



PyQGIS 3.16 developer cookbook

QGIS Project

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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

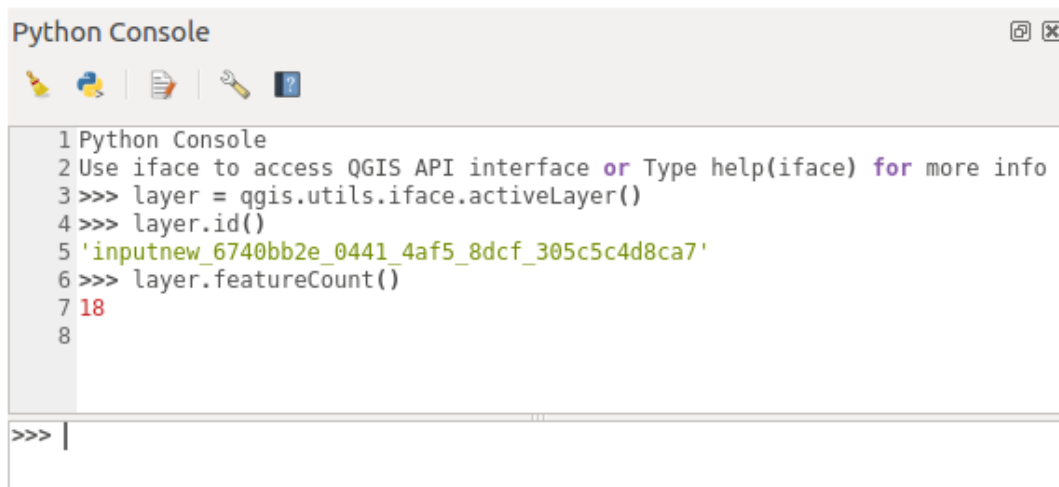
Python è disponibile anche per QGIS Server, inclusi i plugin Python (vedi *QGIS Server and Python*) e i collegamenti Python che possono essere utilizzati per incorporare il server QGIS in un'applicazione Python.

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/>](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* :



```
Python Console
1 Python Console
2 Use iface to access QGIS API interface or Type help(iface) for more info
3 >>> layer = qgis.utils.iface.activeLayer()
4 >>> layer.id()
5 'inputnew_6740bb2e_0441_4af5_8dcf_305c5c4d8ca7'
6 >>> layer.featureCount()
7 18
8
>>> |
```

Fig. 1.1: Console python di GIS

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 due 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.

Nota: Il percorso predefinito dipende dal sistema operativo. Per trovare il percorso adatto a te, apri il terminale Python ed esegui `QStandardPaths.standardLocations(QStandardPaths.AppDataLocation)` per vedere la lista delle cartelle predefinite.

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`, inzializzalo 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:

```

1 from qgis.core import *
2
3 # Supply path to qgis install location
4 QgsApplication.setPrefixPath("/path/to/qgis/installation", True)
5
6 # Create a reference to the QgsApplication. Setting the
7 # second argument to False disables the GUI.
8 qgs = QgsApplication([], False)
9
10 # Load providers
11 qgs.initQgis()
12
13 # Write your code here to load some layers, use processing
14 # algorithms, etc.
15
16 # Finally, exitQgis() is called to remove the
17 # provider and layer registries from memory
18 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:

```
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, carichiamo i fornitori di dati QGIS e il registro dei layer chiamando il metodo `initQgis()`.

```
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.

```
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.

```

1 from qgis.core import *
2
3 # Supply the path to the qgis install location
4 QgsApplication.setPrefixPath("/path/to/qgis/installation", True)
5
6 # Create a reference to the QgsApplication.
7 # Setting the second argument to True enables the GUI. We need
8 # this since this is a custom application.
9

```

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```

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:

```

>>> 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):

```

>>> 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 aggiuntive 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.

1.5 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:

```
1 from qgis.core import (  
2     QgsProject,  
3     QgsPathResolver  
4 )  
5  
6 from qgis.gui import (  
7     QgsLayerTreeMapCanvasBridge,  
8 )
```

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:

```
1 # If you are not inside a QGIS console you first need to import
2 # qgis and PyQt classes you will use in this script as shown below:
3 from qgis.core import QgsProject
4 # Get the project instance
5 project = QgsProject.instance()
6 # Print the current project file name (might be empty in case no projects have_
   ↳been loaded)
7 # print(project.fileName())
8
9 # Load another project
10 project.read('testdata/01_project.qgs')
11 print(project.fileName())
```

```
testdata/01_project.qgs
```

Se vuoi modificare il progetto (ad esempio per aggiungere o rimuovere dei layer) e salvare 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:

```
# 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:

```
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:

```
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:

```
1 def my_processor(path):
2     path= path.replace("user='gis_team'", "user='team_awesome'")
3     path = path.replace("password='cats'", "password='g7as!m*")
4     return path
5
6 QgsPathResolver.setPathPreprocessor(my_processor)
```

Caricamento del vettore

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

```
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:

```
1 # get the path to the shapefile e.g. /home/project/data/ports.shp
2 path_to_airports_layer = "testdata/airports.shp"
3
4 # The format is:
5 # vlayer = QgsVectorLayer(data_source, layer_name, provider_name)
6
7 vlayer = QgsVectorLayer(path_to_airports_layer, "Airports layer", "ogr")
8 if not vlayer.isValid():
9     print("Layer failed to load!")
10 else:
11     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:

```

1 # get the path to a geopackage e.g. /usr/share/qgis/resources/data/world_map.gpkg
2 path_to_gpkg = os.path.join(QgsApplication.pkgDataPath(), "resources", "data",
   ↪ "world_map.gpkg")
3 # append the layername part
4 gpkg_countries_layer = path_to_gpkg + "|layername=countries"
5 # e.g. gpkg_places_layer = "/usr/share/qgis/resources/data/world_map.
   ↪ gpkg|layername=countries"
6 vlayer = QgsVectorLayer(gpkg_countries_layer, "Countries layer", "ogr")
7 if not vlayer.isValid():
8     print("Layer failed to load!")
9 else:
10     QgsProject.instance().addMapLayer(vlayer)

```

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

```

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:

```

vlayer = QgsVectorLayer("testdata/airports.shp", "layer_name_you_like",
   ↪ "ogr")
QgsProject.instance().addMapLayer(vlayer)

```

– per dxf (nota le opzioni nell'origine dati uri):

```

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:

```

1 uri = QgsDataSourceUri()
2 # set host name, port, database name, username and password
3 uri.setConnection("localhost", "5432", "dbname", "johnny", "xxx")
4 # set database schema, table name, geometry column and optionally
5 # subset (WHERE clause)
6 uri.setDataSource("public", "roads", "the_geom", "cityid = 2643", "primary_key_
   ↪ field")
7
8 vlayer = QgsVectorLayer(uri.uri(False), "layer name you like", "postgres")

```

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:

```
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:

```
uri = "file:///some/path/file.csv?delimiter={}&crs=epsg:4723&wktField={}".
↳format(";", "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:

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

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

```
1 uri = QgsDataSourceUri()
2 uri.setDatabase('/home/martin/test-2.3.sqlite')
3 schema = ''
4 table = 'Towns'
5 geom_column = 'Geometry'
6 uri.setDataSource(schema, table, geom_column)
7
8 display_name = 'Towns'
9 vlayer = QgsVectorLayer(uri.uri(), display_name, 'spatialite')
10 QgsProject.instance().addMapLayer(vlayer)
```

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

```
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:

```
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`:

```
1 import urllib
2
3 params = {
4     'service': 'WFS',
5     'version': '2.0.0',
6     'request': 'GetFeature',
7     'typename': 'ms:cities',
8     'srsname': "EPSG:4326"
```

(continues on next page)

(continua dalla pagina precedente)

```

9 }
10 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()` `qgis.core.Qgsvectorlayer.setDataSource()` su un'istanza `Qgsvectorlayer` `qgis.core.Qgsvectorlayer`, come nell'esempio seguente:

```

1 uri = "https://demo.mapserver.org/cgi-bin/wfs?service=WFS&version=2.0.0&
    ↳request=GetFeature&typename=ms:cities"
2 provider_options = QgsDataProvider.ProviderOptions()
3 # Use project's transform context
4 provider_options.transformContext = QgsProject.instance().transformContext()
5 vlayer.setDataSource(uri, "layer name you like", "WFS", provider_options)
6
7 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:

```

1 # get the path to a tif file e.g. /home/project/data/srtm.tif
2 path_to_tif = "qgis-projects/python_cookbook/data/srtm.tif"
3 rlayer = QgsRasterLayer(path_to_tif, "SRTM layer name")
4 if not rlayer.isValid():
5     print("Layer failed to load!")

```

Per caricare un raster da un geopackage:

```

1 # get the path to a geopackage e.g. /home/project/data/data.gpkg
2 path_to_gpkg = os.path.join(os.getcwd(), "testdata", "sublayers.gpkg")
3 # gpkg_raster_layer = "GPKG:/home/project/data/data.gpkg:srtm"
4 gpkg_raster_layer = "GPKG:" + path_to_gpkg + ":srtm"
5
6 rlayer = QgsRasterLayer(gpkg_raster_layer, "layer name you like", "gdal")
7
8 if not rlayer.isValid():
9     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>`:

```
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 "postgraster". Dopo di che il raster può essere aggiunto al progetto.

```

1 uri_config = {
2     # database parameters
3     'dbname':'gis_db',      # The PostgreSQL database to connect to.
4     'host':'localhost',    # The host IP address or localhost.
5     'port':'5432',         # The port to connect on.
6     'sslmode':QgsDataSourceUri.SslDisable, # SslAllow, SslPrefer, SslRequire,
↳SslVerifyCa, SslVerifyFull
7     # user and password are not needed if stored in the authcfg or service
8     'authcfg':'QconfigId', # The QGIS authentication database ID holding
↳connection details.
9     'service': None,       # The PostgreSQL service to be used for connection to
↳the database.
10    'username':None,       # The PostgreSQL user name.
11    'password':None,       # The PostgreSQL password for the user.
12    # table and raster column details
13    'schema':'public',     # The database schema that the table is located in.
14    'table':'my_rasters',  # The database table to be loaded.
15    'geometrycolumn':'rast', # raster column in PostGIS table
16    'sql':None,            # An SQL WHERE clause. It should be placed at the end
↳of the string.
17    'key':None,            # A key column from the table.
18    'srid':None,          # A string designating the SRID of the coordinate
↳reference system.
19    'estimatedmetadata':'False', # A boolean value telling if the metadata is
↳estimated.
20    'type':None,           # A WKT string designating the WKB Type.
21    'selectatid':None,     # Set to True to disable selection by feature ID.
22    'options':None,        # other PostgreSQL connection options not in this list.
23    'enableTime': None,
24    'temporalDefaultTime': None,
25    'temporalFieldIndex': None,
26    'mode':'2',           # GDAL 'mode' parameter, 2 unions raster tiles, 1 adds
↳tiles separately (may require user input)
27 }
28 # remove any NULL parameters
29 uri_config = {key:val for key, val in uri_config.items() if val is not None}
30 # get the metadata for the raster provider and configure the URI
31 md = QgsProviderRegistry.instance().providerMetadata('postgresraster')
32 uri = QgsDataSourceUri(md.encodeUri(uri_config))
33
34 # the raster can then be loaded into the project
35 rlayer = iface.addRasterLayer(uri.uri(False), "raster layer name", "postgresraster
↳")

```

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

```

layer_name = 'modis'
url = "https://demo.mapserver.org/cgi-bin/wcs?identifier={}".format(layer_name)
rlayer = QgsRasterLayer(uri, '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 qgis.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.
- **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 carico della cache, come descritto in QNetworkRequest::CacheLoadControl, ma la richiesta viene rinviata come PreferCache se non riuscita con AlwaysCcache. 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:

```
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()` :

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

Per aggiungere un livello in una posizione assoluta:

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

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

```
# 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()` :

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

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

```
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:

```
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:

```
1 # list of layer names using list comprehension
2 l = [layer.name() for layer in QgsProject.instance().mapLayers().values()]
3 # dictionary with key = layer name and value = layer object
4 layers_list = {}
5 for l in QgsProject.instance().mapLayers().values():
6     layers_list[l.name()] = l
7
8 print(layers_list)
```

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

You can also query the TOC using the name of the layer:

```
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:

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

`root` is a group node and has *children*:

```
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:

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

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

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

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

And groups can also be searched using their names:

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

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

```
# 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 # create a temporary layer
2 layer1 = QgsVectorLayer("path_to_layer", "Layer 1", "memory")
3 # add the layer to the legend, last position
4 root.addLayer(layer1)
5 # add the layer at given position
6 root.insertLayer(5, layer1)

```

2. **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:

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

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

```

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:

```

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

```

1 # clone the group
2 cloned_group1 = node_group1.clone()
3 # move the node (along with sub-groups and layers) to the top
4 root.insertChildNode(0, cloned_group1)
5 # remove the original node
6 root.removeChildNode(node_group1)

```

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

```

1 # get a QgsVectorLayer
2 vl = QgsProject.instance().mapLayersByName("countries")[0]
3 # create a QgsLayerTreeLayer object from vl by its id
4 myvl = root.findLayer(vl.id())
5 # clone the myvl QgsLayerTreeLayer object
6 myvlclone = myvl.clone()
7 # get the parent. If None (layer is not in group) returns ''
8 parent = myvl.parent()
9 # move the cloned layer to the top (0)
10 parent.insertChildNode(0, myvlclone)
11 # remove the original myvl
12 root.removeChildNode(myvl)

```

or moving it to an existing group:

```
1 # get a QgsVectorLayer
2 vl = QgsProject.instance().mapLayersByName("countries")[0]
3 # create a QgsLayerTreeLayer object from vl by its id
4 myvl = root.findLayer(vl.id())
5 # clone the myvl QgsLayerTreeLayer object
6 myvlclone = myvl.clone()
7 # create a new group
8 group1 = root.addGroup("Group1")
9 # get the parent. If None (layer is not in group) returns ''
10 parent = myvl.parent()
11 # move the cloned layer to the top (0)
12 group1.insertChildNode(0, myvlclone)
13 # remove the QgsLayerTreeLayer from its parent
14 parent.removeChildNode(myvl)
```

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

```
1 node_group1 = root.findGroup("Group1")
2 # change the name of the group
3 node_group1.setName("Group X")
4 node_layer2 = root.findLayer(country_layer.id())
5 # change the name of the layer
6 node_layer2.setName("Layer X")
7 # change the visibility of a layer
8 node_group1.setItemVisibilityChecked(True)
9 node_layer2.setItemVisibilityChecked(False)
10 # expand/collapse the group view
11 node_group1.setExpanded(True)
12 node_group1.setExpanded(False)
```

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

```
1 from qgis.core import (
2     QgsRasterLayer,
3     QgsProject,
4     QgsPointXY,
5     QgsRaster,
6     QgsRasterShader,
7     QgsColorRampShader,
8     QgsSingleBandPseudoColorRenderer,
9     QgsSingleBandColorDataRenderer,
10    QgsSingleBandGrayRenderer,
11 )
12
13 from qgis.PyQt.QtGui import (
14     QColor,
15 )
```

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.

```
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 -34.27001076999999896, 20.83945284300000012 -
↪33.75077500700000144>
```

```
# get the extent of the layer as Strings
print(rlayer.extent().toString())
```

```
20.0685680819999988,-34.2700107699999990 : 20.8394528430000001,-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())
```

```
1
```

```
# 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())
```

```
<qgis._core.QgsLayerMetadata object at 0x13711d558>
```

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:

```

1 fcn = QgsColorRampShader()
2 fcn.setColorRampType(QgsColorRampShader.Interpolated)
3 lst = [ QgsColorRampShader.ColorRampItem(0, QColor(0,255,0)),
4         QgsColorRampShader.ColorRampItem(255, QColor(255,255,0)) ]
5 fcn.setColorRampItemList(lst)
6 shader = QgsRasterShader()
7 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:

```

render = QgsSingleBandPseudoColorRenderer(rlayer.dataProvider(), 1, shader)
rlayer.setRenderer(render)

```

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:

```

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):

```

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:

```

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:

```
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.

```
ident = rlayer.dataProvider().identify(QgsPointXY(20.5, -34), QgsRaster.
↳IdentifyFormatValue)

if ident.isValid():
    print(ident.results())
```

```
{1: 323.0}
```

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:

```
1 from qgis.core import (
2     QgsApplication,
3     QgsDataSourceUri,
4     QgsCategorizedSymbolRenderer,
5     QgsClassificationRange,
6     QgsPointXY,
7     QgsProject,
8     QgsExpression,
9     QgsField,
10    QgsFields,
11    QgsFeature,
12    QgsFeatureRequest,
13    QgsFeatureRenderer,
14    QgsGeometry,
15    QgsGraduatedSymbolRenderer,
16    QgsMarkerSymbol,
17    QgsMessageLog,
18    QgsRectangle,
19    QgsRendererCategory,
20    QgsRendererRange,
21    QgsSymbol,
22    QgsVectorDataProvider,
23    QgsVectorLayer,
24    QgsVectorFileWriter,
25    QgsWkbTypes,
26    QgsSpatialIndex,
27    QgsVectorLayerUtils
28 )
29
30 from qgis.core.additions.edit import edit
31
32 from qgis.PyQt.QtGui import (
33     QColor,
34 )
```

- *Recuperare informazioni sugli attributi*
- *Iterare un Vettore.*
- *Selezionare geometrie*
 - *Accedere agli attributi*
 - *Iterare le caratteristiche selezionate*
 - *Iterare un sottoinsieme di caratteristiche*
- *Modificare i Vettori*
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 - *Modificare i Vettori con un Buffer di Modifica*
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- *Usare l'Indice Spaziale*
- *The QgsVectorLayerUtils class*
- *Creating Vector Layers*
 - *From an instance of QgsVectorFileWriter*
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- *Apparenza (Simbologia) dei Vettori*
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 - *Categorized Symbol Renderer*
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 - *Working with Symbols*

- * *Working with Symbol Layers*
- * *Creating Custom Symbol Layer Types*
- *Creating Custom Renderers*
- *Further Topics*

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:

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

```
1 ID Integer64
2 fk_region Integer64
3 ELEV Real
4 NAME String
5 USE String
```

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:

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

```
NAME
```

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.

