS to its debug server and when QGIS connects to the debug server it will allow it to control the python scripts. That’s exactly what we installed the Remote Debug plugin for. So start QGIS in case you did not already and click the bug symbol.

Now you can set a breakpoint and as soon as the code hits it, execution will stop and you can inspect the current state of your plugin. (The breakpoint is the green dot in the image below, set one by double clicking in the white space left to the line you want the breakpoint to be set).

A very interesting thing you can make use of now is the debug console. Make sure that the execution is currently stopped at a breakpoint, before you proceed.

1. Open the Console view (Window ► Show view). It will show the Debug Server console which is not very interesting. But there is a button Open Console which lets you change to a more interesting PyDev Debug Console.
2. Click the arrow next to the Open Console button and choose PyDev Console. A window opens up to ask you which console you want to start.
3. Choose PyDev Debug Console. In case its greyed out and tells you to Start the debugger and select the valid frame, make sure that you’ve got the remote debugger attached and are currently on a breakpoint.

You have now an interactive console which lets you test any commands from within the current context. You can manipulate variables or make API calls or whatever you like.

Suggerimento: A little bit annoying is, that every time you enter a command, the console switches back to the Debug Server. To stop this behavior, you can click the Pin Console button when on the Debug Server page and it should remember this decision at least for the current debug session.
Making eclipse understand the API

A very handy feature is to have Eclipse actually know about the QGIS API. This enables it to check your code for typos. But not only this, it also enables Eclipse to help you with autocompletion from the imports to API calls.

To do this, Eclipse parses the QGIS library files and gets all the information out there. The only thing you have to do is to tell Eclipse where to find the libraries.

1. Click Window ➤ Preferences ➤ PyDev ➤ Interpreter ➤ Python.
   You will see your configured python interpreter in the upper part of the window (at the moment python2.7 for QGIS) and some tabs in the lower part. The interesting tabs for us are Libraries and Forced Builtins.

2. First open the Libraries tab.
3. Add a New Folder and choose the python folder of your QGIS installation. If you do not know where this folder is (it’s not the plugins folder):
   1. Open QGIS
   2. Start a python console
   3. Enter qgis
   4. and press Enter. It will show you which QGIS module it uses and its path.
   5. Strip the trailing /qgis/__init__.pyc from this path and you’ve got the path you are looking for.
4. You should also add your plugins folder here (it is in python/plugins under the user profile folder).
5. Next jump to the Forced Builtins tab, click on New... and enter qgis. This will make Eclipse parse the QGIS API. You probably also want Eclipse to know about the PyQt API. Therefore also add PyQt as forced builtin. That should probably already be present in your libraries tab.

6. Click OK and you're done.

Nota: Every time the QGIS API changes (e.g. if you’re compiling QGIS master and the SIP file changed), you should go back to this page and simply click Apply. This will let Eclipse parse all the libraries again.

16.4.5 Debugging with PyCharm on Ubuntu with a compiled QGIS

PyCharm is an IDE for Python developed by JetBrains. There is a free version called Community Edition and a paid one called Professional. You can download PyCharm on the website: https://www.jetbrains.com/pycharm/download

We are assuming that you have compiled QGIS on Ubuntu with the given build directory ~/dev/qgis/build/master. It’s not compulsory to have a self compiled QGIS, but only this has been tested. Paths must be adapted.

1. In PyCharm, in your Project Properties, Project Interpreter, we are going to create a Python Virtual environment called QGIS.

2. Click the small gear and then Add.

3. Select Virtualenv environment.

4. Select a generic location for all your Python projects such as ~/dev/qgis/venv because we will use this Python interpreter for all our plugins.

5. Choose a Python 3 base interpreter available on your system and check the next two options Inherit global site-packages and Make available to all projects.

1. Click OK, come back on the small gear and click Show all.

2. In the new window, select your new interpreter QGIS and click the last icon in the vertical menu Show paths for the selected interpreter.

3. Finally, add the following absolute path to the list ~/dev/qgis/build/master/output/python.
1. Restart PyCharm and you can start using this new Python virtual environment for all your plugins.

PyCharm will be aware of the QGIS API and also of the PyQt API if you use Qt provided by QGIS like `from qgis.QtCore import QDir`. The autocompletion should work and PyCharm can inspect your code.

In the professional version of PyCharm, remote debugging is working well. For the Community edition, remote debugging is not available. You can only have access to a local debugger, meaning that the code must run inside PyCharm (as script or unittest), not in QGIS itself. For Python code running in QGIS, you might use the First Aid plugin mentioned above.

16.4.6 Debugging using PDB

If you do not use an IDE such as Eclipse or PyCharm, you can debug using PDB, following these steps.

1. First add this code in the spot where you would like to debug

```python
# Use pdb for debugging
import pdb
# also import pyqtRemoveInputHook
from qgis.QtCore import pyqtRemoveInputHook
# These lines allow you to set a breakpoint in the app
pyqtRemoveInputHook()
pdb.set_trace()
```

2. Then run QGIS from the command line.

   On Linux do:
On macOS do:

```bash
$ /Applications/Qgis.app/Contents/MacOS/Qgis
```

3. And when the application hits your breakpoint you can type in the console!

**TODO:** Add testing information

## 16.5 Releasing your plugin

- Metadata and names
- Code and help
- Official Python plugin repository
  - Permissions
  - Trust management
  - Validation
  - Plugin structure

Once your plugin is ready and you think the plugin could be helpful for some people, do not hesitate to upload it to the **Official Python plugin repository**. On that page you can also find packaging guidelines about how to prepare the plugin to work well with the plugin installer. Or in case you would like to set up your own plugin repository, create a simple XML file that will list the plugins and their metadata.

Please take special care to the following suggestions:

### 16.5.1 Metadata and names

- avoid using a name too similar to existing plugins
- if your plugin has a similar functionality to an existing plugin, please explain the differences in the About field, so the user will know which one to use without the need to install and test it
- avoid repeating «plugin» in the name of the plugin itself
- use the description field in metadata for a 1 line description, the About field for more detailed instructions
- include a code repository, a bug tracker, and a home page; this will greatly enhance the possibility of collaboration, and can be done very easily with one of the available web infrastructures (GitHub, GitLab, Bitbucket, etc.)
- choose tags with care: avoid the uninformative ones (e.g. vector) and prefer the ones already used by others (see the plugin website)
- add a proper icon, do not leave the default one; see QGIS interface for a suggestion of the style to be used
16.5.2 Code and help

- do not include generated file (ui_* .py, resources_rc.py, generated help files …) and useless stuff (e.g. .gitignore) in repository
- add the plugin to the appropriate menu (Vector, Raster, Web, Database)
- when appropriate (plugins performing analyses), consider adding the plugin as a subplugin of Processing framework: this will allow users to run it in batch, to integrate it in more complex workflows, and will free you from the burden of designing an interface
- include at least minimal documentation and, if useful for testing and understanding, sample data.

16.5.3 Official Python plugin repository

You can find the official Python plugin repository at https://plugins.qgis.org/.

In order to use the official repository you must obtain an OSGEO ID from the OSGEO web portal.

Once you have uploaded your plugin it will be approved by a staff member and you will be notified.

TODO: Insert a link to the governance document

Permissions

These rules have been implemented in the official plugin repository:

- every registered user can add a new plugin
- staff users can approve or disapprove all plugin versions
- users which have the special permission plugins.can_approve get the versions they upload automatically approved
- users which have the special permission plugins.can_approve can approve versions uploaded by others as long as they are in the list of the plugin owners
- a particular plugin can be deleted and edited only by staff users and plugin owners
- if a user without plugins.can_approve permission uploads a new version, the plugin version is automatically unapproved.

Trust management

Staff members can grant trust to selected plugin creators setting plugins.can_approve permission through the front-end application.

The plugin details view offers direct links to grant trust to the plugin creator or the plugin owners.

Validation

Plugin’s metadata are automatically imported and validated from the compressed package when the plugin is uploaded.

Here are some validation rules that you should aware of when you want to upload a plugin on the official repository:

1. the name of the main folder containing your plugin must contain only ASCII characters (A-Z and a-z), digits and the characters underscore (_) and minus (-), also it cannot start with a digit
2. metadata.txt is required
3. all required metadata listed in metadata table must be present
4. the version metadata field must be unique
### Plugin structure

Following the validation rules the compressed (.zip) package of your plugin must have a specific structure to validate as a functional plugin. As the plugin will be unzipped inside the users plugins folder it must have it's own directory inside the .zip file to not interfere with other plugins. Mandatory files are: `metadata.txt` and `__init__.py`. But it would be nice to have a README and of course an icon to represent the plugin (`resources.qrc`). Following is an example of how a plugin.zip should look like.

```
plugin.zip
 |-- pluginfolder/
 |   |-- i18n
 |     |-- translation_file_de.ts
 |   |-- img
 |     |-- icon.png
 |     `-- iconsource.svg
 |   |-- __init__.py
 |   |-- Makefile
 |   |-- metadata.txt
 |   |-- more_code.py
 |   |-- main_code.py
 |   |-- README
 |   |-- resources.qrc
 |   |-- resources_rc.py
 |   |-- ui_Qt_user_interface_file.ui
```

It is possible to create plugins in the language of programming Python. In contrast to classical plugins written in C++ these would be easier to write, understand, maintain and distribute thanks to the dynamic nature of the language Python.