```
1 # "layer" is a QgsVectorLayer instance
2 layer = iface.activeLayer()
3 features = layer.getFeatures()
4
5 for feature in features:
6     # retrieve every feature with its geometry and attributes
7     print("Feature ID: ", feature.id())
8     # fetch geometry
```

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(continua dalla pagina precedente)

```

9      # show some information about the feature geometry
10     geom = feature.geometry()
11     geomSingleType = QgsWkbTypes.isSingleType(geom.wkbType())
12     if geom.type() == QgsWkbTypes.PointGeometry:
13         # the geometry type can be of single or multi type
14         if geomSingleType:
15             x = geom.asPoint()
16             print("Point: ", x)
17         else:
18             x = geom.asMultiPoint()
19             print("MultiPoint: ", x)
20     elif geom.type() == QgsWkbTypes.LineGeometry:
21         if geomSingleType:
22             x = geom.asPolyline()
23             print("Line: ", x, "length: ", geom.length())
24         else:
25             x = geom.asMultiPolyline()
26             print("MultiLine: ", x, "length: ", geom.length())
27     elif geom.type() == QgsWkbTypes.PolygonGeometry:
28         if geomSingleType:
29             x = geom.asPolygon()
30             print("Polygon: ", x, "Area: ", geom.area())
31         else:
32             x = geom.asMultiPolygon()
33             print("MultiPolygon: ", x, "Area: ", geom.area())
34     else:
35         print("Unknown or invalid geometry")
36     # fetch attributes
37     attrs = feature.attributes()
38     # attrs is a list. It contains all the attribute values of this feature
39     print(attrs)
40     # for this test only print the first feature
41     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:

```

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

```

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

```

# 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:

```
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:

```
1 selected_fid = []
2
3 # Get the first feature id from the layer
4 for feature in layer.getFeatures():
5     selected_fid.append(feature.id())
6     break
7
8 # Add these features to the selected list
9 layer.select(selected_fid)
```

To clear the selection:

```
layer.removeSelection()
```

6.3.1 Accedere agli attributi

Attributes can be referred to by their name:

```
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:

```
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:

```
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:

```
1 areaOfInterest = QgsRectangle(450290,400520, 450750,400780)
2
3 request = QgsFeatureRequest().setFilterRect(areaOfInterest)
4
5 for feature in layer.getFeatures(request):
```

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```

6   # do whatever you need with the feature
7   pass

```

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:

```

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

```

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

```

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

```

```
<qgis._core.QgsFeature object at 0x7f9b78590948>
```

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:

```

# 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.

```

1  # Only return selected fields to increase the "speed" of the request
2  request.setSubsetOfAttributes([0,2])
3
4  # More user friendly version
5  request.setSubsetOfAttributes(['name','id'],layer.fields())
6
7  # Don't return geometry objects to increase the "speed" of the request
8  request.setFlags(QgsFeatureRequest.NoGeometry)
9
10 # Fetch only the feature with id 45
11 request.setFilterFid(45)
12
13 # The options may be chained
14 request.setFilterRect(areaOfInterest).setFlags(QgsFeatureRequest.NoGeometry) \
    ↪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.

```

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:

```
1 caps_string = layer.dataProvider().capabilitiesString()
2 # Print:
3 # 'Add Features, Delete Features, Change Attribute Values, Add Attributes,
4 # Delete Attributes, Rename Attributes, Fast Access to Features at ID,
5 # Presimplify Geometries, Presimplify Geometries with Validity Check,
6 # Transactions, Curved Geometries'
```

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:

```
1 # If caching is enabled, a simple canvas refresh might not be sufficient
2 # to trigger a redraw and you must clear the cached image for the layer
3 if iface.mapCanvas().isCachingEnabled():
4     layer.triggerRepaint()
5 else:
6     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.

```
1 if caps & QgsVectorDataProvider.AddFeatures:
2     feat = QgsFeature(layer.fields())
3     feat.setAttributes([0, 'hello'])
4     # Or set a single attribute by key or by index:
5     feat.setAttribute('name', 'hello')
6     feat.setAttribute(0, 'hello')
7     feat.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(123, 456)))
8     (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.

```
1 fid = 100 # ID of the feature we will modify
2
3 if caps & QgsVectorDataProvider.ChangeAttributeValues:
4     attrs = { 0 : "hello", 1 : 123 }
5     layer.dataProvider().changeAttributeValues({ fid : attrs })
6
7 if caps & QgsVectorDataProvider.ChangeGeometries:
8     geom = QgsGeometry.fromPointXY(QgsPointXY(111,222))
9     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.

```
1 from qgis.PyQt.QtCore import QVariant
2
3 feat1 = feat2 = QgsFeature(layer.fields())
4 fid = 99
5 feat1.setId(fid)
6
7 # add two features (QgsFeature instances)
8 layer.addFeatures([feat1, feat2])
9 # delete a feature with specified ID
10 layer.deleteFeature(fid)
```

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```
11
12 # set new geometry (QgsGeometry instance) for a feature
13 geometry = QgsGeometry.fromWkt("POINT(7 45)")
14 layer.changeGeometry(fid, geometry)
15 # update an attribute with given field index (int) to a given value
16 fieldIndex = 1
17 value = 'My new name'
18 layer.changeAttributeValue(fid, fieldIndex, value)
19
20 # add new field
21 layer.addAttribute(QgsField("mytext", QVariant.String))
22 # remove a field
23 layer.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:

```
1 layer.beginEditCommand("Feature triangulation")
2
3 # ... call layer's editing methods ...
4
5 if problem_occurred:
6     layer.destroyEditCommand()
7     # ... tell the user that there was a problem
8     # and return
9
10 # ... more editing ...
11
12 layer.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:

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

```

1 from qgis.PyQt.QtCore import QVariant
2
3 if caps & QgsVectorDataProvider.AddAttributes:
4     res = layer.dataProvider().addAttributes(
5         [QgsField("mytext", QVariant.String),
6          QgsField("myint", QVariant.Int)])
7
8 if caps & QgsVectorDataProvider.DeleteAttributes:
9     res = layer.dataProvider().deleteAttributes([0])

```

```

1 # Alternate methods for removing fields
2 # first create temporary fields to be removed (f1-3)
3 layer.dataProvider().addAttributes([QgsField("f1",QVariant.Int),QgsField("f2",
4 ↪QVariant.Int),QgsField("f3",QVariant.Int)])
5 layer.updateFields()
6 count=layer.fields().count() # count of layer fields
7 ind_list=list((count-3, count-2)) # create list
8
9 # remove a single field with an index
10 layer.dataProvider().deleteAttributes([count-1])
11
12 # remove multiple fields with a list of indices
13 layer.dataProvider().deleteAttributes(ind_list)

```

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

```
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:

```
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.

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

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

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

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

```
1 # returns array of feature IDs of five nearest features
2 nearest = index.nearestNeighbor(QgsPointXY(25.4, 12.7), 5)
3
4 # returns array of IDs of features which intersect the rectangle
5 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:

```
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:

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

```
(['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`, `gpx`, `delimitedtext`...).

6.7.1 From an instance of `QgsVectorFileWriter`

```

1 # SaveVectorOptions contains many settings for the writer process
2 save_options = QgsVectorFileWriter.SaveVectorOptions()
3 transform_context = QgsProject.instance().transformContext()
4 # Write to a GeoPackage (default)
5 error = QgsVectorFileWriter.writeAsVectorFormatV2(layer,
6                                                  "testdata/my_new_file.gpkg",
7                                                  transform_context,
8                                                  save_options)
9 if error[0] == QgsVectorFileWriter.NoError:
10     print("success!")
11 else:
12     print(error)

```

```

1 # Write to an ESRI Shapefile format dataset using UTF-8 text encoding
2 save_options = QgsVectorFileWriter.SaveVectorOptions()
3 save_options.driverName = "ESRI Shapefile"
4 save_options.fileEncoding = "UTF-8"
5 transform_context = QgsProject.instance().transformContext()
6 error = QgsVectorFileWriter.writeAsVectorFormatV2(layer,
7                                                  "testdata/my_new_shapefile",
8                                                  transform_context,
9                                                  save_options)
10 if error[0] == QgsVectorFileWriter.NoError:
11     print("success again!")
12 else:
13     print(error)

```

```

1 # Write to an ESRI GDB file
2 save_options = QgsVectorFileWriter.SaveVectorOptions()
3 save_options.driverName = "FileGDB"
4 # if no geometry
5 save_options.overrideGeometryType = QgsWkbTypes.Unknown
6 save_options.actionOnExistingFile = QgsVectorFileWriter.CreateOrOverwriteLayer
7 save_options.layerName = 'my_new_layer_name'
8 transform_context = QgsProject.instance().transformContext()
9 gdb_path = "testdata/my_example.gdb"
10 error = QgsVectorFileWriter.writeAsVectorFormatV2(layer,
11                                                  gdb_path,
12                                                  transform_context,
13                                                  save_options)
14 if error[0] == QgsVectorFileWriter.NoError:
15     print("success!")
16 else:
17     print(error)

```

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:

```

1 LIST_FIELD_NAME = 'xxxx'
2
3 class ESRIValueConverter(QgsVectorFileWriter.FieldValueConverter):
4
5     def __init__(self, layer, list_field):
6         QgsVectorFileWriter.FieldValueConverter.__init__(self)
7         self.layer = layer
8         self.list_field_idx = self.layer.fields().indexOfName(list_field)
9
10    def convert(self, fieldIdxInLayer, value):
11        if fieldIdxInLayer == self.list_field_idx:
12            return QgsListFieldFormatter().representValue(layer=vlayer,
13                                                         fieldIndex=self.list_field_idx,
14                                                         config={},
15                                                         cache=None,
16                                                         value=value)
17
18        else:
19            return value
20
21    def fieldDefinition(self, field):
22        idx = self.layer.fields().indexOfName(field.name())
23        if idx == self.list_field_idx:
24            return QgsField(LIST_FIELD_NAME, QVariant.String)
25        else:
26            return self.layer.fields()[idx]
27
28 converter = ESRIValueConverter(vlayer, LIST_FIELD_NAME)
29 opts = QgsVectorFileWriter.SaveVectorOptions()
30 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

```

1 from qgis.PyQt.QtCore import QVariant
2
3 # define fields for feature attributes. A QgsFields object is needed
4 fields = QgsFields()
5 fields.append(QgsField("first", QVariant.Int))
6 fields.append(QgsField("second", QVariant.String))
7
8 """ create an instance of vector file writer, which will create the vector file.
9 Arguments:
10 1. path to new file (will fail if exists already)
11 2. field map
12 3. geometry type - from WKBTYPENUM enum
13 4. layer's spatial reference (instance of
14    QgsCoordinateReferenceSystem)
15 5. coordinate transform context
16 6. save options (driver name for the output file, encoding etc.)

```

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```

17 """
18
19 crs = QgsProject.instance().crs()
20 transform_context = QgsProject.instance().transformContext()
21 save_options = QgsVectorFileWriter.SaveVectorOptions()
22 save_options.driverName = "ESRI Shapefile"
23 save_options.fileEncoding = "UTF-8"
24
25 writer = QgsVectorFileWriter.create(
26     "testdata/my_new_shapefile.shp",
27     fields,
28     QgsWkbTypes.Point,
29     crs,
30     transform_context,
31     save_options
32 )
33
34 if writer.hasError() != QgsVectorFileWriter.NoError:
35     print("Error when creating shapefile: ", writer.errorMessage())
36
37 # add a feature
38 fet = QgsFeature()
39
40 fet.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(10,10)))
41 fet.setAttributes([1, "text"])
42 writer.addFeature(fet)
43
44 # delete the writer to flush features to disk
45 del writer

```

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.

Il provider supporta campi di tipo string, int e double.

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=name: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

```
"Point?crs=epsg:4326&field=id:integer&field=name:string(20)&index=yes"
```

The following example code illustrates creating and populating a memory provider

```
1 from qgis.PyQt.QtCore import QVariant
2
3 # create layer
4 vl = QgsVectorLayer("Point", "temporary_points", "memory")
5 pr = vl.dataProvider()
6
7 # add fields
8 pr.addAttributes([QgsField("name", QVariant.String),
9                     QgsField("age", QVariant.Int),
10                    QgsField("size", QVariant.Double)])
11 vl.updateFields() # tell the vector layer to fetch changes from the provider
12
13 # add a feature
14 fet = QgsFeature()
15 fet.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(10,10)))
16 fet.setAttributes(["Johny", 2, 0.3])
17 pr.addFeatures([fet])
18
19 # update layer's extent when new features have been added
20 # because change of extent in provider is not propagated to the layer
21 vl.updateExtents()
```

Finally, let's check whether everything went well

```
1 # show some stats
2 print("fields:", len(pr.fields()))
3 print("features:", pr.featureCount())
4 e = vl.extent()
5 print("extent:", e.xMinimum(), e.yMinimum(), e.xMaximum(), e.yMaximum())
6
7 # iterate over features
8 features = vl.getFeatures()
9 for fet in features:
10     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:

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

And with that reference, let us explore it a bit

```
print("Type:", renderer.type())
```

```
Type: singleSymbol
```

There are several known renderer types available in the QGIS core library:

Tipo	Classe	Descrizione
singleSymbol	<code>QgsSingleSymbolRenderer</code>	Visualizza tutte le geometria con lo stesso simbolo
categorizedSymbol	<code>QgsCategorizedSymbolRenderer</code>	Visualizza le geometria usando un simbolo diverso per ogni categoria
graduatedSymbol	<code>QgsGraduatedSymbolRenderer</code>	Visualizza le geometrie usando un simbolo diverso per ogni intervallo di valori

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:

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

```
['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

```
renderer.dump()
```

```
SINGLE: MARKER SYMBOL (1 layers) color 190,207,80,255
```

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:

```
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

- equilateral_triangle
- star
- regular_star
- arrow
- filled_arrowhead
- x

To get the full list of properties for the first symbol layer of a symbol instance you can follow the example code:

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

```
{'angle': '0', 'color': '255,0,0,255', 'horizontal_anchor_point': '1', 'joinstyle'  
↳': 'bevel', 'name': 'square', 'offset': '0,0', 'offset_map_unit_scale': '3x:0,0,  
↳0,0,0,0', 'offset_unit': 'MM', 'outline_color': '35,35,35,255', 'outline_style':  
↳'solid', 'outline_width': '0', 'outline_width_map_unit_scale': '3x:0,0,0,0,0,0',  
↳'outline_width_unit': 'MM', 'scale_method': 'diameter', 'size': '2', 'size_map_  
↳unit_scale': '3x:0,0,0,0,0,0', 'size_unit': 'MM', 'vertical_anchor_point': '1'}
```

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

```
1 # You can alter a single property...  
2 layer.renderer().symbol().symbolLayer(0).setSize(3)  
3 # ... but not all properties are accessible from methods,  
4 # you can also replace the symbol completely:  
5 props = layer.renderer().symbol().symbolLayer(0).properties()  
6 props['color'] = 'yellow'  
7 props['name'] = 'square'  
8 layer.renderer().setSymbol(QgsMarkerSymbol.createSimple(props))  
9 # show the changes  
10 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

```
1 categorized_renderer = QgsCategorizedSymbolRenderer()  
2 # Add a few categories  
3 cat1 = QgsRendererCategory('1', QgsMarkerSymbol(), 'category 1')  
4 cat2 = QgsRendererCategory('2', QgsMarkerSymbol(), 'category 2')  
5 categorized_renderer.addCategory(cat1)  
6 categorized_renderer.addCategory(cat2)  
7  
8 for cat in categorized_renderer.categories():  
9     print("{}: {} :: {}".format(cat.value(), cat.label(), cat.symbol()))
```

```
1: category 1 :: <qgis._core.QgsMarkerSymbol object at 0x7f378ffcd9d8>  
2: category 2 :: <qgis._core.QgsMarkerSymbol object at 0x7f378ffcd9d8>
```

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

```

1 graduated_renderer = QgsGraduatedSymbolRenderer()
2 # Add a few categories
3 graduated_renderer.addClassRange(QgsRendererRange(QgsClassificationRange('class 0-
↳100', 0, 100), QgsMarkerSymbol()))
4 graduated_renderer.addClassRange(QgsRendererRange(QgsClassificationRange('class_
↳101-200', 101, 200), QgsMarkerSymbol()))
5
6 for ran in graduated_renderer.ranges():
7     print("{} - {}: {} {}".format(
8         ran.lowerValue(),
9         ran.upperValue(),
10        ran.label(),
11        ran.symbol()
12    ))

```

```

0.0 - 100.0: class 0-100 <qgis._core.QgsMarkerSymbol object at 0x7f8bad281b88>
101.0 - 200.0: class 101-200 <qgis._core.QgsMarkerSymbol object at 0x7f8bad281b88>

```

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)

```

1 from qgis.PyQt import QtGui
2
3 myVectorLayer = QgsVectorLayer("testdata/airports.shp", "airports", "ogr")
4 myTargetField = 'ELEV'
5 myRangeList = []
6 myOpacity = 1
7 # Make our first symbol and range...
8 myMin = 0.0
9 myMax = 50.0
10 myLabel = 'Group 1'
11 myColour = QtGui.QColor('#ffee00')
12 mySymbol1 = QgsSymbol.defaultSymbol(myVectorLayer.geometryType())
13 mySymbol1.setColor(myColour)
14 mySymbol1.setOpacity(myOpacity)
15 myRange1 = QgsRendererRange(myMin, myMax, mySymbol1, myLabel)
16 myRangeList.append(myRange1)
17 #now make another symbol and range...
18 myMin = 50.1
19 myMax = 100
20 myLabel = 'Group 2'
21 myColour = QtGui.QColor('#00eeff')
22 mySymbol2 = QgsSymbol.defaultSymbol(
23     myVectorLayer.geometryType())
24 mySymbol2.setColor(myColour)
25 mySymbol2.setOpacity(myOpacity)
26 myRange2 = QgsRendererRange(myMin, myMax, mySymbol2, myLabel)
27 myRangeList.append(myRange2)
28 myRenderer = QgsGraduatedSymbolRenderer('', myRangeList)
29 myClassificationMethod = QgsApplication.classificationMethodRegistry().method(
↳"EqualInterval")

```

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```

30 myRenderer.setClassificationMethod(myClassificationMethod)
31 myRenderer.setClassAttribute(myTargetField)
32
33 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:

```

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:

```

1 from qgis.core import QgsSymbolLayerRegistry
2 myRegistry = QgsApplication.symbolLayerRegistry()
3 myMetadata = myRegistry.symbolLayerMetadata("SimpleFill")
4 for item in myRegistry.symbolLayersForType(QgsSymbol.Marker):
5     print(item)

```

```

1 EllipseMarker
2 FilledMarker
3 FontMarker
4 GeometryGenerator
5 MaskMarker
6 RasterMarker
7 SimpleMarker
8 SvgMarker
9 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

```

1 from qgis.core import QgsMarkerSymbolLayer
2 from qgis.PyQt.QtGui import QColor
3
4 class FooSymbolLayer(QgsMarkerSymbolLayer):
5
6     def __init__(self, radius=4.0):
7         QgsMarkerSymbolLayer.__init__(self)
8         self.radius = radius
9         self.color = QColor(255,0,0)
10
11    def layerType(self):
12        return "FooMarker"
13
14    def properties(self):
15        return { "radius" : str(self.radius) }
16
17    def startRender(self, context):
18        pass
19
20    def stopRender(self, context):
21        pass
22
23    def renderPoint(self, point, context):
24        # Rendering depends on whether the symbol is selected (QGIS >= 1.5)
25        color = context.selectionColor() if context.selected() else self.color
26        p = context.renderContext().painter()
27        p.setPen(color)
28        p.drawEllipse(point, self.radius, self.radius)
29
30    def clone(self):
31        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

```

1 from qgis.gui import QgsSymbolLayerWidget
2

```

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```

3 class FooSymbolLayerWidget(QgsSymbolLayerWidget):
4     def __init__(self, parent=None):
5         QgsSymbolLayerWidget.__init__(self, parent)
6
7         self.layer = None
8
9         # setup a simple UI
10        self.label = QLabel("Radius:")
11        self.spinRadius = QDoubleSpinBox()
12        self.hbox = QHBoxLayout()
13        self.hbox.addWidget(self.label)
14        self.hbox.addWidget(self.spinRadius)
15        self.setLayout(self.hbox)
16        self.connect(self.spinRadius, SIGNAL("valueChanged(double)"), \
17                    self.radiusChanged)
18
19        def setSymbolLayer(self, layer):
20            if layer.layerType() != "FooMarker":
21                return
22            self.layer = layer
23            self.spinRadius.setValue(layer.radius)
24
25        def symbolLayer(self):
26            return self.layer
27
28        def radiusChanged(self, value):
29            self.layer.radius = value
30            self.emit(SIGNAL("changed()"))

```

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

```

1 from qgis.core import QgsSymbol, QgsSymbolLayerAbstractMetadata, \
   ↳QgsSymbolLayerRegistry
2
3 class FooSymbolLayerMetadata(QgsSymbolLayerAbstractMetadata):
4
5     def __init__(self):
6         super().__init__("FooMarker", "My new Foo marker", QgsSymbol.Marker)
7
8     def createSymbolLayer(self, props):
9         radius = float(props["radius"]) if "radius" in props else 4.0
10        return FooSymbolLayer(radius)
11
12 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

```

1 import random
2 from qgis.core import QgsWkbTypes, QgsSymbol, QgsFeatureRenderer
3
4
5 class RandomRenderer(QgsFeatureRenderer):
6     def __init__(self, syms=None):
7         super().__init__("RandomRenderer")
8         self.syms = syms if syms else [
9             QgsSymbol.defaultSymbol(QgsWkbTypes.geometryType(QgsWkbTypes.Point)),
10            QgsSymbol.defaultSymbol(QgsWkbTypes.geometryType(QgsWkbTypes.Point))
11        ]
12
13    def symbolForFeature(self, feature, context):
14        return random.choice(self.syms)
15
16    def startRender(self, context, fields):
17        super().startRender(context, fields)
18        for s in self.syms:
19            s.startRender(context, fields)
20
21    def stopRender(self, context):
22        super().stopRender(context)
23        for s in self.syms:
24            s.stopRender(context)
25
26    def usedAttributes(self, context):
27        return []
28
29    def clone(self):
30        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

```

1 from qgis.gui import QgsRendererWidget, QgsColorButton
2
3
4 class RandomRendererWidget(QgsRendererWidget):
5     def __init__(self, layer, style, renderer):

```

(continues on next page)

```

6     super().__init__(layer, style)
7     if renderer is None or renderer.type() != "RandomRenderer":
8         self.r = RandomRenderer()
9     else:
10        self.r = renderer
11    # setup UI
12    self.btn1 = QgsColorButton()
13    self.btn1.setColor(self.r.syms[0].color())
14    self.vbox = QVBoxLayout()
15    self.vbox.addWidget(self.btn1)
16    self.setLayout(self.vbox)
17    self.btn1.colorChanged.connect(self.setColor1)
18
19    def setColor1(self):
20        color = self.btn1.color()
21        if not color.isValid(): return
22        self.r.syms[0].setColor(color)
23
24    def renderer(self):
25        return self.r

```

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

```

1  from qgis.core import (
2      QgsRendererAbstractMetadata,
3      QgsRendererRegistry,
4      QgsApplication
5  )
6
7  class RandomRendererMetadata(QgsRendererAbstractMetadata):
8
9      def __init__(self):
10         super().__init__("RandomRenderer", "Random renderer")
11
12     def createRenderer(self, element):
13         return RandomRenderer()
14
15     def createRendererWidget(self, layer, style, renderer):
16         return RandomRendererWidget(layer, style, renderer)
17
18 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

```
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:

```
1 from qgis.core import (  
2     QgsGeometry,  
3     QgsPoint,  
4     QgsPointXY,  
5     QgsWkbTypes,  
6     QgsProject,  
7     QgsFeatureRequest,  
8     QgsVectorLayer,  
9     QgsDistanceArea,  
10    QgsUnitTypes,  
11    QgsCoordinateTransform,  
12    QgsCoordinateReferenceSystem  
13 )
```

Gestione della Geometria

- *Costruzione della Geometria*
- *Accedere alla Geometria*
- *Predicati ed Operazioni delle Geometrie*

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 é effettivamente una collezione di geometrie (parti singole) piú semplici. Se contiene un tipo di geometria semplice, la chiameremo punti multipli, string multi linea o poligoni multipli. Ad esempio, un Paese formato da piú isole puó 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

```
1 gPnt = QgsGeometry.fromPointXY(QgsPointXY(1,1))
2 print(gPnt)
3 gLine = QgsGeometry.fromPolyline([QgsPoint(1, 1), QgsPoint(2, 2)])
4 print(gLine)
5 gPolygon = QgsGeometry.fromPolygonXY([[QgsPointXY(1, 1),
6     QgsPointXY(2, 2), QgsPointXY(2, 1)])]
7 print(gPolygon)
```

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 é una lista di punti, una stringa multi linea é una linea di linee ed un poligono multiplo é una lista di poligoni.

- da well-known text (WKT)

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

- da well-known binary (WKB)

```
1 g = QgsGeometry()
2 wkb = bytes.fromhex("01010000000000000000000045400000000000001440")
3 g.fromWkb(wkb)
4
5 # print WKT representation of the geometry
6 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.

```
1 if gPnt.wkbType() == QgsWkbTypes.Point:
2     print(gPnt.wkbType())
3     # output: 1 for Point
4 if gLine.wkbType() == QgsWkbTypes.LineString:
5     print(gLine.wkbType())
6     # output: 2 for LineString
7 if gPolygon.wkbType() == QgsWkbTypes.Polygon:
8     print(gPolygon.wkbType())
9     # 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.

```
1 print(QgsWkbTypes.displayString(gPnt.wkbType()))
2 # output: 'Point'
3 print(QgsWkbTypes.displayString(gLine.wkbType()))
4 # output: 'LineString'
5 print(QgsWkbTypes.displayString(gPolygon.wkbType()))
6 # output: 'Polygon'
```

```
Point
LineString
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 accessors:

```
1 print(gPnt.asPoint())
2 # output: <QgsPointXY: POINT(1 1)>
3 print(gLine.asPolyline())
```

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```

4 # output: [<QgsPointXY: POINT(1 1)>, <QgsPointXY: POINT(2 2)>]
5 print(gPolygon.asPolygon())
6 # output: [[<QgsPointXY: POINT(1 1)>, <QgsPointXY: POINT(2 2)>, <QgsPointXY:
↵POINT(2 1)>, <QgsPointXY: POINT(1 1)>]]

```

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.

```

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)

```

```

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.

```

1 geom = QgsGeometry.fromWkt( 'MultiPoint( 0 0, 1 1, 2 2)' )
2 for part in geom.parts():
3     part.transform(QgsCoordinateTransform(
4         QgsCoordinateReferenceSystem("EPSG:4326"),
5         QgsCoordinateReferenceSystem("EPSG:3111"),
6         QgsProject.instance())
7     )
8
9 print(geom.asWkt())

```

```

MultiPoint ((-10334726.79314761981368065 -5360105.10101188533008099), (-10462133.
↵82917750626802444 -5217484.34365727473050356), (-10589398.51346865110099316 -
↵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.

```

1 # let's access the 'countries' layer
2 layer = QgsProject.instance().mapLayersByName('countries')[0]
3
4 # let's filter for countries that begin with Z, then get their features
5 query = '"name" LIKE \'Z%\''
6 features = layer.getFeatures(QgsFeatureRequest().setFilterExpression(query))
7
8 # now loop through the features, perform geometry computation and print the results
9 for f in features:
10     geom = f.geometry()
11     name = f.attribute('NAME')
12     print(name)
13     print('Area: ', geom.area())
14     print('Perimeter: ', geom.length())

```

```

1 Zambia
2 Area: 62.822790653431205
3 Perimeter: 50.65232014052552
4 Zimbabwe
5 Area: 33.41113559136521
6 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.

```

1 d = QgsDistanceArea()
2 d.setEllipsoid('WGS84')
3
4 layer = QgsProject.instance().mapLayersByName('countries')[0]
5
6 # let's filter for countries that begin with Z, then get their features
7 query = '"name" LIKE \'Z%\''
8 features = layer.getFeatures(QgsFeatureRequest().setFilterExpression(query))
9
10 for f in features:
11     geom = f.geometry()
12     name = f.attribute('NAME')
13     print(name)
14     print("Perimeter (m):", d.measurePerimeter(geom))
15     print("Area (m2):", d.measureArea(geom))
16
17     # let's calculate and print the area again, but this time in square kilometers
18     print("Area (km2):", d.convertAreaMeasurement(d.measureArea(geom), QgsUnitTypes.
↪AreaSquareKilometers))

```

```

1 Zambia
2 Perimeter (m): 5539361.250080013
3 Area (m2): 752000605894.2937
4 Area (km2): 752000.6058942936
5 Zimbabwe
6 Perimeter (m): 2865021.3323912495
7 Area (m2): 389250992553.95465
8 Area (km2): 389250.99255395465

```

Alternatively, you may want to know the distance and bearing between two points.

```
1 d = QgsDistanceArea()
2 d.setEllipsoid('WGS84')
3
4 # Let's create two points.
5 # Santa claus is a workaholic and needs a summer break,
6 # lets see how far is Tenerife from his home
7 santa = QgsPointXY(25.847899, 66.543456)
8 tenerife = QgsPointXY(-16.5735, 28.0443)
9
10 print("Distance in meters: ", d.measureLine(santa, tenerife))
```

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:

```
1 from qgis.core import (
2     QgsCoordinateReferenceSystem,
3     QgsCoordinateTransform,
4     QgsProject,
5     QgsPointXY,
6 )
```


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

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

```
True
```

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)

```
1 wkt = 'GEOGCS["WGS84", DATUM["WGS84", SPHEROID["WGS84", 6378137.0, 298.
   ↳257223563]],' \
2     'PRIMEM["Greenwich", 0.0], UNIT["degree",0.017453292519943295],' \
3     'AXIS["Longitude",EAST], AXIS["Latitude",NORTH]]'
4 crs = QgsCoordinateReferenceSystem(wkt)
5 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.

```
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:

```
1 crs = QgsCoordinateReferenceSystem("EPSG:4326")
2
3 print("QGIS CRS ID:", crs.srsid())
4 print("PostGIS SRID:", crs.postgisSrid())
5 print("Description:", crs.description())
6 print("Projection Acronym:", crs.projectionAcronym())
7 print("Ellipsoid Acronym:", crs.ellipsoidAcronym())
8 print("Proj String:", crs.toProj())
9 # check whether it's geographic or projected coordinate system
10 print("Is geographic:", crs.isGeographic())
11 # check type of map units in this CRS (values defined in QGis::units enum)
12 print("Map units:", crs.mapUnits())
```

In uscita:

```
1 QGIS CRS ID: 3452
2 PostGIS SRID: 4326
3 Description: WGS 84
4 Projection Acronym: longlat
5 Ellipsoid Acronym: EPSG:7030
6 Proj String: +proj=longlat +datum=WGS84 +no_defs
7 Is geographic: True
8 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.

```
1 crsSrc = QgsCoordinateReferenceSystem("EPSG:4326") # WGS 84
2 crsDest = QgsCoordinateReferenceSystem("EPSG:32633") # WGS 84 / UTM zone 33N
3 transformContext = QgsProject.instance().transformContext()
4 xform = QgsCoordinateTransform(crsSrc, crsDest, transformContext)
5
6 # forward transformation: src -> dest
7 pt1 = xform.transform(QgsPointXY(18,5))
```

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```
8 print("Transformed point:", pt1)
9
10 # inverse transformation: dest -> src
11 pt2 = xform.transform(pt1, QgsCoordinateTransform.ReverseTransform)
12 print("Transformed back:", pt2)
```

In uscita:

```
Transformed point: <QgsPointXY: POINT(832713.79873844375833869 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:

```
1 from qgis.PyQt.QtGui import (
2     QColor,
3 )
4
5 from qgis.PyQt.QtCore import Qt, QRectF
6
7 from qgis.core import (
8     QgsVectorLayer,
9     QgsPoint,
10    QgsPointXY,
11    QgsProject,
12    QgsGeometry,
13    QgsMapRendererJob,
14 )
15
16 from qgis.gui import (
17    QgsMapCanvas,
18    QgsVertexMarker,
19    QgsMapCanvasItem,
20    QgsRubberBand,
21 )
```

Using the Map Canvas

- *Embedding Map Canvas*
- *Rubber Bands and Vertex Markers*
- *Using Map Tools with Canvas*
 - *Select a feature using `QgsMapToolIdentifyFeature`*
- *Writing Custom Map Tools*
- *Writing Custom Map Canvas Items*

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.

```
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.gui` 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

```
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.

```
1 vlayer = QgsVectorLayer('testdata/airports.shp', "Airports layer", "ogr")
2 if not vlayer.isValid():
3     print("Layer failed to load!")
4
5 # add layer to the registry
6 QgsProject.instance().addMapLayer(vlayer)
7
8 # set extent to the extent of our layer
9 canvas.setExtent(vlayer.extent())
10
11 # set the map canvas layer set
12 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:

```
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

```
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

```
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

```
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:

```
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

```
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.

```
1 from qgis.gui import *
2 from qgis.PyQt.QtWidgets import QAction, QMainWindow
3 from qgis.PyQt.QtCore import Qt
4
5 class MyWnd(QMainWindow):
6     def __init__(self, layer):
7         QMainWindow.__init__(self)
8
9         self.canvas = QgsMapCanvas()
10        self.canvas.setCanvasColor(Qt.white)
11
12        self.canvas.setExtent(layer.extent())
13        self.canvas.setLayers([layer])
14
15        self.setCentralWidget(self.canvas)
16
17        self.actionZoomIn = QAction("Zoom in", self)
18        self.actionZoomOut = QAction("Zoom out", self)
```

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```

19     self.actionPan = QAction("Pan", self)
20
21     self.actionZoomIn.setCheckable(True)
22     self.actionZoomOut.setCheckable(True)
23     self.actionPan.setCheckable(True)
24
25     self.actionZoomIn.triggered.connect(self.zoomIn)
26     self.actionZoomOut.triggered.connect(self.zoomOut)
27     self.actionPan.triggered.connect(self.pan)
28
29     self.toolbar = self.addToolBar("Canvas actions")
30     self.toolbar.addAction(self.actionZoomIn)
31     self.toolbar.addAction(self.actionZoomOut)
32     self.toolbar.addAction(self.actionPan)
33
34     # create the map tools
35     self.toolPan = QgsMapToolPan(self.canvas)
36     self.toolPan.setAction(self.actionPan)
37     self.toolZoomIn = QgsMapToolZoom(self.canvas, False) # false = in
38     self.toolZoomIn.setAction(self.actionZoomIn)
39     self.toolZoomOut = QgsMapToolZoom(self.canvas, True) # true = out
40     self.toolZoomOut.setAction(self.actionZoomOut)
41
42     self.pan()
43
44     def zoomIn(self):
45         self.canvas.setMapTool(self.toolZoomIn)
46
47     def zoomOut(self):
48         self.canvas.setMapTool(self.toolZoomOut)
49
50     def pan(self):
51         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

```

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.

```

1  def callback(feature):
2      """Code called when the feature is selected by the user"""
3      print("You clicked on feature {}".format(feature.id()))
4
5  canvas = iface.mapCanvas()
6  feature_identifier = QgsMapToolIdentifyFeature(canvas)
7
8  # indicates the layer on which the selection will be done
9  feature_identifier.setLayer(vlayer)
10
11 # use the callback as a slot triggered when the user identifies a feature
12 feature_identifier.featureIdentified.connect(callback)
13
14 # activation of the map tool
15 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.