Python plugins are listed together with C++ plugins in the QGIS plugin manager. They are searched in the following paths:

- UNIX/Mac: `$(qgis_prefix)/share/qgis/python/plugins`
- Windows: `$(qgis_prefix)/python/plugins`

For definitions of `~` and `$(UserProfile)` see `core_e_external_plugins`.

**Note:** Setting the `QGIS_PLUGINPATH` variable to an existing directory, you can add this path to the list of paths searched for plugins.

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16.5. Releasing your plugin 123
CAPITOLO 17

Scrivere un plugin di Processing

17.1 Creazione da zero

Per creare un plugin da zero che contiene un provider di algoritmi, è possibile seguire questi passaggi utilizzando il Plugin Builder:

1. Installare il plugin Plugin Builder
2. Crea un nuovo plugin usando il Plugin Builder. Quando il Plugin Builder ti chiederà il modello da usare, seleziona «Sorgente di Processing».
3. Il plugin creato contiene una sorgente con un singolo algoritmo. Il file della sorgente e dell'algoritmo sono entrambi commentati e contengono informazioni su come modificare la sorgente e gli algoritmi aggiuntivi. Fai riferimento ad essi per maggiori informazioni.

Dipendentemente dal tipo di plugin che stai per sviluppare, potrebbe essere una scelta conveniente di aggiungere le sue funzionalità quali algoritmo di Processing (o un set di essi). Ciò fornirebbe una migliore integrazione all'interno di QGIS, funzionalità aggiuntive (dal momento che può essere eseguito nei componenti di Processing, come il modellatore o l'interfaccia di elaborazione batch), e un tempo di sviluppo più spedito (dal momento che Processing si farà carico della gran parte del lavoro).

Per distribuire questi algoritmi, è necessario creare un nuovo plugin che li aggiunge al Processing Toolbox. Il plugin dovrebbe contenere un provider di algoritmi, che deve essere registrato quando il plugin viene istanziato.
17.2 Aggiornare un plugin

Se si desidera aggiungere un plugin esistente a Processing, è necessario aggiungere un po' di codice.

1. Nella tua `metadata.txt` file, bisogna che aggiungi una variabile:

   ```
   hasProcessingProvider=yes
   ```

2. Nel file Python dove il tuo plugin è impostato tramite il metodo `initGui`, bisogna adattare qualche linea in questo modo:

   ```python
   from qgis.core import QgsApplication
   from processing_provider.provider import Provider

   class YourPluginName():
       def __init__(self):
           self.provider = None

       def initProcessing(self):
           self.provider = Provider()
           QgsApplication.processingRegistry().addProvider(self.provider)

       def initGui(self):
           self.initProcessing()

       def unload(self):
           QgsApplication.processingRegistry().removeProvider(self.provider)
   ```

3. Puoi creare una cartella `processing_provider` contenente tre file:

   - `__init__.py` con niente dentro. Ciò è necessario per produrre un package Python valido.
   - `provider.py` il quale creerà il Processing provider ed esporrà i tuoi algoritmi.

   ```python
   from qgis.core import QgsProcessingProvider

   from processing_provider.example_processing_algorithm import ExampleProcessingAlgorithm

   class Provider(QgsProcessingProvider):
       def loadAlgorithms(self, *args, **kwargs):
           self.addAlgorithm(ExampleProcessingAlgorithm())
           # add additional algorithms here
           # self.addAlgorithm(MyOtherAlgorithm())

       def id(self, *args, **kwargs):
           return 'yourplugin'

       def name(self, *args, **kwargs):
           return self.tr('Your plugin')
   ```

(continues on next page)
def icon(self):
    """Should return a QIcon which is used for your provider inside the Processing toolbox."
    """
    return QgsProcessingProvider.icon(self)

• example_processing_algorithm.py che contiene il file algoritmo di esempio. Copia/incolla il contenuto del file script template file e modificalo conformemente alle tue esigenze.

4. Ora puoi ricaricare il tuo plugin in QGIS e dovresti vedere il tuo script di esempio nella lista di Processing toolbox e modeler.

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.core import 
    QgsVectorLayer, 
    QgsPointXY,
)```
• Informazioni generali
• Building a graph
• Graph analysis
  – Finding shortest paths
  – Areas of availability

The network analysis library can be used to:
  • create mathematical graph from geographical data (poly line vector layers)
  • implement basic methods from graph theory (currently only Dijkstra’s algorithm)

The network analysis library was created by exporting basic functions from the RoadGraph core plugin and now you can use its methods in plugins or directly from the Python console.

18.1 Informazioni generali

Briefly, a typical use case can be described as:
1. create graph from geodata (usually poly line vector layer)
2. run graph analysis
3. use analysis results (for example, visualize them)
18.2 Building a graph

The first thing you need to do — is to prepare input data, that is to convert a vector layer into a graph. All further actions will use this graph, not the layer.

As a source we can use any polyline vector layer. Nodes of the polylines become graph vertexes, and segments of the polylines are graph edges. If several nodes have the same coordinates then they are the same graph vertex. So two lines that have a common node become connected to each other.

Additionally, during graph creation it is possible to «fix» («tie») to the input vector layer any number of additional points. For each additional point a match will be found — the closest graph vertex or closest graph edge. In the latter case the edge will be split and a new vertex added.

Vector layer attributes and length of an edge can be used as the properties of an edge.

Converting from a vector layer to the graph is done using the Builder programming pattern. A graph is constructed using a so-called Director. There is only one Director for now: QgsVectorLayerDirector. The director sets the basic settings that will be used to construct a graph from a line vector layer, used by the builder to create the graph. Currently, as in the case with the director, only one builder exists: QgsGraphBuilder, that creates QgsGraph objects. You may want to implement your own builders that will build a graph compatible with such libraries as BGL or NetworkX.

To calculate edge properties the programming pattern strategy is used. For now only QgsNetworkDistanceStrategy strategy (that takes into account the length of the route) and QgsNetworkSpeedStrategy (that also considers the speed) are available. You can implement your own strategy that will use all necessary parameters. For example, RoadGraph plugin uses a strategy that computes travel time using edge length and speed value from attributes.

It's time to dive into the process.

First of all, to use this library we should import the analysis module

```python
from qgis.analysis import *
```

Then some examples for creating a director

```python
# don't use information about road direction from layer attributes,
# all roads are treated as two-way
director = QgsVectorLayerDirector(vectorLayer, -1, ',', ',',
                                 QgsVectorLayerDirector.DirectionBoth)

# use field with index 5 as source of information about road direction.
# one-way roads with direct direction have attribute value "yes",
# one-way roads with reverse direction have the value "1", and accordingly
# bidirectional roads have "no". By default roads are treated as two-way.
# This scheme can be used with OpenStreetMap data
director = QgsVectorLayerDirector(vectorLayer, 5, 'yes', '1', 'no',
                                 QgsVectorLayerDirector.DirectionBoth)
```

To construct a director, we should pass a vector layer that will be used as the source for the graph structure and information about allowed movement on each road segment (one-way or bidirectional movement, direct or reverse direction). The call looks like this

```python
director = QgsVectorLayerDirector(vectorLayer,
                                  directionFieldId,
                                  directDirectionValue,
                                  reverseDirectionValue,
                                  bothDirectionValue,
                                  defaultDirection)
```

And here is full list of what these parameters mean:

- vectorLayer — vector layer used to build the graph
• directionFieldId — index of the attribute table field, where information about roads direction is stored. If -1, then don’t use this info at all. An integer.

• directDirectionValue — field value for roads with direct direction (moving from first line point to last one). A string.

• reverseDirectionValue — field value for roads with reverse direction (moving from last line point to first one). A string.

• bothDirectionValue — field value for bidirectional roads (for such roads we can move from first point to last and from last to first). A string.