```

1 class RectangleMapTool(QgsMapToolEmitPoint):
2     def __init__(self, canvas):
3         self.canvas = canvas
4         QgsMapToolEmitPoint.__init__(self, self.canvas)
5         self.rubberBand = QgsRubberBand(self.canvas, True)
6         self.rubberBand.setColor(Qt.red)
7         self.rubberBand.setWidth(1)
8         self.reset()
9
10    def reset(self):
11        self.startPoint = self.endPoint = None
12        self.isEmittingPoint = False
13        self.rubberBand.reset(True)
14
15    def canvasPressEvent(self, e):
16        self.startPoint = self.toMapCoordinates(e.pos())
17        self.endPoint = self.startPoint
18        self.isEmittingPoint = True
19        self.showRect(self.startPoint, self.endPoint)
20
21    def canvasReleaseEvent(self, e):
22        self.isEmittingPoint = False
23        r = self.rectangle()
24        if r is not None:
25            print("Rectangle:", r.xMinimum(),
26                  r.yMinimum(), r.xMaximum(), r.yMaximum()
27                  )
28
29    def canvasMoveEvent(self, e):
30        if not self.isEmittingPoint:
31            return
32
33        self.endPoint = self.toMapCoordinates(e.pos())
34        self.showRect(self.startPoint, self.endPoint)
35
36    def showRect(self, startPoint, endPoint):
37        self.rubberBand.reset(QGis.Polygon)
38        if startPoint.x() == endPoint.x() or startPoint.y() == endPoint.y():
39            return
40
41        point1 = QgsPoint(startPoint.x(), startPoint.y())
42        point2 = QgsPoint(startPoint.x(), endPoint.y())
43        point3 = QgsPoint(endPoint.x(), endPoint.y())
44        point4 = QgsPoint(endPoint.x(), startPoint.y())
45
46        self.rubberBand.addPoint(point1, False)
47        self.rubberBand.addPoint(point2, False)
48        self.rubberBand.addPoint(point3, False)
49        self.rubberBand.addPoint(point4, True)    # true to update canvas
50        self.rubberBand.show()
51

```

(continues on next page)

```

52 def rectangle(self):
53     if self.startPoint is None or self.endPoint is None:
54         return None
55     elif (self.startPoint.x() == self.endPoint.x() or \
56           self.startPoint.y() == self.endPoint.y()):
57         return None
58
59     return QgsRectangle(self.startPoint, self.endPoint)
60
61 def deactivate(self):
62     QgsMapTool.deactivate(self)
63     self.deactivated.emit()

```

9.5 Writing Custom Map Canvas Items

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

```

1 class CircleCanvasItem(QgsMapCanvasItem):
2     def __init__(self, canvas):
3         super().__init__(canvas)
4         self.center = QgsPoint(0, 0)
5         self.size = 100
6
7     def setCenter(self, center):
8         self.center = center
9
10    def center(self):
11        return self.center
12
13    def setSize(self, size):
14        self.size = size
15
16    def size(self):
17        return self.size
18
19    def boundingRect(self):
20        return QRectF(self.center.x() - self.size/2,
21                      self.center.y() - self.size/2,
22                      self.center.x() + self.size/2,
23                      self.center.y() + self.size/2)
24
25    def paint(self, painter, option, widget):
26        path = QPainterPath()
27        path.moveTo(self.center.x(), self.center.y());
28        path.arcTo(self.boundingRect(), 0.0, 360.0)
29        painter.fillPath(path, QColor("red"))
30
31
32    # Using the custom item:
33    item = CircleCanvasItem(iface.mapCanvas())
34    item.setCenter(QgsPointXY(200,200))
35    item.setSize(80)

```

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

```

1 import os
2
3 from qgis.core import (

```

(continues on next page)

(continua dalla pagina precedente)

```
4     QgsGeometry,  
5     QgsMapSettings,  
6     QgsPrintLayout,  
7     QgsMapSettings,  
8     QgsMapRendererParallelJob,  
9     QgsLayoutItemLabel,  
10    QgsLayoutItemLegend,  
11    QgsLayoutItemMap,  
12    QgsLayoutItemPolygon,  
13    QgsLayoutItemScaleBar,  
14    QgsLayoutExporter,  
15    QgsLayoutItem,  
16    QgsLayoutPoint,  
17    QgsLayoutSize,  
18    QgsUnitTypes,  
19    QgsProject,  
20    QgsFillSymbol,  
21 )  
22  
23 from qgis.PyQt.QtGui import (  
24     QPolygonF,  
25     QColor,  
26 )  
27  
28 from qgis.PyQt.QtCore import (  
29     QPointF,  
30     QRectF,  
31     QSize,  
32 )
```

Visualizzazione e Stampa di una Mappa

- *Visualizzazione Semplice*
- *Visualizzare layer con diversi SR*
- *Output using print layout*
 - *Exporting the layout*
 - *Exporting a layout atlas*

There are generally two approaches when input data should be rendered as a map: either do it quick way using `QgsMapRendererJob` or produce more fine-tuned output by composing the map with the `QgsLayout` class.

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:

```
1 image_location = os.path.join(QgsProject.instance().homePath(), "render.png")
2
3 vlayer = iface.activeLayer()
4 settings = QgsMapSettings()
5 settings.setLayers([vlayer])
6 settings.setBackgroundColor(QColor(255, 255, 255))
7 settings.setOutputSize(QSize(800, 600))
8 settings.setExtent(vlayer.extent())
9
10 render = QgsMapRendererParallelJob(settings)
11
12 def finished():
13     img = render.renderedImage()
14     # save the image; e.g. img.save("/Users/myuser/render.png", "png")
15     img.save(image_location, "png")
16
```

(continues on next page)

```
17 render.finished.connect (finished)
18
19 # Start the rendering
20 render.start ()
21
22 # The following loop is not normally required, we
23 # are using it here because this is a standalone example.
24 from qgis.PyQt.QtCore import QEventLoop
25 loop = QEventLoop ()
26 render.finished.connect (loop.quit)
27 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

```
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:

```
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:

```
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

```

1 map = QgsLayoutItemMap(layout)
2 # Set map item position and size (by default, it is a 0 width/0 height item.
  ↳placed at 0,0)
3 map.attemptMove(QgsLayoutPoint(5,5, QgsUnitTypes.LayoutMillimeters))
4 map.attemptResize(QgsLayoutSize(200,200, QgsUnitTypes.LayoutMillimeters))
5 # Provide an extent to render
6 map.zoomToExtent(iface.mapCanvas().extent())
7 layout.addLayoutItem(map)

```

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

```

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

```

- **legenda**

```

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

```

- **barra di scala**

```

1 item = QgsLayoutItemScaleBar(layout)
2 item.setStyle('Numeric') # optionally modify the style
3 item.setLinkedMap(map) # map is an instance of QgsLayoutItemMap
4 item.applyDefaultSize()
5 layout.addLayoutItem(item)

```

- **freccia**
- **immagine**
- **basic shape**
- **nodes based shape**

```

1 polygon = QPolygonF()
2 polygon.append(QPointF(0.0, 0.0))
3 polygon.append(QPointF(100.0, 0.0))
4 polygon.append(QPointF(200.0, 100.0))
5 polygon.append(QPointF(100.0, 200.0))
6
7 polygonItem = QgsLayoutItemPolygon(polygon, layout)
8 layout.addLayoutItem(polygonItem)
9
10 props = {}
11 props["color"] = "green"
12 props["style"] = "solid"
13 props["style_border"] = "solid"
14 props["color_border"] = "black"
15 props["width_border"] = "10.0"
16 props["joinstyle"] = "miter"
17
18 symbol = QgsFillSymbol.createSimple(props)
19 polygonItem.setSymbol(symbol)

```

- **tabella**

Once an item is added to the layout, it can be moved and resized:

```
item.attemptMove(QgsLayoutPoint(1.4, 1.8, QgsUnitTypes.LayoutCentimeters))
item.attemptResize(QgsLayoutSize(2.8, 2.2, QgsUnitTypes.LayoutCentimeters))
```

A frame is drawn around each item by default. You can remove it as follows:

```
# 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.

```
1 base_path = os.path.join(QgsProject.instance().homePath())
2 pdf_path = os.path.join(base_path, "output.pdf")
3
4 exporter = QgsLayoutExporter(layout)
5 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:

```
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:

```
1 from qgis.core import (
2     edit,
3     QgsExpression,
4     QgsExpressionContext,
5     QgsFeature,
6     QgsFeatureRequest,
7     QgsField,
8     QgsFields,
9     QgsVectorLayer,
10    QgsPointXY,
11    QgsGeometry,
12    QgsProject,
13    QgsExpressionContextUtils
14 )
```

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 racchiuse tra apici singoli: 'hello world'
- riferimento a colonna – durante la valutazione, il riferimento é 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(angolo) > 0`
- `'Hello' LIKE 'He%'`
- `(x > 10 AND y > 10) OR z = 0`

Esempi di espressioni scalari:

- `2 ^ 10`
- `sqrt(val)`
- `$length + 1`

11.1 Analisi di Espressioni

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

```
1 exp = QgsExpression('1 + 1 = 2')
2 assert(not exp.hasParserError())
3
4 exp = QgsExpression('1 + 1 = ')
5 assert(exp.hasParserError())
6
7 assert(exp.parserErrorMessage() == '\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:

```
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)

```
exp = QgsExpression('1 + 1 = 2')
exp.evaluate()
# 1
```

11.2.2 Espressioni con geometrie

To evaluate an expression against a feature, a `QgsExpressionContext` object has to be created and passed to the evaluate function in order to allow the expression to access the feature's field values.

The following example shows how to create a feature with a field called «Column» and how to add this feature to the expression context.

```

1 fields = QgsFields()
2 field = QgsField('Column')
3 fields.append(field)
4 feature = QgsFeature()
5 feature.setFields(fields)
6 feature.setAttribute(0, 99)
7
8 exp = QgsExpression("Column")
9 context = QgsExpressionContext()
10 context.setFeature(feature)
11 exp.evaluate(context)
12 # 99

```

The following is a more complete example of how to use expressions in the context of a vector layer, in order to compute new field values:

```

1 from qgis.PyQt.QtCore import QVariant
2
3 # create a vector layer
4 vl = QgsVectorLayer("Point", "Companies", "memory")
5 pr = vl.dataProvider()
6 pr.addAttributes([QgsField("Name", QVariant.String),
7                    QgsField("Employees", QVariant.Int),
8                    QgsField("Revenue", QVariant.Double),
9                    QgsField("Rev. per employee", QVariant.Double),
10                   QgsField("Sum", QVariant.Double),
11                   QgsField("Fun", QVariant.Double)])
12 vl.updateFields()
13
14 # add data to the first three fields
15 my_data = [
16     {'x': 0, 'y': 0, 'name': 'ABC', 'emp': 10, 'rev': 100.1},
17     {'x': 1, 'y': 1, 'name': 'DEF', 'emp': 2, 'rev': 50.5},
18     {'x': 5, 'y': 5, 'name': 'GHI', 'emp': 100, 'rev': 725.9}]
19
20 for rec in my_data:
21     f = QgsFeature()
22     pt = QgsPointXY(rec['x'], rec['y'])
23     f.setGeometry(QgsGeometry.fromPointXY(pt))
24     f.setAttributes([rec['name'], rec['emp'], rec['rev']])
25     pr.addFeature(f)
26
27 vl.updateExtents()
28 QgsProject.instance().addMapLayer(vl)
29
30 # The first expression computes the revenue per employee.
31 # The second one computes the sum of all revenue values in the layer.
32 # The final third expression doesn't really make sense but illustrates
33 # the fact that we can use a wide range of expression functions, such
34 # as area and buffer in our expressions:
35 expression1 = QgsExpression("Revenue/" + "Employees")
36 expression2 = QgsExpression("sum(Revenue)")
37 expression3 = QgsExpression("area(buffer($geometry, " + "Employees"))")
38

```

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```

39 # QgsExpressionContextUtils.globalProjectLayerScopes() is a convenience
40 # function that adds the global, project, and layer scopes all at once.
41 # Alternatively, those scopes can also be added manually. In any case,
42 # it is important to always go from "most generic" to "most specific"
43 # scope, i.e. from global to project to layer
44 context = QgsExpressionContext()
45 context.appendScopes(QgsExpressionContextUtils.globalProjectLayerScopes(vl))
46
47 with edit(vl):
48     for f in vl.getFeatures():
49         context.setFeature(f)
50         f['Rev. per employee'] = expression1.evaluate(context)
51         f['Sum'] = expression2.evaluate(context)
52         f['Fun'] = expression3.evaluate(context)
53         vl.updateFeature(f)
54
55 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.

```

1 layer = QgsVectorLayer("Point?field=Test:integer",
2                       "addfeat", "memory")
3
4 layer.startEditing()
5
6 for i in range(10):
7     feature = QgsFeature()
8     feature.setAttributes([i])
9     assert(layer.addFeature(feature))
10 layer.commitChanges()
11
12 expression = 'Test >= 3'
13 request = QgsFeatureRequest().setFilterExpression(expression)
14
15 matches = 0
16 for f in layer.getFeatures(request):
17     matches += 1
18
19 print(matches)

```

7

11.3 Handling expression errors

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

```

1 exp = QgsExpression("1 + 1 = 2")
2 if exp.hasParserError():
3     raise Exception(exp.parserErrorString())
4
5 value = exp.evaluate()

```

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```
6 if exp.hasEvalError():  
7     raise ValueError(exp.evalErrorString())
```

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

```
1 from qgis.core import (  
2     QgsProject,  
3     QgsSettings,  
4     QgsVectorLayer  
5 )
```

Leggere E Memorizzare Impostazioni

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.

```
1 def store():
2     s = QgsSettings()
3     s.setValue("myplugin/mytext", "hello world")
4     s.setValue("myplugin/myint", 10)
5     s.setValue("myplugin/myreal", 3.14)
6
7 def read():
8     s = QgsSettings()
9     mytext = s.value("myplugin/mytext", "default text")
10    myint = s.value("myplugin/myint", 123)
11    myreal = s.value("myplugin/myreal", 2.71)
12    nonexistent = s.value("myplugin/nonexistent", None)
13    print(mytext)
14    print(myint)
15    print(myreal)
16    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.

```

1 proj = QgsProject.instance()
2
3 # store values
4 proj.writeEntry("myplugin", "mytext", "hello world")
5 proj.writeEntry("myplugin", "myint", 10)
6 proj.writeEntryDouble("myplugin", "mydouble", 0.01)
7 proj.writeEntryBool("myplugin", "mybool", True)
8
9 # read values (returns a tuple with the value, and a status boolean
10 # which communicates whether the value retrieved could be converted to
11 # its type, in these cases a string, an integer, a double and a boolean
12 # respectively)
13
14 mytext, type_conversion_ok = proj.readEntry("myplugin",
15                                           "mytext",
16                                           "default text")
17 myint, type_conversion_ok = proj.readNumEntry("myplugin",
18                                              "myint",
19                                              123)
20 mydouble, type_conversion_ok = proj.readDoubleEntry("myplugin",
21                                                    "mydouble",
22                                                    123)
23 mybool, type_conversion_ok = proj.readBoolEntry("myplugin",
24                                                "mybool",
25                                                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.

```

1 vlayer = QgsVectorLayer()
2 # save a value
3 vlayer.setCustomProperty("mytext", "hello world")
4
5 # read the value again (returning "default text" if not found)
6 mytext = vlayer.customProperty("mytext", "default text")

```

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

```

1 from qgis.core import (
2     QgsMessageLog,
3     QgsGeometry,
4 )
5
6 from qgis.gui import (
7     QgsMessageBar,
8 )
9
10 from qgis.PyQt.QtWidgets import (
11     QSizePolicy,
12     QPushButton,
13     QDialog,

```

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```
14     QGridLayout,  
15     QDialogButtonBox,  
16 )
```


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 nella barra dei messaggi utilizzando il seguente codice

```
from qgis.core import Qgs
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
```

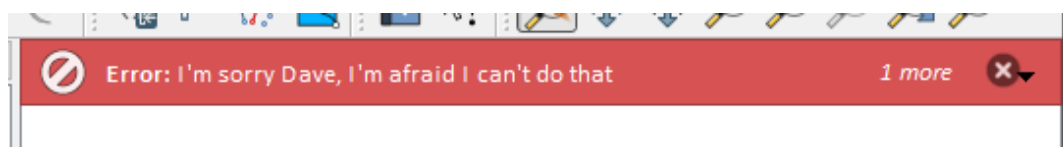


Fig. 13.1: Barra dei messaggi di QGIS

É possibile impostare una durata per mostrarlo per un tempo limitato

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

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

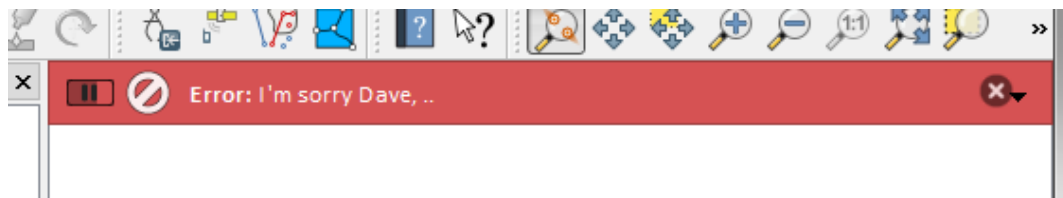


Fig. 13.2: Barra dei messaggi di QGIS con timer

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

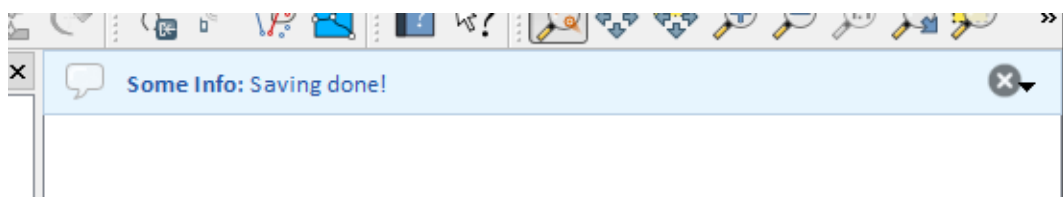


Fig. 13.3: Barra dei messaggi di QGIS (informazioni)

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

```
1 def showError():
2     pass
3
4 widget = iface.messageBar().createMessage("Missing Layers", "Show Me")
5 button = QPushButton(widget)
6 button.setText("Show Me")
7 button.pressed.connect(showError)
8 widget.layout().addWidget(button)
9 iface.messageBar().pushWidget(widget, Qgis.Warning)
```

Messages(1): Missing Layers : Show Me

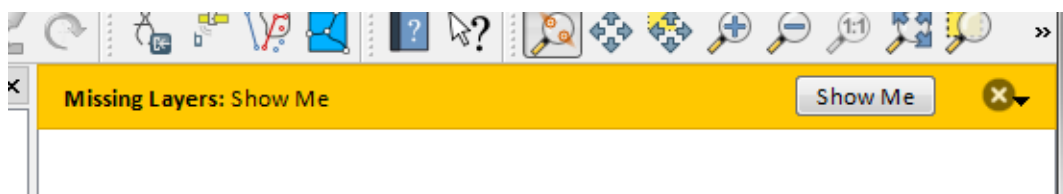


Fig. 13.4: Barra dei messaggi di QGIS con un pulsante

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.

```

1 class MyDialog(QDialog):
2     def __init__(self):
3         QDialog.__init__(self)
4         self.bar = QgsMessageBar()
5         self.bar.setSizePolicy(QSizePolicy.Minimum, QSizePolicy.Fixed)
6         self.setLayout(QGridLayout())
7         self.layout().setContentsMargins(0, 0, 0, 0)
8         self.buttonbox = QDialogButtonBox(QDialogButtonBox.Ok)
9         self.buttonbox.accepted.connect(self.run)
10        self.layout().addWidget(self.buttonbox, 0, 0, 2, 1)
11        self.layout().addWidget(self.bar, 0, 0, 1, 1)
12    def run(self):
13        self.bar.pushMessage("Hello", "World", level=Qgis.Info)
14
15 myDlg = MyDialog()
16 myDlg.show()

```

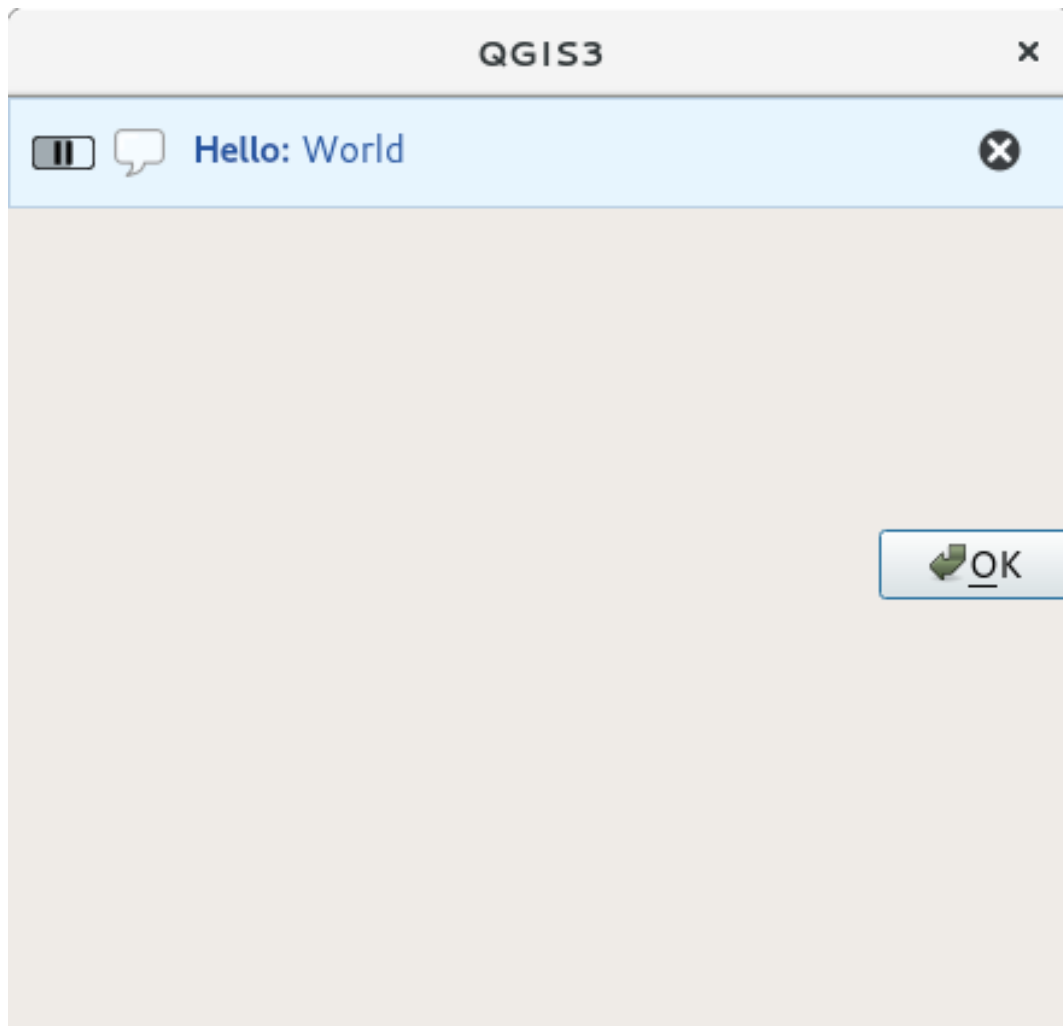


Fig. 13.5: Barra dei messaggi di QGIS in una finestra di dialogo personalizzata

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.

```

1 import time
2 from qgis.PyQt.QtWidgets import QProgressBar
3 from qgis.PyQt.QtCore import *
4 progressMessageBar = iface.messageBar().createMessage("Doing something boring...")
5 progress = QProgressBar()
6 progress.setMaximum(10)
7 progress.setAlignment(Qt.AlignLeft|Qt.AlignVCenter)
8 progressMessageBar.layout().addWidget(progress)
9 iface.messageBar().pushWidget(progressMessageBar, Qgis.Info)
10
11 for i in range(10):
12     time.sleep(1)
13     progress.setValue(i + 1)
14
15 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:

```

1 vlayer = iface.activeLayer()
2
3 count = vlayer.featureCount()
4 features = vlayer.getFeatures()
5
6 for i, feature in enumerate(features):
7     # do something time-consuming here
8     print('.') # printing should give enough time to present the progress
9
10     percent = i / float(count) * 100
11     # iface.mainWindow().statusBar().showMessage("Processed {} %".
↪format(int(percent)))
12     iface.statusBarIface().showMessage("Processed {} %".format(int(percent)))
13
14 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

```
# 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

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

The `basicConfig` method configures the 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:

```
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:

```
1 from qgis.core import (
2     QgsApplication,
3     QgsRasterLayer,
4     QgsAuthMethodConfig,
5     QgsDataSourceUri,
6     QgsPkiBundle,
7     QgsMessageLog,
8 )
9
10 from qgis.gui import (
11     QgsAuthAuthoritiesEditor,
12     QgsAuthConfigEditor,
13     QgsAuthConfigSelect,
14     QgsAuthSettingsWidget,
15 )
16
17 from qgis.PyQt.QtWidgets import (
18     QWidget,
19     QTabWidget,
20 )
21
22 from qgis.PyQt.QtNetwork import QSslCertificate
```

Authentication infrastructure

- *Introduzione*
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 - *Init the manager and set the master password*
 - *Populate authdb with a new Authentication Configuration entry*
 - * *Available Authentication methods*
 - * *Populate Authorities*
 - * *Manage PKI bundles with QgsPkiBundle*
 - *Remove an entry from authdb*
 - *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* crypted 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.

```

1 authMgr = QgsApplication.authManager()
2
3 # check if QgsAuthManager has already been initialized... a side effect
4 # of the QgsAuthManager.init() is that AuthDbPath is set.
5 # QgsAuthManager.init() is executed during QGIS application init and hence
6 # you do not normally need to call it directly.
7 if authMgr.authenticationDatabasePath():
8     # already initialized => we are inside a QGIS app.
9     if authMgr.masterPasswordIsSet():
10        msg = 'Authentication master password not recognized'
11        assert authMgr.masterPasswordSame("your master password"), msg
12    else:
13        msg = 'Master password could not be set'
14        # The verify parameter checks if the hash of the password was
15        # already saved in the authentication db
16        assert authMgr.setMasterPassword("your master password",
17                                         verify=True), msg
18 else:
19     # outside qgis, e.g. in a testing environment => setup env var before
20     # db init
21     os.environ['QGIS_AUTH_DB_DIR_PATH'] = "/path/where/located/qgis-auth.db"
22     msg = 'Master password could not be set'
23     assert authMgr.setMasterPassword("your master password", True), msg
24     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:

```
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:

```

1 authMgr = QgsApplication.authManager()
2 # set alice PKI data
3 config = QgsAuthMethodConfig()
4 config.setName("alice")
5 config.setMethod("PKI-Paths")
6 config.setUri("https://example.com")
7 config.setConfig("certpath", "path/to/alice-cert.pem" )
8 config.setConfig("keypath", "path/to/alice-key.pem" )
9 # check if method parameters are correctly set
10 assert config.isValid()
11
12 # register alice data in authdb returning the ``authcfg`` of the stored
13 # configuration
14 authMgr.storeAuthenticationConfig(config)
15 newAuthCfgId = config.id()
16 assert newAuthCfgId

```

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

```
1 authMgr = QgsApplication.authManager()
2 # add authorities
3 cacerts = QSslCertificate.fromPath( "/path/to/ca_chains.pem" )
4 assert cacerts is not None
5 # store CA
6 authMgr.storeCertAuthorities(cacerts)
7 # and rebuild CA caches
8 authMgr.rebuildCaCertsCache()
9 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:

```
1 # add alice cert in case of key with pwd
2 caBundlesList = [] # List of CA bundles
3 bundle = QgsPkiBundle.fromPemPaths( "/path/to/alice-cert.pem",
4                                     "/path/to/alice-key_w-pass.pem",
5                                     "unlock_pwd",
6                                     caBundlesList )
7 assert bundle is not None
8 # You can check bundle validity by calling:
9 # 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 its `authCfg` identifier with the following snippet:

```
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:

```
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:

```
1 authCfg = 'fm1s770'
2 quri = QgsDataSourceUri()
3 quri.setParam("layers", 'usa:states')
4 quri.setParam("styles", '')
5 quri.setParam("format", 'image/png')
6 quri.setParam("crs", 'EPSG:4326')
7 quri.setParam("dpiMode", '7')
8 quri.setParam("featureCount", '10')
9 quri.setParam("authcfg", authCfg) # <---- here my authCfg url parameter
10 quri.setParam("contextualWMSLegend", '0')
11 quri.setParam("url", 'https://my_auth_enabled_server_ip/wms')
12 rlayer = QgsRasterLayer(str(quri.encodedUri(), "utf-8"), '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:

```
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:

```

1 http = NetworkAccessManager(authid="my_authCfg", exception_class=My_
   ↳FailedRequestError)
2 try:
3     response, content = http.request( "my_rest_url" )
4 except My_FailedRequestError, e:
5     # Handle exception
6     pass

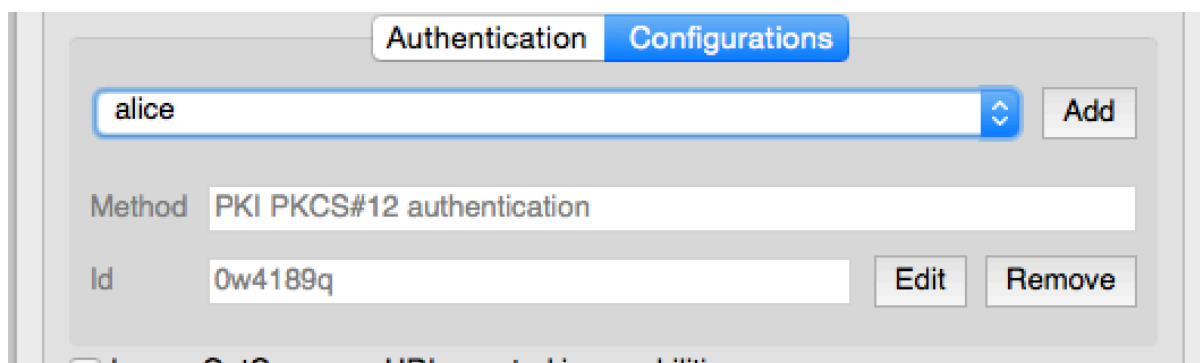
```

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:

```

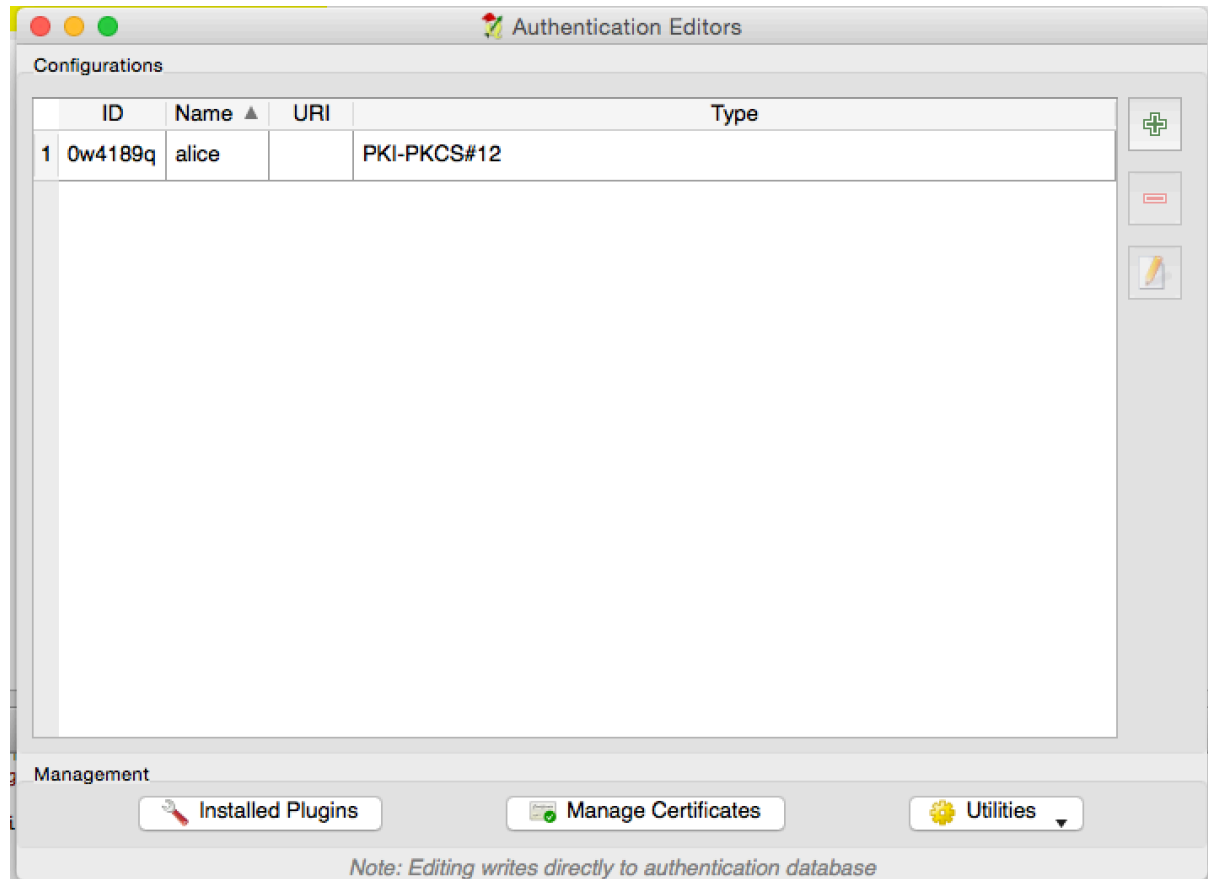
1 # create the instance of the QgsAuthConfigSelect GUI hierarchically linked to
2 # the widget referred with `parent`
3 parent = QWidget() # Your GUI parent widget
4 gui = QgsAuthConfigSelect( parent, "postgres" )
5 # add the above created gui in a new tab of the interface where the
6 # GUI has to be integrated
7 tabGui = QTabWidget()
8 tabGui.insertTab( 1, 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.



and can be used as in the following snippet:

```

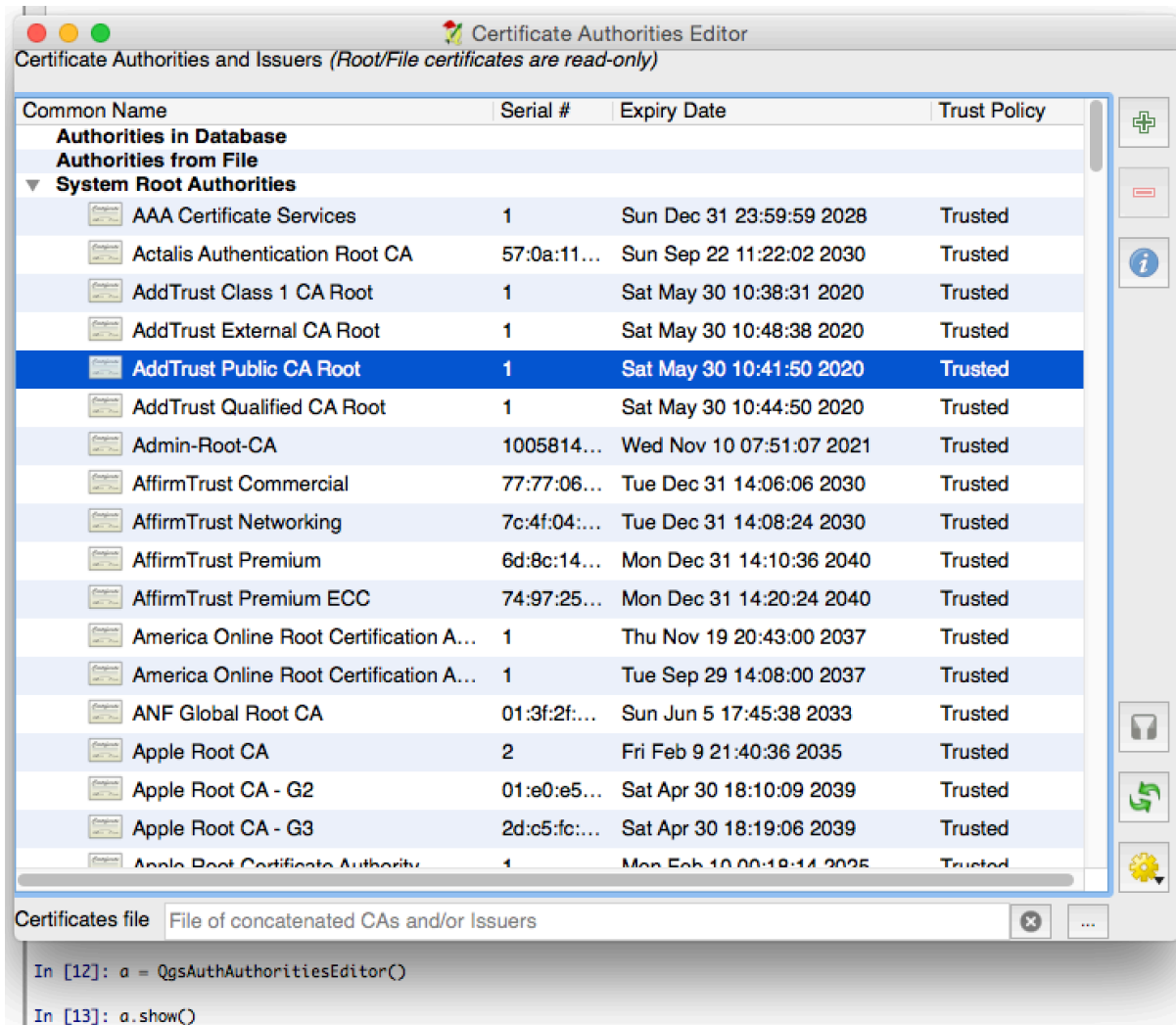
1 # create the instance of the QgsAuthEditorWidgets GUI hierarchically linked to
2 # the widget referred with `parent`
3 parent = QWidget() # Your GUI parent widget
4 gui = QgsAuthConfigSelect( parent )
5 gui.show()

```

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.



and can be used as in the following snippet:

```

1 # create the instance of the QgsAuthAuthoritiesEditor GUI hierarchically
2 # linked to the widget referred with `parent`
3 parent = QWidget() # Your GUI parent widget
4 gui = QgsAuthAuthoritiesEditor( parent )
5 gui.show()

```

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

```

1 from qgis.core import (
2     QgsProcessingContext,
3     QgsTaskManager,
4     QgsTask,
5     QgsProcessingAlgRunnerTask,
6     Qgis,
7     QgsProcessingFeedback,
8     QgsApplication,
9     QgsMessageLog,
10 )

```

Tasks - doing heavy work in the background

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`

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

- Create a task from a function

```
1 def heavyFunction():
2     # Some CPU intensive processing ...
3     pass
4
5 def workdone():
6     # ... do something useful with the results
7     pass
8
9 task = QgsTask.fromFunction('heavy function', heavyFunction,
10                             onfinished=workdone)
```

- Create a task from a processing algorithm

```
1 params = dict()
2 context = QgsProcessingContext()
3 feedback = QgsProcessingFeedback()
```

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```

4
5 buffer_alg = QgsApplication.instance().processingRegistry().algorithmById(
    ↳'native:buffer')
6 task = QgsProcessingAlgRunnerTask(buffer_alg, params, context,
7                                   feedback)

```

Avvertimento: Any background task (regardless of how it is created) must NEVER use any QObject that lives on the main thread, such as accessing QgsVectorLayer, QgsProject or perform any GUI based operations like creating new widgets or interacting with existing widgets. Qt widgets must only be accessed or modified from the main thread. Data that is used in a task must be copied before the task is started. Attempting to use them from background threads will result in crashes.