• defaultDirection — default road direction. This value will be used for those roads where field directionFieldId is not set or has some value different from any of the three values specified above. Possible values are:
  - QgsVectorLayerDirector.DirectionForward — One-way direct
  - QgsVectorLayerDirector.DirectionBackward — One-way reverse
  - QgsVectorLayerDirector.DirectionBoth — Two-way

It is necessary then to create a strategy for calculating edge properties

```
# The index of the field that contains information about the edge speed
attributeId = 1
# Default speed value
defaultValue = 50
# Conversion from speed to metric units ('1' means no conversion)
toMetricFactor = 1
strategy = QgsNetworkSpeedStrategy(attributeId, defaultValue, toMetricFactor)
```

And tell the director about this strategy

```
director = QgsVectorLayerDirector(vectorLayer, -1, '', '', '', 3)
director.addStrategy(strategy)
```

Now we can use the builder, which will create the graph. The QgsGraphBuilder class constructor takes several arguments:

• crs — coordinate reference system to use. Mandatory argument.

• otfEnabled — use «on the fly» reprojection or no. By default True (use OTF).

• topologyTolerance — topological tolerance. Default value is 0.

• ellipsoidID — ellipsoid to use. By default «WGS84».

```
# only CRS is set, all other values are defaults
builder = QgsGraphBuilder(vectorLayer.crs())
```

Also we can define several points, which will be used in the analysis. For example

```
startPoint = QgsPointXY(1179720.1871, 5419067.3507)
endPoint = QgsPointXY(1180616.0205, 5419745.7839)
```

Now all is in place so we can build the graph and «tie» these points to it

```
tiedPoints = director.makeGraph(builder, [startPoint, endPoint])
```

Building the graph can take some time (which depends on the number of features in a layer and layer size). tiedPoints is a list with coordinates of «tied» points. When the build operation is finished we can get the graph and use it for the analysis

```
graph = builder.graph()
```

With the next code we can get the vertex indexes of our points
startId = graph.findVertex(tiedPoints[0])
endId = graph.findVertex(tiedPoints[1])

18.3 Graph analysis

Networks analysis is used to find answers to two questions: which vertexes are connected and how to find a shortest path. To solve these problems the network analysis library provides Dijkstra’s algorithm.

Dijkstra’s algorithm finds the shortest route from one of the vertexes of the graph to all the others and the values of the optimization parameters. The results can be represented as a shortest path tree.

The shortest path tree is a directed weighted graph (or more precisely a tree) with the following properties:

• only one vertex has no incoming edges — the root of the tree
• all other vertexes have only one incoming edge
• if vertex B is reachable from vertex A, then the path from A to B is the single available path and it is optimal (shortest) on this graph

To get the shortest path tree use the methods shortestTree() and dijkstra() of the QgsGraphAnalyzer class. It is recommended to use the dijkstra() method because it works faster and uses memory more efficiently.

The shortestTree() method is useful when you want to walk around the shortest path tree. It always creates a new graph object (QgsGraph) and accepts three variables:

• source — input graph
• startVertexIdx — index of the point on the tree (the root of the tree)
• criterionNum — number of edge property to use (started from 0).

tree = QgsGraphAnalyzer.shortestTree(graph, startId, 0)

The dijkstra() method has the same arguments, but returns two arrays. In the first array element \( n \) contains index of the incoming edge or -1 if there are no incoming edges. In the second array element \( n \) contains the distance from the root of the tree to vertex \( n \) or DOUBLE_MAX if vertex \( n \) is unreachable from the root.

(tree, cost) = QgsGraphAnalyzer.dijkstra(graph, startId, 0)

Here is some very simple code to display the shortest path tree using the graph created with the shortestTree() method (select linestring layer in Layers panel and replace coordinates with your own).

Avvertimento: Use this code only as an example, it creates a lot of QgsRubberBand objects and may be slow on large datasets.
pStart = QgsPointXY(1179661.925139, 5419188.074362)
tiedPoint = director.makeGraph(builder, [pStart])
pStart = tiedPoint[0]
graph = builder.graph()
idStart = graph.findVertex(pStart)
tree = QgsGraphAnalyzer.shortestTree(graph, idStart, 0)
i = 0
while (i < tree.edgeCount()):
    rb = QgsRubberBand(iface.mapCanvas())
    rb.setColor (Qt.red)
    rb.addPoint (tree.vertex(tree.edge(i).fromVertex()).point())
    rb.addPoint (tree.vertex(tree.edge(i).toVertex()).point())
i = i + 1

Same thing but using the dijkstra() method

```python
from qgis.core import *
from qgis.gui import *
from qgis.analysis import *
from qgis.PyQt.QtCore import *
from qgis.PyQt.QtGui import *

vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines',
                           'lines')
director = QgsVectorLayerDirector(vectorLayer, -1, '','','','-
                                QgsVectorLayerDirector.DirectionBoth)
strategy = QgsNetworkDistanceStrategy()
director.addStrategy(strategy)
builder = QgsGraphBuilder(vectorLayer.crs())
pStart = QgsPointXY(1179661.925139, 5419188.074362)
tiedPoint = director.makeGraph(builder, [pStart])
pStart = tiedPoint[0]
graph = builder.graph()
idStart = graph.findVertex(pStart)
(tree, costs) = QgsGraphAnalyzer.dijkstra(graph, idStart, 0)

for edgeId in tree:
    if edgeId == -1:
        continue
    rb = QgsRubberBand(iface.mapCanvas())
    rb.setColor (Qt.red)
    rb.addPoint (graph.vertex(graph.edge(edgeId).fromVertex()).point())
    rb.addPoint (graph.vertex(graph.edge(edgeId).toVertex()).point())
```
Finding shortest paths

To find the optimal path between two points the following approach is used. Both points (start A and end B) are «tied» to the graph when it is built. Then using the shortestTree() or dijkstra() method we build the shortest path tree with root in the start point A. In the same tree we also find the end point B and start to walk through the tree from point B to point A. The whole algorithm can be written as:

```python
assign T = B
while T != B
    add point T to path
    get incoming edge for point T
    look for point TT, that is start point of this edge
    assign T = TT
add point A to path
```

At this point we have the path, in the form of the inverted list of vertexes (vertexes are listed in reversed order from end point to start point) that will be visited during traveling by this path.

Here is the sample code for QGIS Python Console (you may need to load and select a linestring layer in TOC and replace coordinates in the code with yours) that uses the shortestTree() method.

```python
from qgis.core import *
from qgis.gui import *
from qgis.analysis import *

vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines', ¬'lines')
builder = QgsGraphBuilder(vectorLayer.sourceCrs())
director = QgsVectorLayerDirector(vectorLayer, -1, '', '','','
QgsVectorLayerDirector.DirectionBoth)
startPoint = QgsPointXY(1179661.925139, 5419188.074362)
endPoint = QgsPointXY(1180942.970617, 5420040.097560)
tiedPoints = director.makeGraph(builder, [startPoint, endPoint])
tStart, tStop = tiedPoints
graph = builder.graph()
idxStart = graph.findVertex(tStart)
tree = QgsGraphAnalyzer.shortestTree(graph, idxStart, 0)
idxStart = tree.findVertex(tStart)
idxEnd = tree.findVertex(tStop)
if idxEnd == -1:
    raise Exception('No route!')
else:
    # Add last point
    route = [tree.vertex(idxEnd).point()]
    # Iterate the graph
    while idxEnd != idxStart:
        edgeIds = tree.vertex(idxEnd).incomingEdges()
        if len(edgeIds) == 0:
            break
        edge = tree.edge(edgeIds[0])
        route.insert(0, tree.vertex(edge.fromVertex()).point())
        idxEnd = edge.fromVertex()
```

(continues on next page)
# Display
```
rub = QgsRubberBand(iface.mapCanvas())
rub.setColor(Qt.green)
```

And here is the same sample but using the `dijkstra()` method

```
from qgis.core import *
from qgis.gui import *
from qgis.analysis import *

from qgis.PyQt.QtCore import *
from qgis.PyQt.QtGui import *

vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines',  
                             'lines')
director = QgsVectorLayerDirector(vectorLayer, -1, '', '', '',  
                                  QgsVectorLayerDirector.DirectionBoth)
strategy = QgsNetworkDistanceStrategy()
director.addStrategy(strategy)

builder = QgsGraphBuilder(vectorLayer.sourceCrs())
startPoint = QgsPointXY(1179661.925139, 5419188.074362)
endPoint = QgsPointXY(1180942.970617, 5420040.097560)
tiedPoints = director.makeGraph(builder, [startPoint, endPoint])
tStart, tStop = tiedPoints

tree, costs = QgsGraphAnalyzer.dijkstra(graph, idxStart, 0)
```

```
if tree[idxEnd] == -1:
    raise Exception('No route!')
```

```
# Total cost
cost = costs[idxEnd]

# Add last point
route = [graph.vertex(idxEnd).point()]

# Iterate the graph
while idxEnd != idxStart:
    idxEnd = graph.edge(tree[idxEnd]).fromVertex()
    route.insert(0, graph.vertex(idxEnd).point())
```

```
# Display
rub = QgsRubberBand(iface.mapCanvas())
rub.setColor(Qt.red)
```

(continues on next page)
18.3.2 Areas of availability

The area of availability for vertex A is the subset of graph vertexes that are accessible from vertex A and the cost of the paths from A to these vertexes are not greater that some value.