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.

```

1 import random
2 from time import sleep
3
4 from qgis.core import (
5     QgsApplication, QgsTask, QgsMessageLog,
6     )
7
8 MESSAGE_CATEGORY = 'RandomIntegerSumTask'
9
10 class RandomIntegerSumTask(QgsTask):
11     """This shows how to subclass QgsTask"""
12
13     def __init__(self, description, duration):
14         super().__init__(description, QgsTask.CanCancel)
15         self.duration = duration
16         self.total = 0
17         self.iterations = 0
18         self.exception = None
19

```

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```

20 def run(self):
21     """Here you implement your heavy lifting.
22     Should periodically test for isCanceled() to gracefully
23     abort.
24     This method MUST return True or False.
25     Raising exceptions will crash QGIS, so we handle them
26     internally and raise them in self.finished
27     """
28     QgsMessageLog.logMessage('Started task "{}".format(
29         self.description()),
30         MESSAGE_CATEGORY, Qgis.Info)
31     wait_time = self.duration / 100
32     for i in range(100):
33         sleep(wait_time)
34         # use setProgress to report progress
35         self.setProgress(i)
36         arandominteger = random.randint(0, 500)
37         self.total += arandominteger
38         self.iterations += 1
39         # check isCanceled() to handle cancellation
40         if self.isCanceled():
41             return False
42         # simulate exceptions to show how to abort task
43         if arandominteger == 42:
44             # DO NOT raise Exception('bad value!')
45             # this would crash QGIS
46             self.exception = Exception('bad value!')
47             return False
48     return True
49
50 def finished(self, result):
51     """
52     This function is automatically called when the task has
53     completed (successfully or not).
54     You implement finished() to do whatever follow-up stuff
55     should happen after the task is complete.
56     finished is always called from the main thread, so it's safe
57     to do GUI operations and raise Python exceptions here.
58     result is the return value from self.run.
59     """
60     if result:
61         QgsMessageLog.logMessage(
62             'RandomTask "{name}" completed\n' \
63             'RandomTotal: {total} (with {iterations} '\
64             'iterations)'.format(
65                 name=self.description(),
66                 total=self.total,
67                 iterations=self.iterations),
68             MESSAGE_CATEGORY, Qgis.Success)
69     else:
70         if self.exception is None:
71             QgsMessageLog.logMessage(
72                 'RandomTask "{name}" not successful but without '\
73                 'exception (probably the task was manually '\
74                 'canceled by the user)'.format(
75                     name=self.description(),
76                     MESSAGE_CATEGORY, Qgis.Warning)
77         else:
78             QgsMessageLog.logMessage(
79                 'RandomTask "{name}" Exception: {exception}'.format(
80                     name=self.description(),

```

(continues on next page)

```

81         exception=self.exception),
82         MESSAGE_CATEGORY, Qgis.Critical)
83         raise self.exception
84
85     def cancel(self):
86         QgsMessageLog.logMessage(
87             'RandomTask "{name}" was canceled'.format(
88                 name=self.description()),
89             MESSAGE_CATEGORY, Qgis.Info)
90         super().cancel()
91
92
93     longtask = RandomIntegerSumTask('waste cpu long', 20)
94     shorttask = RandomIntegerSumTask('waste cpu short', 10)
95     minitask = RandomIntegerSumTask('waste cpu mini', 5)
96     shortsubtask = RandomIntegerSumTask('waste cpu subtask short', 5)
97     longsubtask = RandomIntegerSumTask('waste cpu subtask long', 10)
98     shortestsubtask = RandomIntegerSumTask('waste cpu subtask shortest', 4)
99
100     # Add a subtask (shortsubtask) to shorttask that must run after
101     # minitask and longtask has finished
102     shorttask.addSubTask(shortsubtask, [minitask, longtask])
103     # Add a subtask (longsubtask) to longtask that must be run
104     # before the parent task
105     longtask.addSubTask(longsubtask, [], QgsTask.ParentDependsOnSubTask)
106     # Add a subtask (shortestsubtask) to longtask
107     longtask.addSubTask(shortestsubtask)
108
109     QgsApplication.taskManager().addTask(longtask)
110     QgsApplication.taskManager().addTask(shorttask)
111     QgsApplication.taskManager().addTask(minitask)

```

```

1 RandomIntegerSumTask(0): Started task "waste cpu subtask shortest"
2 RandomIntegerSumTask(0): Started task "waste cpu short"
3 RandomIntegerSumTask(0): Started task "waste cpu mini"
4 RandomIntegerSumTask(0): Started task "waste cpu subtask long"
5 RandomIntegerSumTask(3): Task "waste cpu subtask shortest" completed
6 RandomTotal: 25452 (with 100 iterations)
7 RandomIntegerSumTask(3): Task "waste cpu mini" completed
8 RandomTotal: 23810 (with 100 iterations)
9 RandomIntegerSumTask(3): Task "waste cpu subtask long" completed
10 RandomTotal: 26308 (with 100 iterations)
11 RandomIntegerSumTask(0): Started task "waste cpu long"
12 RandomIntegerSumTask(3): Task "waste cpu long" completed
13 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`.

```

1 import random
2 from time import sleep
3
4 MESSAGE_CATEGORY = 'TaskFromFunction'
5
6 def doSomething(task, wait_time):

```

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```

7      """
8      Raises an exception to abort the task.
9      Returns a result if success.
10     The result will be passed, together with the exception (None in
11     the case of success), to the on_finished method.
12     If there is an exception, there will be no result.
13     """
14     QgsMessageLog.logMessage('Started task {}'.format(task.description()),
15                             MESSAGE_CATEGORY, Qgis.Info)
16     wait_time = wait_time / 100
17     total = 0
18     iterations = 0
19     for i in range(100):
20         sleep(wait_time)
21         # use task.setProgress to report progress
22         task.setProgress(i)
23         arandominteger = random.randint(0, 500)
24         total += arandominteger
25         iterations += 1
26         # check task.isCanceled() to handle cancellation
27         if task.isCanceled():
28             stopped(task)
29             return None
30         # raise an exception to abort the task
31         if arandominteger == 42:
32             raise Exception('bad value!')
33     return {'total': total, 'iterations': iterations,
34           'task': task.description()}
35
36 def stopped(task):
37     QgsMessageLog.logMessage(
38         'Task "{name}" was canceled'.format(
39             name=task.description()),
40         MESSAGE_CATEGORY, Qgis.Info)
41
42 def completed(exception, result=None):
43     """This is called when doSomething is finished.
44     Exception is not None if doSomething raises an exception.
45     result is the return value of doSomething."""
46     if exception is None:
47         if result is None:
48             QgsMessageLog.logMessage(
49                 'Completed with no exception and no result '\
50                 '(probably manually canceled by the user)',
51                 MESSAGE_CATEGORY, Qgis.Warning)
52         else:
53             QgsMessageLog.logMessage(
54                 'Task {name} completed\n'
55                 'Total: {total} ( with {iterations} '
56                 'iterations)'.format(
57                     name=result['task'],
58                     total=result['total'],
59                     iterations=result['iterations']),
60                 MESSAGE_CATEGORY, Qgis.Info)
61         else:
62             QgsMessageLog.logMessage("Exception: {}".format(exception),
63                                     MESSAGE_CATEGORY, Qgis.Critical)
64         raise exception
65
66 # Create a few tasks
67 task1 = QgsTask.fromFunction('Waste cpu 1', doSomething,

```

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```

68         on_finished=completed, wait_time=4)
69 task2 = QgsTask.fromFunction('Waste cpu 2', doSomething,
70                             on_finished=completed, wait_time=3)
71 QgsApplication.taskManager().addTask(task1)
72 QgsApplication.taskManager().addTask(task2)

```

```

1 RandomIntegerSumTask(0): Started task "waste cpu subtask short"
2 RandomTaskFromFunction(0): Started task Waste cpu 1
3 RandomTaskFromFunction(0): Started task Waste cpu 2
4 RandomTaskFromFunction(0): Task Waste cpu 2 completed
5 RandomTotal: 23263 ( with 100 iterations)
6 RandomTaskFromFunction(0): Task Waste cpu 1 completed
7 RandomTotal: 25044 ( with 100 iterations)

```

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.

```

1 from functools import partial
2 from qgis.core import (QgsTaskManager, QgsMessageLog,
3                       QgsProcessingAlgRunnerTask, QgsApplication,
4                       QgsProcessingContext, QgsProcessingFeedback,
5                       QgsProject)
6
7 MESSAGE_CATEGORY = 'AlgRunnerTask'
8
9 def task_finished(context, successful, results):
10     if not successful:
11         QgsMessageLog.logMessage('Task finished unsuccessfully',
12                                 MESSAGE_CATEGORY, Qgs.Warning)
13     output_layer = context.getMapLayer(results['OUTPUT'])
14     # because getMapLayer doesn't transfer ownership, the layer will
15     # be deleted when context goes out of scope and you'll get a
16     # crash.
17     # takeMapLayer transfers ownership so it's then safe to add it
18     # to the project and give the project ownership.
19     if output_layer and output_layer.isValid():
20         QgsProject.instance().addMapLayer(
21             context.takeResultLayer(output_layer.id()))
22
23 alg = QgsApplication.processingRegistry().algorithmById(
24         'qgis:randompointsinextent')
25 context = QgsProcessingContext()
26 feedback = QgsProcessingFeedback()
27 params = {
28     'EXTENT': '0.0,10.0,40,50 [EPSG:4326]',
29     'MIN_DISTANCE': 0.0,
30     'POINTS_NUMBER': 50000,
31     'TARGET_CRS': 'EPSG:4326',
32     'OUTPUT': 'memory:My random points'
33 }
34 task = QgsProcessingAlgRunnerTask(alg, params, context, feedback)
35 task.executed.connect(partial(task_finished, context))
36 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

```
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.

Metadata name	Required	Notes
name	True	a short string containing the name of the plugin
qgisMinimumVersion	True	dotted notation of minimum QGIS version
qgisMaximumVersion	False	dotted notation of maximum QGIS version
Descrizione	True	short text which describes the plugin, no HTML allowed
about	True	longer text which describes the plugin in details, no HTML allowed
version	True	short string with the version dotted notation
author	True	author name
email	True	email of the author, only shown on the website to logged in users, but visible in the Plugin Manager after the plugin is installed
changelog	False	string, can be multiline, no HTML allowed
experimental	False	boolean flag, True or False - True if this version is experimental
deprecated	False	boolean flag, True or False, applies to the whole plugin and not just to the uploaded version
etichette	False	comma separated list, spaces are allowed inside individual tags
homepage	False	a valid URL pointing to the homepage of your plugin
repository	True	a valid URL for the source code repository
tracker	False	a valid URL for tickets and bug reports
icon	False	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)
category	False	one of Raster, Vector, Database and Web
plugin_dependencies	False	PIP-like comma separated list of other plugins to install
server	False	boolean flag, True or False, determines if the plugin has a server interface
hasProcessingProvider	False	boolean flag, True or False, determines if the plugin provides processing algorithms

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`

```
; 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
; end of mandatory metadata

; 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 are in comma separated value format, spaces are allowed within the
; tag name.
; Tags should be in English language. Please also check for existing tags and
; synonyms before creating a new one.
tags=wkt,raster,hello world

; these metadata can be empty, they will eventually become mandatory.
homepage=https://www.itopen.it
icon=icon.png

; 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
```

`__init__.py`

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

```
def classFactory(iface):
    from .mainPlugin import TestPlugin
    return TestPlugin(iface)

# any other initialisation needed
```

`mainPlugin.py`

This is where the magic happens and this is how magic looks like: (e.g. `mainPlugin.py`)

```
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 from 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, painter):
```

(continues on next page)

```
# use painter for drawing to map canvas
print("TestPlugin: renderTest called!")
```

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:

```
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()`

```
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

```
self.iface.unregisterMainWindowAction(self.key_action)
```

The method that is called when CTRL+I is pressed

```
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

```
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

```

1 def change_value(value):
2     """Change the value in the second column for all selected features.
3
4     :param value: The new value.
5     """
6     layer = iface.activeLayer()
7     if layer:
8         count_selected = layer.selectedFeatureCount()
9         if count_selected > 0:
10            layer.startEditing()
11            id_features = layer.selectedFeatureIds()
12            for i in id_features:
13                layer.changeAttributeValue(i, 1, value) # 1 being the second column
14            layer.commitChanges()
15        else:
16            iface.messageBar().pushCritical("Error",
17                "Please select at least one feature from current layer")
18    else:
19        iface.messageBar().pushCritical("Error", "Please select a layer")
20
21 # The method requires one parameter (the new value for the second
22 # field of the selected feature(s)) and can be called by
23 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.

```

1 class MyPluginOptionsFactory(QgsOptionsWidgetFactory):
2
3     def __init__(self):
4         super().__init__()
5
6     def icon(self):
7         return QIcon('icons/my_plugin_icon.svg')
8
9     def createWidget(self, parent):
10        return ConfigOptionsPage(parent)
11
12
13 class ConfigOptionsPage(QgsOptionsPageWidget):
14
15     def __init__(self, parent):
16         super().__init__(parent)
17         layout = QHBoxLayout()
18         layout.setContentsMargins(0, 0, 0, 0)
19         self.setLayout(layout)

```

Finally we are adding the imports and modifying the `__init__` function:

```

1 from qgis.PyQt.QtWidgets import QHBoxLayout
2 from qgis.gui import QgsOptionsWidgetFactory, QgsOptionsPageWidget

```

(continues on next page)

```

3
4
5 class MyPlugin:
6     """QGIS Plugin Implementation."""
7
8     def __init__(self, iface):
9         """Constructor.
10
11         :param iface: An interface instance that will be passed to this class
12             which provides the hook by which you can manipulate the QGIS
13             application at run time.
14         :type iface: QgsInterface
15         """
16         # Save reference to the QGIS interface
17         self.iface = iface
18
19
20     def initGui(self):
21         self.options_factory = MyPluginOptionsFactory()
22         self.options_factory.setTitle(self.tr('My Plugin'))
23         iface.registerOptionsWidgetFactory(self.options_factory)
24
25     def unload(self):
26         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.

```

1 class WatermarkLayerRenderer(QgsMapLayerRenderer):
2
3     def __init__(self, layerId, rendererContext):
4         super().__init__(layerId, rendererContext)
5
6     def render(self):
7         image = QImage("/usr/share/icons/hicolor/128x128/apps/qgis.png")
8         painter = self.rendererContext().painter()
9         painter.save()
10        painter.drawImage(10, 10, image)
11        painter.restore()
12        return True

```

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```

13
14 class WatermarkPluginLayer(QgsPluginLayer):
15
16     LAYER_TYPE="watermark"
17
18     def __init__(self):
19         super().__init__(WatermarkPluginLayer.LAYER_TYPE, "Watermark plugin layer")
20         self.setValid(True)
21
22     def createMapRenderer(self, rendererContext):
23         return WatermarkLayerRenderer(self.id(), rendererContext)
24
25     def setTransformContext(self, ct):
26         pass
27
28     # Methods for reading and writing specific information to the project file can
29     # also be added:
30
31     def readXml(self, node, context):
32         pass
33
34     def writeXml(self, node, doc, context):
35         pass

```

Il layer plugin può essere aggiunto al progetto e al mappa come qualsiasi altro layer della mappa:

```

plugin_layer = WatermarkPluginLayer()
QgsProject.instance().addMapLayer(plugin_layer)

```

Quando si carica un progetto contenente un layer di questo tipo, è necessaria una classe factory:

```

1 class WatermarkPluginLayerType(QgsPluginLayerType):
2
3     def __init__(self):
4         super().__init__(WatermarkPluginLayer.LAYER_TYPE)
5
6     def createLayer(self):
7         return WatermarkPluginLayer()
8
9     # You can also add GUI code for displaying custom information
10    # in the layer properties
11    def showLayerProperties(self, layer):
12        pass
13
14
15    # Keep a reference to the instance in Python so it won't
16    # be garbage collected
17    plt = WatermarkPluginLayerType()
18
19    assert QgsApplication.pluginLayerRegistry().addPluginLayerType(plt)

```

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 QGIS.
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

```
@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.

```
call "C:\OSGeo4W\bin\o4w_env.bat"
set PATH=%PATH%;C:\path\to\your\qgis_core.dll\parent\folder
start /B 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.

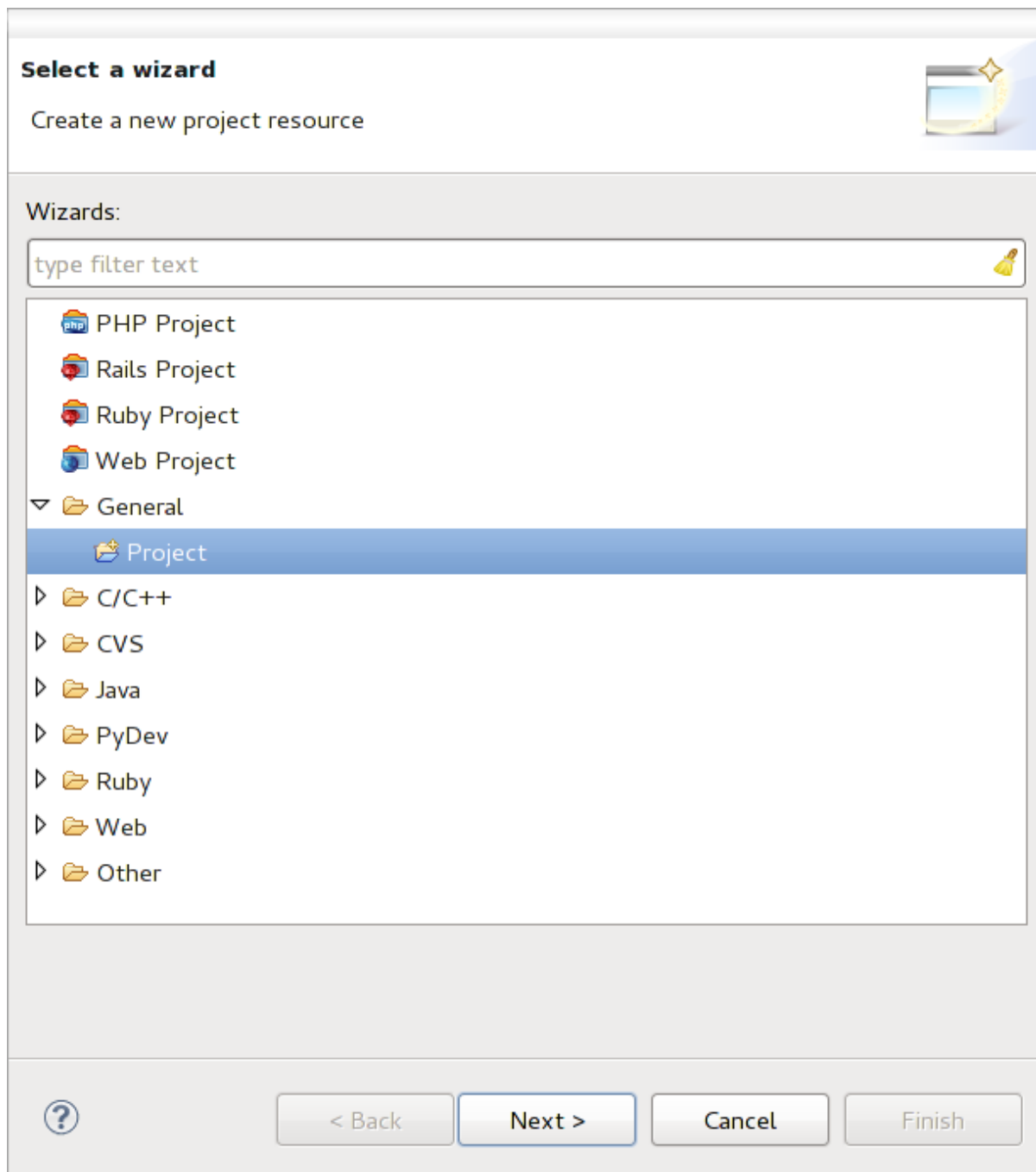


Fig. 16.1: Eclipse project

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).