More clearly this can be shown with the following example: «There is a fire station. Which parts of city can a fire truck reach in 5 minutes? 10 minutes? 15 minutes?». Answers to these questions are fire station’s areas of availability.

To find the areas of availability we can use the dijkstra() method of the QgsGraphAnalyzer class. It is enough to compare the elements of the cost array with a predefined value. If cost[i] is less than or equal to a predefined value, then vertex i is inside the area of availability, otherwise it is outside.

A more difficult problem is to get the borders of the area of availability. The bottom border is the set of vertexes that are still accessible, and the top border is the set of vertexes that are not accessible. In fact this is simple: it is the availability border based on the edges of the shortest path tree for which the source vertex of the edge is accessible and the target vertex of the edge is not.

Here is an example

```python
director = QgsVectorLayerDirector(vectorLayer, -1, 'l', 'l', 'l', 
QgsVectorLayerDirector.DirectionBoth)
strategy = QgsNetworkDistanceStrategy()
director.addStrategy(strategy)
builder = QgsGraphBuilder(vectorLayer.crs())

def pStart = QgsPointXY(1179661.925139, 5419188.074362)
delta = iface.mapCanvas().getCoordinateTransform().mapUnitsPerPixel() * 1
rb = QgsRubberBand(iface.mapCanvas(), True)
rb.setColor(Qt.green)
rb.addPoint(QgsPointXY(pStart.x() - delta, pStart.y() - delta))
r.addPoint(QgsPointXY(pStart.x() + delta, pStart.y() - delta))
r.addPoint(QgsPointXY(pStart.x() + delta, pStart.y() + delta))
r.addPoint(QgsPointXY(pStart.x() - delta, pStart.y() + delta))
tiedPoints = director.makeGraph(builder, [pStart])
graph = builder.graph()
tStart = tiedPoints[0]
(tStart, cost) = QgsGraphAnalyzer.dijkstra(graph, idStart, 0)
upperBound = []
r = 1500.0
i = 0
tree.reverse()
while i < len(cost):
  if cost[i] > r and tree[i] != -1:
    outVertexId = graph.edge(tree[i]).toVertex()
    if cost[outVertexId] < r:
      upperBound.append(i)
  i = i + 1

for i in upperBound:
  centerPoint = graph.vertex(i).point()
```

(capitolo 18. libreria per l’analisi di reti)
rb = QgsRubberBand(iface.mapCanvas(), True)
rb.setColor(Qt.red)
rb.addPoint(QgsPointXY(centerPoint.x() - delta, centerPoint.y() - delta))
r.addPoint(QgsPointXY(centerPoint.x() + delta, centerPoint.y() - delta))
r.addPoint(QgsPointXY(centerPoint.x() + delta, centerPoint.y() + delta))
r.addPoint(QgsPointXY(centerPoint.x() - delta, centerPoint.y() + delta))
19.1 Introduzione

To learn more about QGIS Server, read the QGIS-Server-manual.

QGIS Server is three different things:

1. QGIS Server library: a library that provides an API for creating OGC web services
2. QGIS Server FCGI: a FCGI binary application `qgis_maserv.fcgi` that together with a web server implements a set of OGC services (WMS, WFS, WCS etc.) and OGC APIs (WFS3/OAPIF)
3. QGIS Development Server: a development server binary application `qgis_mapserver` that implements a set of OGC services (WMS, WFS, WCS etc.) and OGC APIs (WFS3/OAPIF)

This chapter of the cookbook focuses on the first topic and by explaining the usage of QGIS Server API it shows how it is possible to use Python to extend, enhance or customize the server behavior or how to use the QGIS Server API to embed QGIS server into another application.

There are a few different ways you can alter the behavior of QGIS Server or extend its capabilities to offer new custom services or APIs, these are the main scenarios you may face:

- **EMBEDDING** → Use QGIS Server API from another Python application
- **STANDALONE** → Run QGIS Server as a standalone WSGI/HTTP service
- **FILTERS** → Enhance/Customize QGIS Server with filter plugins
- **SERVICES** → Add a new SERVICE
- **OGC APIs** → Add a new OGC API

Embedding and standalone applications require using the QGIS Server Python API directly from another Python script or application. The remaining options are better suited for when you want to add custom features to a standard QGIS Server binary application (FCGI or development server): in this case you’ll need to write a Python plugin for the server application and register your custom filters, services or APIs.
19.2 Server API basics

The fundamental classes involved in a typical QGIS Server application are:

- **QgsServer**: the server instance (typically a single instance for the whole application life)
- **QgsServerRequest**: the request object (typically recreated on each request)
- **QgsServer.handleRequest(request, response)**: processes the request and populates the response

The QGIS Server FCGI or development server workflow can be summarized as follows:

```
initialize the QgsApplication
create the QgsServer
the main server loop waits forever for client requests:
for each incoming request:
    create a QgsServerRequest request
    create a QgsServerResponse response
    call QgsServer.handleRequest(request, response)
    filter plugins may be executed
    send the output to the client
```

Inside the `QgsServer.handleRequest(request, response)` method the filter plugins callbacks are called and `QgsServerRequest` and `QgsServerResponse` are made available to the plugins through the `QgsServerInterface` class.

**Avvertimento**: QGIS server classes are not thread safe, you should always use a multiprocessing model or containers when building scalable applications based on QGIS Server API.

19.3 Standalone or embedding

For standalone server applications or embedding, you will need to use the above mentioned server classes directly, wrapping them up into a web server implementation that manages all the HTTP protocol interactions with the client.

A minimal example of the QGIS Server API usage (without the HTTP part) follows:

```python
from qgis.core import QgsApplication
from qgis.server import *

app = QgsApplication([], False)

server = QgsServer()

# Create the request by specifying the full URL and an optional body
# (for example for POST requests)
request = QgsBufferServerRequest(
    'http://localhost:8081/?MAP=/qgis-server/projects/helloworld.qgs' +
    '&SERVICE=WMS&REQUEST=GetCapabilities')

# Create a response objects
response = QgsBufferServerResponse()

# Handle the request
server.handleRequest(request, response)

print(response.headers())
print(response.body().data().decode('utf8'))
```

(continues on next page)
Here is a complete standalone application example developed for the continuous integrations testing on QGIS source code repository, it showcases a wide set of different plugin filters and authentication schemes (not mean for production because they were developed for testing purposes only but still interesting for learning): https://github.com/qgis/QGIS/blob/release-3_16/tests/src/python/qgis_wrapped_server.py

19.4 Server plugins

Server python plugins are loaded once when the QGIS Server application starts and can be used to register filters, services or APIs.

The structure of a server plugin is very similar to their desktop counterpart, a QgsServerInterface object is made available to the plugins and the plugins can register one or more custom filters, services or APIs to the corresponding registry by using one of the methods exposed by the server interface.

19.4.1 Server filter plugins

Filters come in three different flavors and they can be instanciated by subclassing one of the classes below and by calling the corresponding method of QgsServerInterface:

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Base Class</th>
<th>QgsServerInterface registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/O</td>
<td>QgsServerFilter</td>
<td>registerFilter()</td>
</tr>
<tr>
<td>Access Control</td>
<td>QgsAccessControlFilter</td>
<td>registerAccessControl()</td>
</tr>
<tr>
<td>Cache</td>
<td>QgsServerCacheFilter</td>
<td>registerServerCache()</td>
</tr>
</tbody>
</table>

I/O filters

I/O filters can modify the server input and output (the request and the response) of the core services (WMS, WFS etc.) allowing to do any kind of manipulation of the services workflow. It is possible for example to restrict the access to selected layers, to inject an XSL stylesheet to the XML response, to add a watermark to a generated WMS image and so on.

From this point, you might find useful a quick look to the server plugins API docs.

Each filter should implement at least one of three callbacks:

- requestReady()
- responseComplete()
- sendResponse()

All filters have access to the request/response object (QgsRequestHandler) and can manipulate all its properties (input/output) and raise exceptions (while in a quite particular way as we’ll see below).

Here is the pseudo code showing how the server handles a typical request and when the filter’s callbacks are called:

```python
for each incoming request:
    create GET/POST request handler
    pass request to an instance of QgsServerInterface
    call requestReady filters
    if there is not a response:
        if SERVICE is WMS/WFS/WCS:
            create WMS/WFS/WCS service
            call service's executeRequest
```
possibly call sendResponse for each chunk of bytes
sent to the client by a streaming services (WFS)
call responseComplete
call sendResponse
request handler sends the response to the client

The following paragraphs describe the available callbacks in details.

**requestReady**

This is called when the request is ready: incoming URL and data have been parsed and before entering the core services (WMS, WFS etc.) switch, this is the point where you can manipulate the input and perform actions like:

- authentication/authorization
- redirects
- add/remove certain parameters (typenames for example)
- raise exceptions

You could even substitute a core service completely by changing SERVICE parameter and hence bypassing the core service completely (not that this make much sense though).

**sendResponse**

This is called whenever any output is sent to FCGI stdout (and from there, to the client). This is normally done after core services have finished their process and after responseComplete hook was called, but in a few cases XML can become so huge that a streaming XML implementation is needed (WFS GetFeature is one of them). In that case, instead of a single call to sendResponse(), the method might be exceptionally called multiple times before the response is complete, and in that case (and only in that case) it is also called before responseComplete().

sendResponse() is the best place for direct manipulation of core service's output and while responseComplete() is typically also an option, sendResponse() is the only viable option in case of streaming services.

**responseComplete**

This is called once when core services (if hit) finish their process and the request is ready to be sent to the client. As discussed above, this is normally called before sendResponse() except for streaming services (or other plugin filters) that might have called sendResponse() earlier.

responseComplete() is the ideal place to provide new services implementation (WPS or custom services) and to perform direct manipulation of the output coming from core services (for example to add a watermark upon a WMS image).

**Raising exceptions from a plugin**

Some work has still to be done on this topic: the current implementation can distinguish between handled and unhandled exceptions by setting a QgsRequestHandler property to an instance of QgsMapServiceException, this way the main C++ code can catch handled python exceptions and ignore unhandled exceptions (or better: log them).

This approach basically works but it is not very «pythonic»: a better approach would be to raise exceptions from python code and see them bubbling up into C++ loop for being handled there.
Writing a server plugin

A server plugin is a standard QGIS Python plugin as described in Sviluppo di plugin Python, that just provides an additional (or alternative) interface: a typical QGIS desktop plugin has access to QGIS application through the `QgisInterface` instance, a server plugin has only access to a `QgsServerInterface` when it is executed within the QGIS Server application context.

To make QGIS Server aware that a plugin has a server interface, a special metadata entry is needed (in `metadata.txt`):

```
server=True
```

**Importante:** Only plugins that have the `server=True` metadata set will be loaded and executed by QGIS Server.

The example plugin discussed here (with many more) is available on github at https://github.com/elpaso/qgis3-server-vagrant/tree/master/resources/web/plugins, a few server plugins are also published in the official QGIS plugins repository.

Plugin files

Here’s the directory structure of our example server plugin.

```
PYTHON_PLUGINS_PATH/
HelloServer/
    __init__.py -- required
    HelloServer.py -- required
    metadata.txt -- required
```

**__init__.py**

This file is required by Python’s import system. Also, QGIS Server requires that this file contains a `serverClassFactory()` function, which is called when the plugin gets loaded into QGIS Server when the server starts. It receives reference to instance of `QgsServerInterface` and must return instance of your plugin’s class. This is how the example plugin `__init__.py` looks like:

```python
def serverClassFactory(serverIface):
    from .HelloServer import HelloServerServer
    return HelloServerServer(serverIface)
```

**HelloServer.py**

This is where the magic happens and this is how magic looks like: (e.g. `HelloServer.py`)

A server plugin typically consists in one or more callbacks packed into instances of a `QgsServerFilter`. Each `QgsServerFilter` implements one or more of the following callbacks:

- `requestReady()`
- `responseComplete()`
- `sendResponse()`

The following example implements a minimal filter which prints `HelloServer!` in case the `SERVICE` parameter equals to “HELLO”:
class HelloFilter(QgsServerFilter):
    def __init__(self, serverIface):
        super().__init__(serverIface)

    def requestReady(self):
        QgsMessageLog.logMessage("HelloFilter.requestReady")

    def sendResponse(self):
        QgsMessageLog.logMessage("HelloFilter.sendResponse")

    def responseComplete(self):
        QgsMessageLog.logMessage("HelloFilter.responseComplete")
        request = self.serverInterface().requestHandler()
        params = request.parameterMap()
        if params.get('SERVICE', '').upper() == 'HELLO':
            request.clear()
            request.setResponseHeader('Content-type', 'text/plain')
            # Note that the content is of type "bytes"
            request.appendBody(b'HelloServer!')

The filters must be registered into the serverIface as in the following example:

class HelloServerServer:
    def __init__(self, serverIface):
        serverIface.registerFilter(HelloFilter(serverIface), 100)

The second parameter of registerFilter() sets a priority which defines the order for the callbacks with the same name (the lower priority is invoked first).

By using the three callbacks, plugins can manipulate the input and/or the output of the server in many different ways. In every moment, the plugin instance has access to the QgsRequestHandler through the QgsServerInterface. The QgsRequestHandler class has plenty of methods that can be used to alter the input parameters before entering the core processing of the server (by using requestReady()) or after the request has been processed by the core services (by using sendResponse()).

The following examples cover some common use cases:

Modifying the input

The example plugin contains a test example that changes input parameters coming from the query string, in this example a new parameter is injected into the (already parsed) parameterMap, this parameter is then visible by core services (WMS etc.), at the end of core services processing we check that the parameter is still there:

class ParamsFilter(QgsServerFilter):
    def __init__(self, serverIface):
        super(ParamsFilter, self).__init__(serverIface)

    def requestReady(self):
        request = self.serverInterface().requestHandler()
        params = request.parameterMap()
        request.setParameter('TEST_NEW_PARAM', 'ParamsFilter')

    def responseComplete(self):
        request = self.serverInterface().requestHandler()
        params = request.parameterMap()
        if params.get('TEST_NEW_PARAM') == 'ParamsFilter':
            QgsMessageLog.logMessage("SUCCESS - ParamsFilter.responseComplete")
        else:
            QgsMessageLog.logMessage("FAIL - ParamsFilter.responseComplete")
This is an extract of what you see in the log file:

```
1. src/core/qgsmessagelog.cpp: 45: (logMessage) [0ms] 2014-12-12T12:39:29 plugin[0] -
   HelloServerServer - loading filter ParamsFilter
2. src/core/qgsmessagelog.cpp: 45: (logMessage) [1ms] 2014-12-12T12:39:29 Server[0] -
   Server plugin HelloServer loaded!
3. src/core/qgsmessagelog.cpp: 45: (logMessage) [0ms] 2014-12-12T12:39:29 Server[0] -
   Server python plugins loaded
4. src/mapserver/qgshttprequesthandler.cpp: 547: (requestStringToParameterMap) [1ms] -
   inserting pair SERVICE // HELLO into the parameter map
5. src/mapserver/qgsserverfilter.cpp: 42: (requestReady) [0ms] QgsServerFilter -
   plugin default requestReady called
6. src/core/qgsmessagelog.cpp: 45: (logMessage) [0ms] 2014-12-12T12:39:29 plugin[0] -
   SUCCESS - ParamsFilter.responseComplete
```

On the highlighted line the “SUCCESS” string indicates that the plugin passed the test.

The same technique can be exploited to use a custom service instead of a core one: you could for example skip a WFS SERVICE request or any other core request just by changing the SERVICE parameter to something different and the core service will be skipped. Then you can inject your custom results into the output and send them to the client (this is explained below).

**Suggerimento:** If you really want to implement a custom service it is recommended to subclass `QgsService` and register your service on `registerFilter()` by calling its `registerService(service)`

---

**Modifying or replacing the output**

The watermark filter example shows how to replace the WMS output with a new image obtained by adding a watermark image on the top of the WMS image generated by the WMS core service:

```python
from qgis.server import *
from qgis.PyQt.QtCore import *
from qgis.PyQt.QtGui import *

class WatermarkFilter(QgsServerFilter):
    def __init__(self, serverIface):
        super().__init__(serverIface)

    def responseComplete(self):
        request = self.serverInterface().requestHandler()
        params = request.parameterMap()
        # Do some checks
        if (params.get('SERVICE').upper() == 'WMS' \
            and params.get('REQUEST').upper() == 'GETMAP' \
            and not request.exceptionRaised() ):
            QgsMessageLog.logMessage("WatermarkFilter.responseComplete: image_ready $s" % request.parameter("FORMAT"))
            # Get the image
            img = QImage()
            img.loadFromData(request.body())
            # Adds the watermark
            watermark = QImage(os.path.join(os.path.dirname(__file__), 'media/watermark.png'))
            p = QPainter(img)
            p.drawImage(QRect(20, 20, 40, 40), watermark)
            p.end()
            ba = QByteArray()
            buffer = QBuffer(ba)
```

(continues on next page)
In this example the SERVICE parameter value is checked and if the incoming request is a WMS GETMAP and no exceptions have been set by a previously executed plugin or by the core service (WMS in this case), the WMS generated image is retrieved from the output buffer and the watermark image is added. The final step is to clear the output buffer and replace it with the newly generated image. Please note that in a real-world situation we should also check for the requested image type instead of supporting PNG or JPG only.