```

87         self.verticalExaggerationChanged.emit(val)
88
89     def printProfile(self):
90         printer = QPrinter( QPrinter.HighResolution )
91         printer.setOutputFormat( QPrinter.PdfFormat )
92         printer.setPaperSize( QPrinter.A4 )
93         printer.setOrientation( QPrinter.Landscape )
94
95         printPreviewDlg = QPrintPreviewDialog( )
96         printPreviewDlg.paintRequested.connect( self.printRequested )
97
98         printPreviewDlg.exec_()
99
100    @pyqtSlot( QPrinter )
101    def printRequested( self, printer ):
102        self.webView.print_( printer )

```

Fig. 16.2: Breakpoint

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.

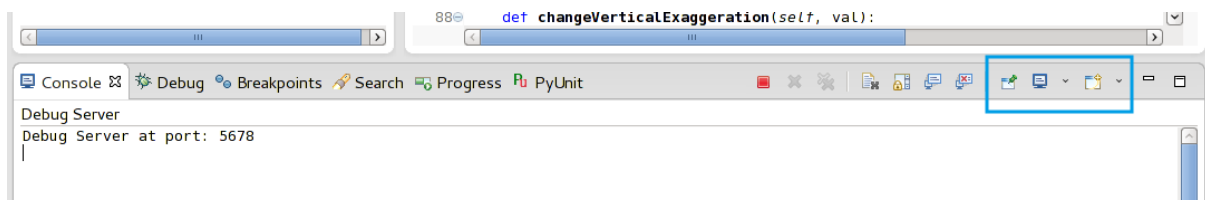


Fig. 16.3: PyDev Debug Console

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*.

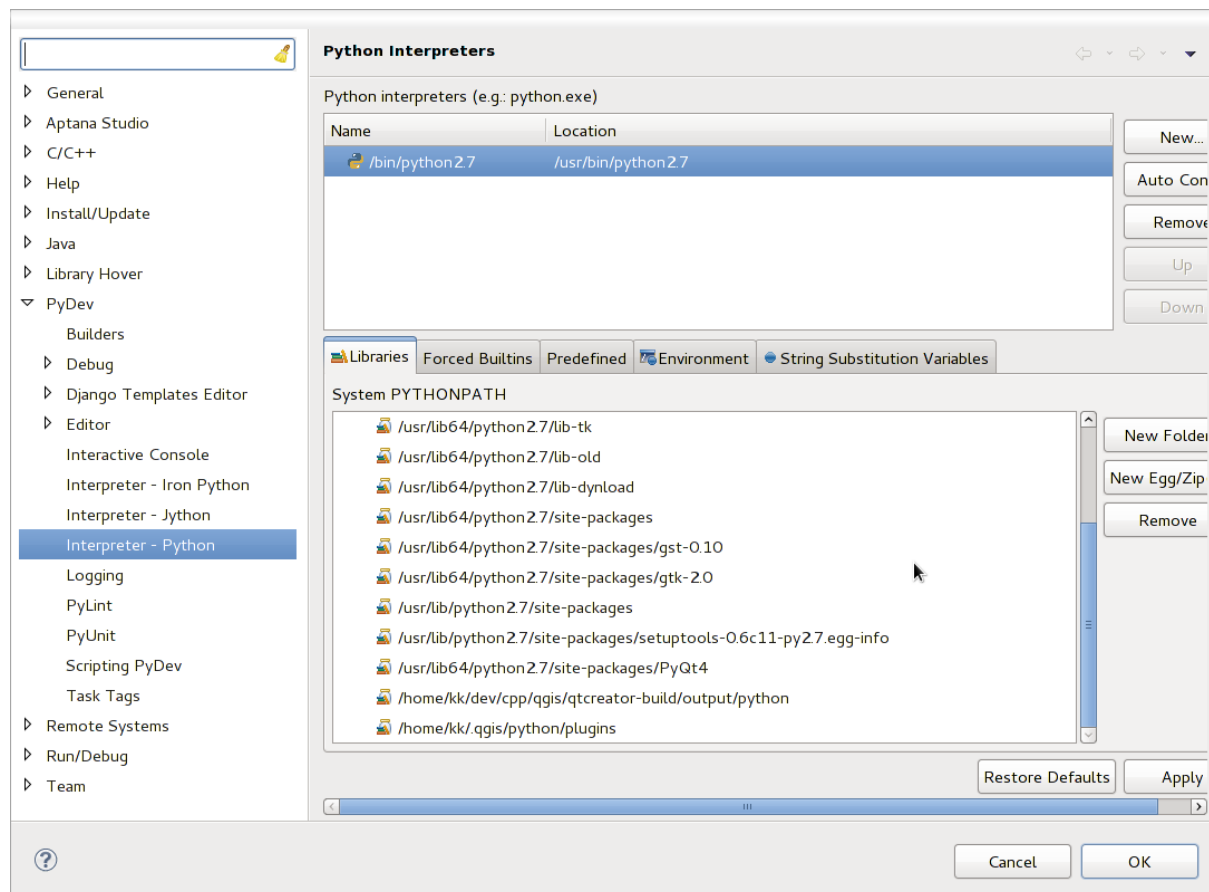


Fig. 16.4: PyDev Debug Console

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).

- 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.
- Click *OK* and you're done.

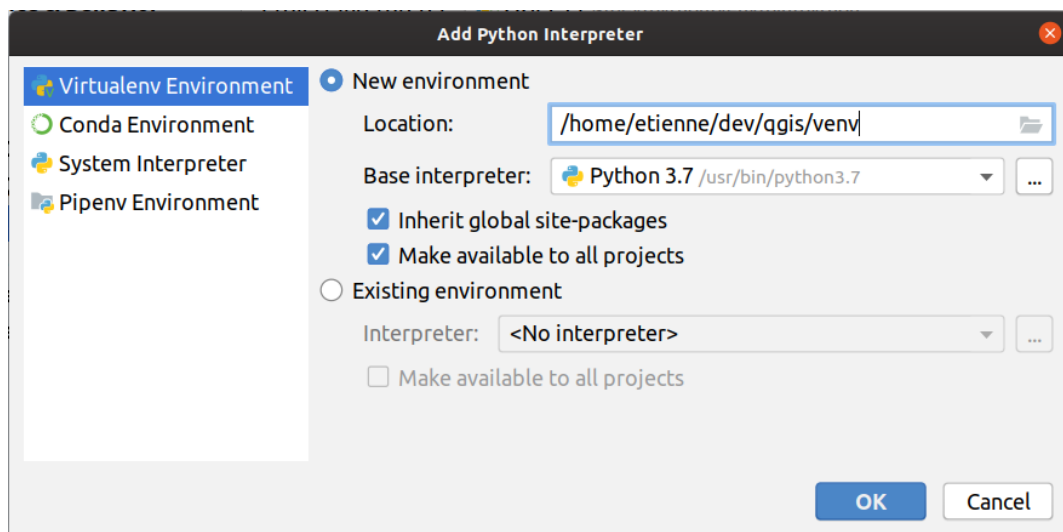
Nota: Every time the QGIS API changes (e.g. if you're compiling QGIS master and the SIP file changed), you should go back to this page and simply click *Apply*. This will let Eclipse parse all the libraries again.

16.4.5 Debugging with PyCharm on Ubuntu with a compiled QGIS

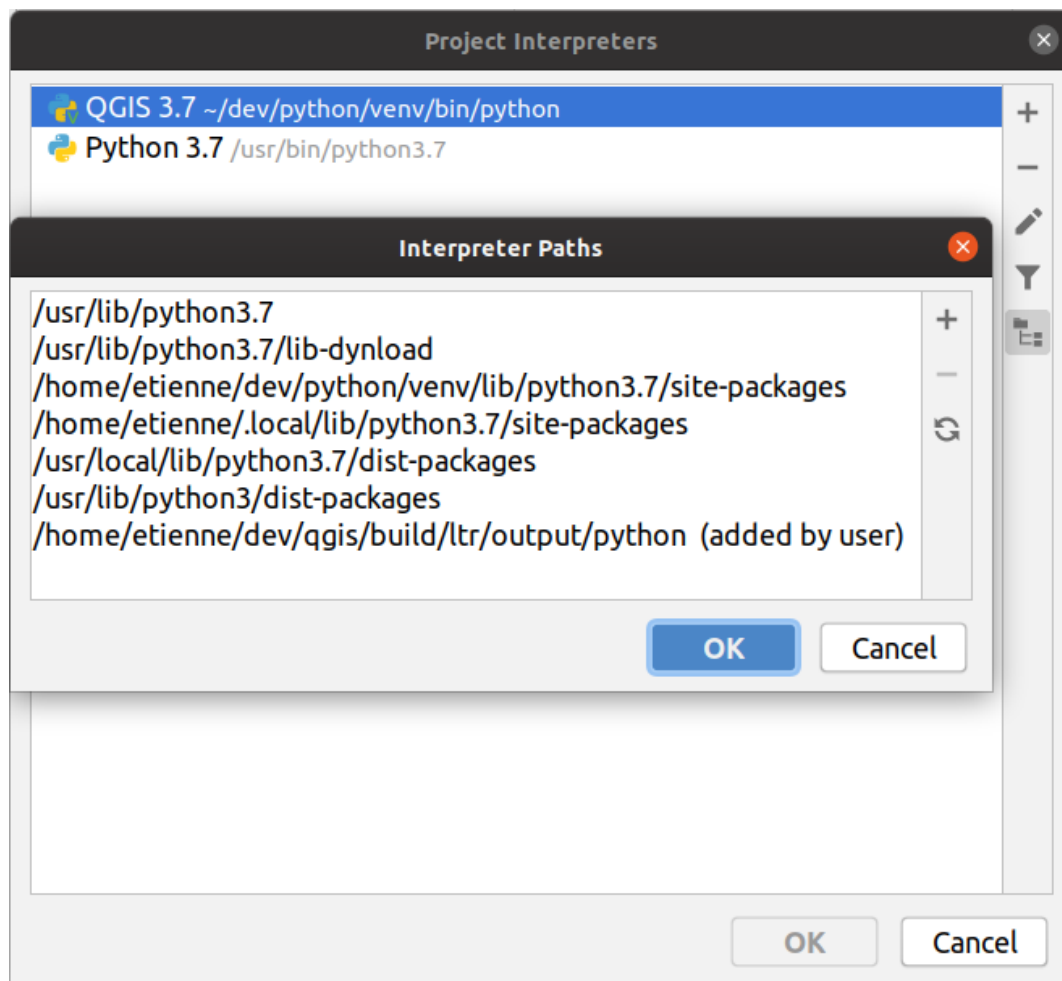
PyCharm is an IDE for Python developed by JetBrains. There is a free version called Community Edition and a paid one called Professional. You can download PyCharm on the website: <https://www.jetbrains.com/pycharm/download>

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.

- In PyCharm, in your *Project Properties*, *Project Interpreter*, we are going to create a Python Virtual environment called `QGIS`.
- Click the small gear and then *Add*.
- Select *Virtualenv environment*.
- 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.
- 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*.



- Click *OK*, come back on the small gear and click *Show all*.
- In the new window, select your new interpreter `QGIS` and click the last icon in the vertical menu *Show paths for the selected interpreter*.
- 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.PyQt.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

```
# Use pdb for debugging
import pdb
# also import pyqtRemoveInputHook
from qgis.PyQt.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:

```
$ ./Qgis
```

On macOS do:

```
$ /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 *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
```

È possibile creare plugin nel linguaggio di programmazione Python. In confronto ai classici plugin scritti in C++ questi dovrebbero essere più facili da scrivere, capire, mantenere e distribuire grazie alla natura dinamica del linguaggio Python.

I plugin Python sono elencati insieme ai plugin C++ nel gestore dei plugin di QGIS. Vengono cercati in `~/ (UserProfile) /python/plugins` e in questi percorsi:

- UNIX/Mac: `(qgis_prefix) /share/qgis/python/plugins`
- Windows: `(qgis_prefix) /python/plugins`

Per le definizioni di `~` e `(UserProfile)` vedi `core_e_external_plugins`.

Nota: Impostando `QGIS_PLUGINPATH` a un percorso di cartella esistente, puoi aggiungere questo percorso alla lista dei percorsi che vengono cercati per i plugin.

Scrivere un plugin di Processing

- *Creazione da zero*
- *Aggiornare un plugin*

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.

17.1 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.

17.2 Aggiornare un plugin

Se si desidera aggiungere il plugin esistente a Processing, è necessario aggiungere un po' di codice.

1. Nel tuo `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:

```
1 from qgis.core import QgsApplication
2 from processing_provider.provider import Provider
3
4 class YourPluginName():
5
6     def __init__(self):
7         self.provider = None
8
9     def initProcessing(self):
10        self.provider = Provider()
11        QgsApplication.processingRegistry().addProvider(self.provider)
12
13    def initGui(self):
14        self.initProcessing()
15
16    def unload(self):
17        QgsApplication.processingRegistry().removeProvider(self.provider)
```

3. Puoi creare una cartella `processing_provider` contenente tre files:

- `__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.

```
1 from qgis.core import QgsProcessingProvider
2
3 from processing_provider.example_processing_algorithm import
4 ↪ExampleProcessingAlgorithm
5
6 class Provider(QgsProcessingProvider):
7
8     def loadAlgorithms(self, *args, **kwargs):
9         self.addAlgorithm(ExampleProcessingAlgorithm())
10        # add additional algorithms here
11        # self.addAlgorithm(MyOtherAlgorithm())
12
13    def id(self, *args, **kwargs):
14        """The ID of your plugin, used for identifying the provider.
15
16        This string should be a unique, short, character only string,
17        eg "qgis" or "gdal". This string should not be localised.
18        """
19        return 'yourplugin'
20
21    def name(self, *args, **kwargs):
22        """The human friendly name of your plugin in Processing.
23
24        This string should be as short as possible (e.g. "Lastools", not
25        "Lastools version 1.0.1 64-bit") and localised.
26        """
27        return self.tr('Your plugin')
```

(continues on next page)

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```
28
29     def icon(self):
30         """Should return a QIcon which is used for your provider inside
31         the Processing toolbox.
32         """
33         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:

```
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 (polyline 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 polyline 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

```
from qgis.analysis import *
```

Then some examples for creating a director

```
1 # don't use information about road direction from layer attributes,
2 # all roads are treated as two-way
3 director = QgsVectorLayerDirector(vectorLayer, -1, '', '', '',
4     ↳QgsVectorLayerDirector.DirectionBoth)
5
6 # use field with index 5 as source of information about road direction.
7 # one-way roads with direct direction have attribute value "yes",
8 # one-way roads with reverse direction have the value "1", and accordingly
9 # bidirectional roads have "no". By default roads are treated as two-way.
10 director = QgsVectorLayerDirector(vectorLayer, 5, 'yes', '1', 'no',
11     ↳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

```
1 director = QgsVectorLayerDirector(vectorLayer,
2     directionFieldId,
3     directDirectionValue,
4     reverseDirectionValue,
5     bothDirectionValue,
6     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

```

1 # The index of the field that contains information about the edge speed
2 attributeId = 1
3 # Default speed value
4 defaultValue = 50
5 # Conversion from speed to metric units ('1' means no conversion)
6 toMetricFactor = 1
7 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.

```
1 from qgis.core import *
2 from qgis.gui import *
3 from qgis.analysis import *
4 from qgis.PyQt.QtCore import *
5 from qgis.PyQt.QtGui import *
6
7 vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines',
8 ↪ 'lines')
9 director = QgsVectorLayerDirector(vectorLayer, -1, '', '', '',
10 ↪ QgsVectorLayerDirector.DirectionBoth)
11 strategy = QgsNetworkDistanceStrategy()
12 director.addStrategy(strategy)
13 builder = QgsGraphBuilder(vectorLayer.crs())
```

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```

12
13 pStart = QgsPointXY(1179661.925139,5419188.074362)
14 tiedPoint = director.makeGraph(builder, [pStart])
15 pStart = tiedPoint[0]
16
17 graph = builder.graph()
18
19 idStart = graph.findVertex(pStart)
20
21 tree = QgsGraphAnalyzer.shortestTree(graph, idStart, 0)
22
23 i = 0
24 while (i < tree.edgeCount()):
25     rb = QgsRubberBand(iface.mapCanvas())
26     rb.setColor (Qt.red)
27     rb.addPoint (tree.vertex(tree.edge(i).fromVertex()).point())
28     rb.addPoint (tree.vertex(tree.edge(i).toVertex()).point())
29     i = i + 1

```

Same thing but using the `dijkstra()` method