**Access control filters**

Access control filters gives the developer a fine-grained control over which layers, features and attributes can be accessed, the following callbacks can be implemented in an access control filter:

- layerFilterExpression(layer)
- layerFilterSubsetString(layer)
- layerPermissions(layer)
- authorizedLayerAttributes(layer, attributes)
- allowToEdit(layer, feature)
- cacheKey()

**Plugin files**

Here’s the directory structure of our example plugin:

```
PYTHON_PLUGINS_PATH/
  MyAccessControl/
  __init__.py --> *required*
  AccessControl.py --> *required*
  metadata.txt --> *required*
```

**__init__.py**

This file is required by Python’s import system. As for all QGIS server plugins, this file contains a serverClassFactory() function, which is called when the plugin gets loaded into QGIS Server at startup. It receives a reference to an instance of QgsServerInterface and must return an instance of your plugin’s class. This is how the example plugin __init__.py looks like:

```python
def serverClassFactory(serverIface):
    from MyAccessControl.AccessControl import AccessControlServer
    return AccessControlServer(serverIface)
```
AccessControl.py

```python
class AccessControlFilter(QgsAccessControlFilter):
    def __init__(self, server_iface):
        super().__init__(server_iface)

    def layerFilterExpression(self, layer):
        """ Return an additional expression filter """
        return super().layerFilterExpression(layer)

    def layerFilterSubsetString(self, layer):
        """ Return an additional subset string (typically SQL) filter """
        return super().layerFilterSubsetString(layer)

    def layerPermissions(self, layer):
        """ Return the layer rights """
        return super().layerPermissions(layer)

    def authorizedLayerAttributes(self, self, layer, attributes):
        """ Return the authorised layer attributes """
        return super().authorizedLayerAttributes(layer, attributes)

    def allowToEdit(self, self, layer, feature):
        """ Are we authorised to modify the following geometry """
        return super().allowToEdit(layer, feature)

class AccessControlServer:
    def __init__(self, serverIface):
        """ Register AccessControlFilter """
        serverIface.registerAccessControl(AccessControlFilter(serverIface), 100)
```

This example gives a full access for everybody.

It’s the role of the plugin to know who is logged on.

On all those methods we have the layer on argument to be able to customise the restriction per layer.

**layerFilterExpression**

Used to add an Expression to limit the results, e.g.:

```python
def layerFilterExpression(self, layer):
    return "$role = 'user'"
```

To limit on feature where the attribute role is equals to «user».
**layerFilterSubsetString**

Same than the previous but use the `SubsetString` (executed in the database)

```python
def layerFilterSubsetString(self, layer):
    return "role = 'user'"
```

To limit on feature where the attribute role is equals to «user».

**layerPermissions**

Limit the access to the layer.

Return an object of type `LayerPermissions()`, which has the properties:

- `canRead` to see it in the GetCapabilities and have read access.
- `canInsert` to be able to insert a new feature.
- `canUpdate` to be able to update a feature.
- `canDelete` to be able to delete a feature.

Example:

```python
def layerPermissions(self, layer):
    rights = QgsAccessControlFilter.LayerPermissions()
    rights.canRead = True
    rights.canInsert = rights.canUpdate = rights.canDelete = False
    return rights
```

To limit everything on read only access.

**authorizedLayerAttributes**

Used to limit the visibility of a specific subset of attribute.

The argument attribute return the current set of visible attributes.

Example:

```python
def authorizedLayerAttributes(self, layer, attributes):
    return [a for a in attributes if a != "role"]
```

To hide the “role” attribute.

**allowToEdit**

This is used to limit the editing on a subset of features.

It is used in the WFS-Transaction protocol.

Example:

```python
def allowToEdit(self, layer, feature):
    return feature.attribute('role') == 'user'
```

To be able to edit only feature that has the attribute role with the value user.
19.4.2 Custom services

In QGIS Server, core services such as WMS, WFS and WCS are implemented as subclasses of `QgsService`. To implement a new service that will be executed when the query string parameter `SERVICE` matches the service name, you can implement your own `QgsService` and register your service on the `serviceRegistry()` by calling its `registerService(service)`.

Here is an example of a custom service named CUSTOM:

```python
from qgis.server import QgsService
from qgis.core import QgsMessageLog

class CustomServiceService(QgsService):
    def __init__(self):
        QgsService.__init__(self)
    
    def name(self):
        return "CUSTOM"
    
    def version(self):
        return "1.0.0"
    
    def executeRequest(self, request, response, project):
        response.setStatusCode(200)
        QgsMessageLog.logMessage('Custom service executeRequest')
        response.write("Custom service executeRequest")

class CustomService:
    def __init__(self, serverIface):
        serverIface.serviceRegistry().registerService(CustomServiceService())
```

19.4.3 Custom APIs

In QGIS Server, core OGC APIs such OAPIF (aka WFS3) are implemented as collections of `QgsServerOgcApiHandler` subclasses that are registered to an instance of `QgsServerOgcApi` (or its parent class `QgsServerApi`).

To implement a new API that will be executed when the url path matches a certain URL, you can implemented your own `QgsServerOgcApiHandler` instances, add them to an `QgsServerOgcApi` and register the API on the `serviceRegistry()` by calling its `registerApi(api)`.

Here is an example of a custom API that will be executed when the URL contains /customapi:

```python
import json
import os
from qgis.PyQt.QtCore import QBuffer, QIODevice, QTextStream, QRegularExpression
from qgis.server import (QgsServiceRegistry, QgsService, QgsServerFilter,
                        )
```

(continues on next page)
QgsServerOgcApi,
QgsServerQueryStringParameter,
QgsServerOgcApiHandler,
)

from qgis.core import (
    QgsMessageLog,
    QgsJsonExporter,
    QgsCircle,
    QgsFeature,
    QgsPoint,
    QgsGeometry,
)

class CustomApiHandler (QgsServerOgcApiHandler):
    def __init__(self):
        super(CustomApiHandler, self).__init__()
        self.setContentTypes([QgsServerOgcApi.HTML, QgsServerOgcApi.JSON])

    def path(self):
        return QRegularExpression("/customapi")

    def operationId(self):
        return "CustomApiXYCircle"

    def summary(self):
        return "Creates a circle around a point"

    def description(self):
        return "Creates a circle around a point"

    def linkTitle(self):
        return "Custom Api XY Circle"

    def linkType(self):
        return QgsServerOgcApi.data

    def handleRequest(self, self, context):
        """Simple Circle""
        values = self.values(context)
        x = values['x']
        y = values['y']
        r = values['r']
        f = QgsFeature()
        f.setAttributes([x, y, r])
        f.setGeometry(QgsCircle(QgsPoint(x, y), r).toCircularString())
        exporter = QgsJsonExporter()
        self.write(json.loads(exporter.exportFeature(f)), context)

    def templatePath(self, context):
        # The template path is used to serve HTML content
        return os.path.join(os.path.dirname(__file__), 'circle.html')

    def parameters(self, context):
        return [QgsServerQueryStringParameter('x', True,
                        QgsServerQueryStringLengthParameter.Type.Double, 'X coordinate'),
                QgsServerQueryStringParameter('y', True, QgsServerQueryStringLengthParameter.Type.Double, 'Y coordinate'),]
QgsServerQueryStringParameter('r', True, 
- QgsServerQueryStringParameter.Type.Double, 'radius'))

class CustomApi():
    def __init__(self, serverIface):
        api = QgsServerOgcApi(serverIface, '/customapi',
                              'custom api', 'a custom api', '1.1')
        handler = CustomApiHandler()
        api.registerHandler(handler)
        serverIface.serviceRegistry().registerApi(api)

The code snippets on this page need the following imports if you’re outside the pyqgis console:

```python
from qgis.PyQt.QtCore import (QRectF,)

from qgis.core import (QgsProject, QgsLayerTreeModel,)

from qgis.gui import (QgsLayerTreeView,)
```

19.4. Server plugins
20.1 User Interface

Change Look & Feel

```python
from qgis.PyQt.QtWidgets import QApplication

app = QApplication.instance()
app.setStyleSheet(".QWidget { color: blue; background-color: yellow; }")
# You can even read the stylesheet from a file
with open("testdata/file.qss") as qss_file_content:
    app.setStyleSheet(qss_file_content.read())
```

Change icon and title

```python
from qgis.PyQt.QtGui import QIcon

icon = QIcon("/path/to/logo/file.png")
iface.mainWindow().setWindowIcon(icon)
iface.mainWindow().setWindowTitle("My QGIS")
```

20.2 Impostazioni

Get QgsSettings list

```python
from qgis.core import QgsSettings

qs = QgsSettings()

for k in sorted(qs.allKeys()):
    print(k)
```
20.3 Barre degli strumenti

Remove toolbar

```python
1 toolbar = iface.helpToolBar()
2 parent = toolbar.parentWidget()
3 parent.removeToolBar(toolbar)

# and add again
4 parent.addToolBar(toolbar)
```

Remove actions toolbar

```python
actions = iface.attributesToolBar().actions()
iface.attributesToolBar().clear()
iface.attributesToolBar().addAction(actions[4])
iface.attributesToolBar().addAction(actions[3])
```

20.4 Menus

Remove menu

```python
# for example Help Menu
1 menu = iface.helpMenu()
2 menubar = menu.parentWidget()
3 menubar.removeAction(menu.menuAction())

# and add again
4 menubar.addAction(menu.menuAction())
```

20.5 Canvas

Access canvas

```python
canvas = iface.mapCanvas()
```

Change canvas color

```python
from qgis.QtCore import Qt
iface.mapCanvas().setCanvasColor(Qt.black)
iface.mapCanvas().refresh()
```

Map Update interval

```python
from qgis.core import QgsSettings
# Set milliseconds (150 milliseconds)
QgsSettings().setValue("/qgis/map_update_interval", 150)
```
20.6 Layer

Add vector layer

```python
layer = iface.addVectorLayer("testdata/airports.shp", "layer name you like", "ogr")
if not layer or not layer.isValid():
    print("Layer failed to load!")
```

Get active layer

```python
layer = iface.activeLayer()
```

List all layers

```python
from qgis.core import QgsProject
QgsProject.instance().mapLayers().values()
```

Obtain layers name

```python
from qgis.core import QgsVectorLayer
layer = QgsVectorLayer("Point?crs=EPSG:4326", "layer name you like", "memory")
QgsProject.instance().addMapLayer(layer)
layers_names = []
for layer in QgsProject.instance().mapLayers().values():
    layers_names.append(layer.name())
print("layers TOC = " + format(layers_names))
```

Otherwise

```python
layers_names = [layer.name() for layer in QgsProject.instance().mapLayers().values()]
print("layers TOC = " + format(layers_names))
```

Find layer by name

```python
from qgis.core import QgsProject
layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
print(layer.name())
```

Set active layer

```python
from qgis.core import QgsProject
layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
iface.setActiveLayer(layer)
```

Refresh layer at interval

```python
from qgis.core import QgsProject
```
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```python
layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
# Set seconds (5 seconds)
layer.setAutoRefreshInterval(5000)
# Enable auto refresh
layer.setAutoRefreshEnabled(True)
```

Show methods

```python
dir(layer)
```

Adding new feature with feature form

```python
from qgis.core import QgsFeature, QgsGeometry

feat = QgsFeature()
geom = QgsGeometry()
feat.setGeometry(geom)
feat.setFields(layer.fields())
iface.openFeatureForm(layer, feat, False)
```

Adding new feature without feature form

```python
from qgis.core import QgsGeometry, QgsPointXY, QgsFeature

pr = layer.dataProvider()
feat = QgsFeature()
feat.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(10, 10)))
pr.addFeatures([feat])
```

Get features

```python
for f in layer.getFeatures():
    print (f)
</qgis._core.QgsFeature object at 0x7f45cc64b678>
```

Get selected features

```python
for f in layer.selectedFeatures():
    print (f)
```

Get selected features IDs

```python
selected_ids = layer.selectedFeatureIds()
print(selected_ids)
```

Create a memory layer from selected features IDs

```python
from qgis.core import QgsFeatureRequest

memory_layer = layer.materialize(QgsFeatureRequest().setFilterFids(layer.
                                --selectedFeatureIds()))
QgsProject.instance().addMapLayer(memory_layer)
```

Get geometry

```python
# Point layer
for f in layer.getFeatures():
geom = f.geometry()
    print ('%f, %f' % (geom.asPoint().y(), geom.asPoint().x()))
```
Move geometry

```python
from qgis.core import QgsFeature, QgsGeometry
poly = QgsFeature()
geom = QgsGeometry.fromWkt("POINT(7 45)")
geom.translate(1, 1)
poly.setGeometry(geom)
print(poly.geometry())
```

Set the CRS

```python
from qgis.core import QgsProject, QgsCoordinateReferenceSystem
for layer in QgsProject.instance().mapLayers().values():
    layer.setCrs(QgsCoordinateReferenceSystem('EPSG:4326'))
```

See the CRS

```python
from qgis.core import QgsProject
for layer in QgsProject.instance().mapLayers().values():
    crs = layer.crs().authid()
    layer.setName('{} ({})'.format(layer.name(), crs))
```

Hide a field column

```python
from qgis.core import QgsEditorWidgetSetup
def fieldVisibility(layer, fname):
    setup = QgsEditorWidgetSetup('Hidden', {})
    for i, column in enumerate(layer.fields()):
        if column.name() == fname:
            layer.setEditorWidgetSetup(i, setup)
            break
        else:
            continue
```

Layer from WKT

```python
from qgis.core import QgsVectorLayer, QgsFeature, QgsGeometry, QgsProject
layer = QgsVectorLayer('Polygon?crs=epsg:4326', 'Mississippi', 'memory')
pr = layer.dataProvider()
poly = QgsFeature()
geom = QgsGeometry.fromWkt("POLYGON ((-88.82 34.99,-88.0934.89,-88.39 30.34,-89.57
    -30.18,-89.73 31,-91.63 30.99,-90.8732.37,-91.23 33.44,-90.93 34.23,-90.30 34.99,-
    -88.82 34.99))")
poly.setGeometry(geom)
pr.addFeatures([poly])
layer.updateExtents()
QgsProject.instance().addMapLayers([[layer]])
```

Load all vector layers from GeoPackage

```python
from qgis.core import QgsDataProvider
fileName = "testdata/sublayers.gpkg"
```
Layers

```python
layer = QgsVectorLayer(fileName, "test", "ogr")
subLayers = layer.dataProvider().subLayers()

for subLayer in subLayers:
    name = subLayer.split(QgsDataProvider.SUBLAYER_SEPARATOR)[1]
    uri = "${layername}=${" % (fileName, name,)
    # Create layer
    sub_vlayer = QgsVectorLayer(uri, name, 'ogr')
    # Add layer to map
    QgsProject.instance().addMapLayer(sub_vlayer)
```

Load tile layer (XYZ-Layer)

```python
from qgis.core import QgsRasterLayer, QgsProject

def loadXYZ(url, name):
    rasterLyr = QgsRasterLayer("type=xyz&url=" + url, name, "wms")
    QgsProject.instance().addMapLayer(rasterLyr)

urlWithParams = 'https://tile.openstreetmap.org/%7Bz%7D/%7Bx%7D/%7By%7D.png&
    zmax=19&zmin=0&crs=EPSG3857'
loadXYZ(urlWithParams, 'OpenStreetMap')
```

Remove all layers

```python
QgsProject.instance().removeAllMapLayers()
```

Remove all

```python
QgsProject.instance().clear()
```

### 20.7 Table of contents

**Access checked layers**

```python
iface.mapCanvas().layers()
```

**Remove contextual menu**

```python
ltv = iface.layerTreeView()
mp = ltv.menuProvider()
ltv.setMenuProvider(None)
    # Restore
ltv.setMenuProvider(mp)
```

### 20.8 Advanced TOC

**Root node**

```python
from qgis.core import QgsVectorLayer, QgsProject, QgsLayerTreeLayer
root = QgsProject.instance().layerTreeRoot()
node_group = root.addGroup("My Group")
layer = QgsVectorLayer("Point?crs=EPSG:4326", "layer name you like", "memory")
```
QgsProject.instance().addMapLayer(layer, False)
node_group.addLayer(layer)
print(root)
print(root.children())

Access the first child node

from qgis.core import QgsLayerTreeGroup, QgsLayerTreeLayer, QgsLayerTree
child0 = root.children()[0]
print(child0.name())
print(type(child0))
print(isinstance(child0, QgsLayerTreeLayer))
print(isinstance(child0.parent(), QgsLayerTree))

My Group
<class 'qgis._core.QgsLayerTreeGroup'>
False
True

Find groups and nodes

from qgis.core import QgsLayerTreeGroup, QgsLayerTreeLayer

def get_group_layers(group):
    print('- group: ' + group.name())
    for child in group.children():
        if isinstance(child, QgsLayerTreeGroup):
            # Recursive call to get nested groups
            get_group_layers(child)
        else:
            print('- layer: ' + child.name())
root = QgsProject.instance().layerTreeRoot()
for child in root.children():
    if isinstance(child, QgsLayerTreeGroup):
        get_group_layers(child)
    elif isinstance(child, QgsLayerTreeLayer):
        print('- layer: ' + child.name())

- group: My Group
- layer: layer name you like

Find group by name

print(root.findGroup("My Group"))

<qgis._core.QgsLayerTreeGroup object at 0x7fd75560cee8>

Find layer by id

print(root.findLayer(layer.id()))

<qgis._core.QgsLayerTreeLayer object at 0x7f56087af288>

Add layer
from qgis.core import QgsVectorLayer, QgsProject

layer1 = QgsVectorLayer("Point?crs=EPSG:4326", "layer name you like 2", "memory")
QgsProject.instance().addMapLayer(layer1, False)

node_layer1 = root.addLayer(layer1)

# Remove it
QgsProject.instance().removeMapLayer(layer1)

Add group

from qgis.core import QgsLayerTreeGroup

node_group2 = QgsLayerTreeGroup("Group 2")
root.addChildNode(node_group2)
QgsProject.instance().mapLayersByName("layer name you like")

Move loaded layer

layer = QgsProject.instance().mapLayersByName("layer name you like")

root = QgsProject.instance().layerTreeRoot()
myLayer = root.findLayer(layer.id())
myClone = myLayer.clone()

parent = myLayer.parent()

myGroup = root.findGroup("My Group")

# Insert in first position
myGroup.insertChildNode(0, myClone)

parent.removeChildNode(myLayer)

Move loaded layer to a specific group

QgsProject.instance().addMapLayer(layer, False)

root = QgsProject.instance().layerTreeRoot()
myGroup = root.findGroup("My Group")
myOriginalLayer = root.findLayer(layer.id())
myLayer = myOriginalLayer.clone()

parent.removeChildNode(myOriginalLayer)

parent.removeChildNode(myLayer)

myGroup.insertChildNode(0, myLayer)

parent.removeChildNode(myOriginalLayer)

Changing visibility

myGroup.setItemVisibilityChecked(False)
myLayer.setItemVisibilityChecked(False)

Is group selected

def isMyGroupSelected( groupName ):
    myGroup = QgsProject.instance().layerTreeRoot().findGroup( groupName )
    return myGroup in iface.layerTreeView().selectedNodes()

print(isMyGroupSelected( 'my group name' ))

False

Expand node

print(myGroup.isExpanded())
myGroup.setExpanded(False)
Hidden node trick

```python
from qgis.core import QgsProject

model = iface.layerTreeView().layerTreeModel()
ltv = iface.layerTreeView()
root = QgsProject.instance().layerTreeRoot()

layer = QgsProject.instance().mapLayersByName('layer name you like')[0]
node = root.findLayer(layer.id())

index = model.node2index(node)
ltv.setRowHidden(index.row(), index.parent(), True)
node.setCustomProperty('nodeHidden', True)
ltv.setCurrentIndex(model.node2index(root))
```

Node signals

```python
def onWillAddChildren(node, indexFrom, indexTo):
    print("WILL ADD", node, indexFrom, indexTo)

def onAddedChildren(node, indexFrom, indexTo):
    print("ADDED", node, indexFrom, indexTo)

root.willAddChildren.connect(onWillAddChildren)
root.addedChildren.connect(onAddedChildren)
```

Remove layer

```python
root.removeLayer(layer)
```

Remove group

```python
root.removeChildNode(node_group2)
```

Create new table of contents (TOC)

```python
root = QgsProject.instance().layerTreeRoot()
model = QgsLayerTreeModel(root)
view = QgsLayerTreeView()
view.setModel(model)
view.show()
```

Move node

```python
cloned_group1 = node_group.clone()
root.insertChildNode(0, cloned_group1)
root.removeChildNode(node_group)
```

Rename node

```python
cloned_group1.setName("Group X")
node_layer1.setName("Layer X")
```
20.9 Processing algorithms

Get algorithms list

```python
from qgis.core import QgsApplication
for alg in QgsApplication.processingRegistry().algorithms():
    if 'buffer' == alg.name():
        print("\(\):{} \rightarrow {}\).format(alg.provider().name(), alg.name(), alg.displayName()))
```

QGIS (native c++):buffer --> Buffer

Get algorithms help

Random selection

```python
from qgis import processing
processing.algorithmHelp("native:buffer")
```

Run the algorithm

For this example, the result is stored in a temporary memory layer which is added to the project.

```python
from qgis import processing
result = processing.run("native:buffer", {'INPUT': layer, 'OUTPUT': 'memory:'})
QgsProject.instance().addMapLayer(result["OUTPUT"])
```

Processing(0): Results: {'OUTPUT': 'output_d27a2008_970c_4687_b025_f057abbd7319'}

How many algorithms are there?

```python
len(QgsApplication.processingRegistry().algorithms())
```

How many providers are there?

```python
from qgis.core import QgsApplication
len(QgsApplication.processingRegistry().providers())
```

How many expressions are there?

```python
from qgis.core import QgsExpression
len(QgsExpression.Functions())
```

20.10 Decorators

CopyRight

```python
from qgis.Qt.Qt import QTextDocument
from qgis.Qt.QtGui import QFont
mQFont = "Sans Serif"
mFontSize = 9
mLabelQString = "© QGIS 2019"
```

(continues on next page)
mMarginHorizontal = 0
mMarginVertical = 0
mLabelQColor = "#FF0000"

INCHES_TO_MM = 0.0393700787402 # 1 millimeter = 0.0393700787402 inches
case = 2

```python
def add_copyright(p, text, xOffset, yOffset):
    p.translate(xOffset, yOffset)
    text.drawContents(p)
    p.setWorldTransform(p.worldTransform())

def _on_render_complete(p):
    deviceHeight = p.device().height() # Get paint device height on which this...
    deviceWidth = p.device().width() # Get paint device width on which this...
    # Create new container for structured rich text
    text = QTextDocument()
    font = QFont()
    font.setFamily(mQFont)
    font.setPointSize(int(mQFontsize))
    textsetDefaultFont(font)
    style = "<style type="text/css"> p {color: " + mLabelQColor + "}</style>"
    text.setHtml(style + "<p>" + mLabelQString + "</p>"
    # Text Size
    size = text.size()
    # RenderMillimeters
    pixelsInchX = p.device().logicalDpiX()
    pixelsInchY = p.device().logicalDpiY()
    xOffset = pixelsInchX * INCHES_TO_MM * int(mMarginHorizontal)
    yOffset = pixelsInchY * INCHES_TO_MM * int(mMarginVertical)
    # Calculate positions
    if case == 0:
        # Top Left
        add_copyright(p, text, xOffset, yOffset)
    elif case == 1:
        # Bottom Left
        yOffset = deviceHeight - yOffset - size.height()
        add_copyright(p, text, xOffset, yOffset)
    elif case == 2:
        # Top Right
        xOffset = deviceWidth - xOffset - size.width()
        add_copyright(p, text, xOffset, yOffset)
    elif case == 3:
        # Bottom Right
        yOffset = deviceHeight - yOffset - size.height()
        xOffset = deviceWidth - xOffset - size.width()
        add_copyright(p, text, xOffset, yOffset)
    elif case == 4:
        # Top Center
        xOffset = deviceWidth / 2
        add_copyright(p, text, xOffset, yOffset)
    else:
```

(continues on next page)
# Bottom Center

\[
yOffset = deviceHeight - yOffset - size.height()
\]

\[
oxOffset = deviceWidth / 2
\]

\[
add_copyright(p, text, xOffset, yOffset)
\]

# Emitted when the canvas has rendered

iface.mapCanvas().renderComplete.connect(on_render_complete)

# Repaint the canvas map

iface.mapCanvas().refresh()

## 20.11 Composer

Get print layout by name

```python
composerTitle = 'MyComposer'  # Name of the composer
project = QgsProject.instance()
projectLayoutManager = project.layoutManager()
layout = projectLayoutManager.layoutByName(composerTitle)
```

## 20.12 Sources

- QGIS Python (PyQGIS) API
- QGIS C++ API
- StackOverFlow QGIS questions
- Script by Klas Karlsson