```

1 from qgis.core import *
2 from qgis.gui import *
3 from qgis.analysis import *
4 from qgis.PyQt.QtCore import *
5 from qgis.PyQt.QtGui import *
6
7 vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines',
8 ↪ 'lines')
9
10 director = QgsVectorLayerDirector(vectorLayer, -1, '', '', '', ↪
11 ↪ QgsVectorLayerDirector.DirectionBoth)
12 strategy = QgsNetworkDistanceStrategy()
13 director.addStrategy(strategy)
14 builder = QgsGraphBuilder(vectorLayer.crs())
15
16 pStart = QgsPointXY(1179661.925139,5419188.074362)
17 tiedPoint = director.makeGraph(builder, [pStart])
18 pStart = tiedPoint[0]
19
20 graph = builder.graph()
21
22 idStart = graph.findVertex(pStart)
23
24 (tree, costs) = QgsGraphAnalyzer.dijkstra(graph, idStart, 0)
25
26 for edgeId in tree:
27     if edgeId == -1:
28         continue
29     rb = QgsRubberBand(iface.mapCanvas())
30     rb.setColor (Qt.red)
31     rb.addPoint (graph.vertex(graph.edge(edgeId).fromVertex()).point())
32     rb.addPoint (graph.vertex(graph.edge(edgeId).toVertex()).point())

```

18.3.1 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:

```

1 assign T = B
2 while T != B
3     add point T to path
4     get incoming edge for point T
5     look for point TT, that is start point of this edge
6     assign T = TT
7 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

```

1 from qgis.core import *
2 from qgis.gui import *
3 from qgis.analysis import *
4
5 from qgis.PyQt.QtCore import *
6 from qgis.PyQt.QtGui import *
7
8 vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines',
9 ↪ 'lines')
10 builder = QgsGraphBuilder(vectorLayer.sourceCrs())
11 director = QgsVectorLayerDirector(vectorLayer, -1, '|', '|', '|', ↪
12 ↪ QgsVectorLayerDirector.DirectionBoth)
13
14 startPoint = QgsPointXY(1179661.925139,5419188.074362)
15 endPoint = QgsPointXY(1180942.970617,5420040.097560)
16
17 tiedPoints = director.makeGraph(builder, [startPoint, endPoint])
18 tStart, tStop = tiedPoints
19
20 graph = builder.graph()
21 idxStart = graph.findVertex(tStart)
22
23 tree = QgsGraphAnalyzer.shortestTree(graph, idxStart, 0)
24
25 idxStart = tree.findVertex(tStart)
26 idxEnd = tree.findVertex(tStop)
27
28 if idxEnd == -1:
29     raise Exception('No route!')
30
31 # Add last point
32 route = [tree.vertex(idxEnd).point()]
33
34 # Iterate the graph
35 while idxEnd != idxStart:
36     edgeIds = tree.vertex(idxEnd).incomingEdges()
37     if len(edgeIds) == 0:
38         break
39     edge = tree.edge(edgeIds[0])
40     route.insert(0, tree.vertex(edge.fromVertex()).point())
41     idxEnd = edge.fromVertex()

```

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```

40
41 # Display
42 rb = QgsRubberBand(iface.mapCanvas())
43 rb.setColor(Qt.green)
44
45 # This may require coordinate transformation if project's CRS
46 # is different than layer's CRS
47 for p in route:
48     rb.addPoint(p)

```

And here is the same sample but using the `dijkstra()` method

```

1  from qgis.core import *
2  from qgis.gui import *
3  from qgis.analysis import *
4
5  from qgis.PyQt.QtCore import *
6  from qgis.PyQt.QtGui import *
7
8  vectorLayer = QgsVectorLayer('testdata/network.gpkg|layername=network_lines',
9  ↪ 'lines')
10 director = QgsVectorLayerDirector(vectorLayer, -1, '|', '|', '|', ↪
11 ↪ QgsVectorLayerDirector.DirectionBoth)
12 strategy = QgsNetworkDistanceStrategy()
13 director.addStrategy(strategy)
14
15 builder = QgsGraphBuilder(vectorLayer.sourceCrs())
16
17 startPoint = QgsPointXY(1179661.925139,5419188.074362)
18 endPoint = QgsPointXY(1180942.970617,5420040.097560)
19
20 tiedPoints = director.makeGraph(builder, [startPoint, endPoint])
21 tStart, tStop = tiedPoints
22
23 graph = builder.graph()
24 idxStart = graph.findVertex(tStart)
25 idxEnd = graph.findVertex(tStop)
26
27 (tree, costs) = QgsGraphAnalyzer.dijkstra(graph, idxStart, 0)
28
29 if tree[idxEnd] == -1:
30     raise Exception('No route!')
31
32 # Total cost
33 cost = costs[idxEnd]
34
35 # Add last point
36 route = [graph.vertex(idxEnd).point()]
37
38 # Iterate the graph
39 while idxEnd != idxStart:
40     idxEnd = graph.edge(tree[idxEnd]).fromVertex()
41     route.insert(0, graph.vertex(idxEnd).point())
42
43 # Display
44 rb = QgsRubberBand(iface.mapCanvas())
45 rb.setColor(Qt.red)
46
47 # This may require coordinate transformation if project's CRS
48 # is different than layer's CRS
49 for p in route:

```

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```
48 rb.addPoint(p)
```

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 than 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

```
1 director = QgsVectorLayerDirector(vectorLayer, -1, '|', '|', '|',
2   ↳QgsVectorLayerDirector.DirectionBoth)
3 strategy = QgsNetworkDistanceStrategy()
4 director.addStrategy(strategy)
5 builder = QgsGraphBuilder(vectorLayer.crs())
6
7 pStart = QgsPointXY(1179661.925139, 5419188.074362)
8 delta = iface.mapCanvas().getCoordinateTransform().mapUnitsPerPixel() * 1
9
10 rb = QgsRubberBand(iface.mapCanvas(), True)
11 rb.setColor(Qt.green)
12 rb.addPoint(QgsPointXY(pStart.x() - delta, pStart.y() - delta))
13 rb.addPoint(QgsPointXY(pStart.x() + delta, pStart.y() - delta))
14 rb.addPoint(QgsPointXY(pStart.x() + delta, pStart.y() + delta))
15 rb.addPoint(QgsPointXY(pStart.x() - delta, pStart.y() + delta))
16
17 tiedPoints = director.makeGraph(builder, [pStart])
18 graph = builder.graph()
19 tStart = tiedPoints[0]
20
21 idStart = graph.findVertex(tStart)
22
23 (tree, cost) = QgsGraphAnalyzer.dijkstra(graph, idStart, 0)
24
25 upperBound = []
26 r = 1500.0
27 i = 0
28 tree.reverse()
29
30 while i < len(cost):
31     if cost[i] > r and tree[i] != -1:
32         outVertexId = graph.edge(tree[i]).toVertex()
33         if cost[outVertexId] < r:
34             upperBound.append(i)
35         i = i + 1
36
37 for i in upperBound:
38     centerPoint = graph.vertex(i).point()
```

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```
39 rb = QgsRubberBand( iface.mapCanvas(), True)
40 rb.setColor( Qt.red)
41 rb.addPoint( QgsPointXY( centerPoint.x() - delta, centerPoint.y() - delta))
42 rb.addPoint( QgsPointXY( centerPoint.x() + delta, centerPoint.y() - delta))
43 rb.addPoint( QgsPointXY( centerPoint.x() + delta, centerPoint.y() + delta))
44 rb.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:

```

1 initialize the QgsApplication
2 create the QgsServer
3 the main server loop waits forever for client requests:
4     for each incoming request:
5         create a QgsServerRequest request
6         create a QgsServerResponse response
7         call QgsServer.handleRequest(request, response)
8             filter plugins may be executed
9         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:

```

1 from qgis.core import QgsApplication
2 from qgis.server import *
3 app = QgsApplication([], False)
4
5 # Create the server instance, it may be a single one that
6 # is reused on multiple requests
7 server = QgsServer()
8
9 # Create the request by specifying the full URL and an optional body
10 # (for example for POST requests)
11 request = QgsBufferServerRequest(
12     'http://localhost:8081/?MAP=/qgis-server/projects/helloworld.qgs' +
13     '&SERVICE=WMS&REQUEST=GetCapabilities')
14
15 # Create a response objects
16 response = QgsBufferServerResponse()
17
18 # Handle the request
19 server.handleRequest(request, response)
20
21 print(response.headers())
22 print(response.body().data().decode('utf8'))

```

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```

23
24 app.exitQgis()

```

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 instantiated by subclassing one of the classes below and by calling the corresponding method of `QgsServerInterface`:

Filter Type	Base Class	QgsServerInterface registration
I/O	<code>QgsServerFilter</code>	<code>registerFilter()</code>
Access Control	<code>QgsAccessControlFilter</code>	<code>registerAccessControl()</code>
Cache	<code>QgsServerCacheFilter</code>	<code>registerServerCache()</code>

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:

```

1 for each incoming request:
2     create GET/POST request handler
3     pass request to an instance of QgsServerInterface
4     call requestReady filters
5     if there is not a response:
6         if SERVICE is WMS/WFS/WCS:
7             create WMS/WFS/WCS service
8             call service's executeRequest

```

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```
9         possibly call sendResponse for each chunk of bytes
10         sent to the client by a streaming services (WFS)
11     call responseComplete
12     call sendResponse
13 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 (typename 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.

```
1 PYTHON_PLUGINS_PATH/
2   HelloServer/
3     __init__.py    --> *required*
4     HelloServer.py --> *required*
5     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:

```
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":

```

1 class HelloFilter(QgsServerFilter):
2
3     def __init__(self, serverIface):
4         super().__init__(serverIface)
5
6     def requestReady(self):
7         QgsMessageLog.logMessage("HelloFilter.requestReady")
8
9     def sendResponse(self):
10        QgsMessageLog.logMessage("HelloFilter.sendResponse")
11
12    def responseComplete(self):
13        QgsMessageLog.logMessage("HelloFilter.responseComplete")
14        request = self.serverInterface().requestHandler()
15        params = request.parameterMap()
16        if params.get('SERVICE', '').upper() == 'HELLO':
17            request.clear()
18            request.setResponseHeader('Content-type', 'text/plain')
19            # Note that the content is of type "bytes"
20            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:

```

1 class ParamsFilter(QgsServerFilter):
2
3     def __init__(self, serverIface):
4         super(ParamsFilter, self).__init__(serverIface)
5
6     def requestReady(self):
7         request = self.serverInterface().requestHandler()
8         params = request.parameterMap()
9         request.setParameter('TEST_NEW_PARAM', 'ParamsFilter')
10
11    def responseComplete(self):
12        request = self.serverInterface().requestHandler()
13        params = request.parameterMap()
14        if params.get('TEST_NEW_PARAM') == 'ParamsFilter':
15            QgsMessageLog.logMessage("SUCCESS - ParamsFilter.responseComplete")
16        else:
17            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:

```

1  from qgis.server import *
2  from qgis.PyQt.QtCore import *
3  from qgis.PyQt.QtGui import *
4
5  class WatermarkFilter(QgsServerFilter):
6
7      def __init__(self, serverIface):
8          super().__init__(serverIface)
9
10     def responseComplete(self):
11         request = self.serverInterface().requestHandler()
12         params = request.parameterMap()
13         # Do some checks
14         if (params.get('SERVICE').upper() == 'WMS' \
15             and params.get('REQUEST').upper() == 'GETMAP' \
16             and not request.exceptionRaised()):
17             QgsMessageLog.logMessage("WatermarkFilter.responseComplete: image_
↳ready %s" % request.parameter("FORMAT"))
18             # Get the image
19             img = QImage()
20             img.loadFromData(request.body())
21             # Adds the watermark
22             watermark = QImage(os.path.join(os.path.dirname(__file__), 'media/
↳watermark.png'))
23             p = QPainter(img)
24             p.drawImage(QRect( 20, 20, 40, 40), watermark)
25             p.end()
26             ba = QByteArray()
27             buffer = QBuffer(ba)

```

(continues on next page)

```

28     buffer.open(QIODevice.WriteOnly)
29     img.save(buffer, "PNG" if "png" in request.parameter("FORMAT") else
↪ "JPG")
30     # Set the body
31     request.clearBody()
32     request.appendBody(ba)

```

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:

```

1 PYTHON_PLUGINS_PATH/
2   MyAccessControl/
3     __init__.py    --> *required*
4     AccessControl.py --> *required*
5     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:

```

def serverClassFactory(serverIface):
    from MyAccessControl.AccessControl import AccessControlServer
    return AccessControlServer(serverIface)

```


AccessControl.py

```

1 class AccessControlFilter(QgsAccessControlFilter):
2
3     def __init__(self, server_iface):
4         super().__init__(server_iface)
5
6     def layerFilterExpression(self, layer):
7         """ Return an additional expression filter """
8         return super().layerFilterExpression(layer)
9
10    def layerFilterSubsetString(self, layer):
11        """ Return an additional subset string (typically SQL) filter """
12        return super().layerFilterSubsetString(layer)
13
14    def layerPermissions(self, layer):
15        """ Return the layer rights """
16        return super().layerPermissions(layer)
17
18    def authorizedLayerAttributes(self, layer, attributes):
19        """ Return the authorised layer attributes """
20        return super().authorizedLayerAttributes(layer, attributes)
21
22    def allowToEdit(self, layer, feature):
23        """ Are we authorised to modify the following geometry """
24        return super().allowToEdit(layer, feature)
25
26    def cacheKey(self):
27        return super().cacheKey()
28
29 class AccessControlServer:
30
31    def __init__(self, server_iface):
32        """ Register AccessControlFilter """
33        server_iface.registerAccessControl(AccessControlFilter(server_iface), 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.:

```

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)

```
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:

```
1 def layerPermissions(self, layer):  
2     rights = QgsAccessControlFilter.LayerPermissions()  
3     rights.canRead = True  
4     rights.canInsert = rights.canUpdate = rights.canDelete = False  
5     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:

```
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:

```
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.

cacheKey

QGIS server maintain a cache of the capabilities then to have a cache per role you can return the role in this method. Or return None to completely disable the cache.

19.4.2 Custom services

In QGIS Server, core services such as WMS, WFS and WCS are implemented as subclasses of `QgsService`.

To implemented a new service that will be executed when the query string parameter `SERVICE` matches the service name, you can implemented 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:

```

1 from qgis.server import QgsService
2 from qgis.core import QgsMessageLog
3
4 class CustomServiceService(QgsService):
5
6     def __init__(self):
7         QgsService.__init__(self)
8
9     def name(self):
10        return "CUSTOM"
11
12    def version(self):
13        return "1.0.0"
14
15    def executeRequest(self, request, response, project):
16        response.setStatusCode(200)
17        QgsMessageLog.logMessage('Custom service executeRequest')
18        response.write("Custom service executeRequest")
19
20
21 class CustomService():
22
23     def __init__(self, serverIface):
24         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 it's parent class `QgsServerApi`).

To implemented 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`:

```

1 import json
2 import os
3
4 from qgis.PyQt.QtCore import QBuffer, QIODevice, QTextStream, QRegularExpression
5 from qgis.server import (
6     QgsServiceRegistry,
7     QgsService,
8     QgsServerFilter,

```

(continues on next page)

```

9     QgsServerOgcApi,
10    QgsServerQueryStringParameter,
11    QgsServerOgcApiHandler,
12 )
13
14 from qgis.core import (
15     QgsMessageLog,
16     QgsJsonExporter,
17     QgsCircle,
18     QgsFeature,
19     QgsPoint,
20     QgsGeometry,
21 )
22
23
24 class CustomApiHandler(QgsServerOgcApiHandler):
25
26     def __init__(self):
27         super(CustomApiHandler, self).__init__()
28         self.setContentTypes([QgsServerOgcApi.HTML, QgsServerOgcApi.JSON])
29
30     def path(self):
31         return QRegularExpression("/customapi")
32
33     def operationId(self):
34         return "CustomApiXYCircle"
35
36     def summary(self):
37         return "Creates a circle around a point"
38
39     def description(self):
40         return "Creates a circle around a point"
41
42     def linkTitle(self):
43         return "Custom Api XY Circle"
44
45     def linkType(self):
46         return QgsServerOgcApi.data
47
48     def handleRequest(self, context):
49         """Simple Circle"""
50
51         values = self.values(context)
52         x = values['x']
53         y = values['y']
54         r = values['r']
55         f = QgsFeature()
56         f.setAttributes([x, y, r])
57         f.setGeometry(QgsCircle(QgsPoint(x, y), r).toCircularString())
58         exporter = QgsJsonExporter()
59         self.write(json.loads(exporter.exportFeature(f)), context)
60
61     def templatePath(self, context):
62         # The template path is used to serve HTML content
63         return os.path.join(os.path.dirname(__file__), 'circle.html')
64
65     def parameters(self, context):
66         return [QgsServerQueryStringParameter('x', True,
67 ↪QgsServerQueryStringParameter.Type.Double, 'X coordinate'),
68             QgsServerQueryStringParameter(
69                 'y', True, QgsServerQueryStringParameter.Type.Double, 'Y_
70 ↪coordinate'),

```

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```

69         QgsServerQueryStringParameter('r', True, ↵
↵QgsServerQueryStringParameter.Type.Double, 'radius'])
70
71
72 class CustomApi():
73
74     def __init__(self, serverIface):
75         api = QgsServerOgcApi(serverIface, '/customapi',
76                               'custom api', 'a custom api', '1.1')
77         handler = CustomApiHandler()
78         api.registerHandler(handler)
79         serverIface.serviceRegistry().registerApi(api)

```

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

```

1  from qgis.PyQt.QtCore import (
2      QRectF,
3  )
4
5  from qgis.core import (
6      QgsProject,
7      QgsLayerTreeModel,
8  )
9
10 from qgis.gui import (
11     QgsLayerTreeView,
12 )

```


20.1 User Interface

Change Look & Feel

```
1 from qgis.PyQt.QtWidgets import QApplication
2
3 app = QApplication.instance()
4 app.setStyleSheet(".QWidget {color: blue; background-color: yellow;}")
5 # You can even read the stylesheet from a file
6 with open("testdata/file.qss") as qss_file_content:
7     app.setStyleSheet(qss_file_content.read())
```

Change icon and title

```
1 from qgis.PyQt.QtGui import QIcon
2
3 icon = QIcon("/path/to/logo/file.png")
4 iface.mainWindow().setWindowIcon(icon)
5 iface.mainWindow().setWindowTitle("My QGIS")
```

20.2 Impostazioni

Get QgsSettings list

```
1 from qgis.core import QgsSettings
2
3 qs = QgsSettings()
4
5 for k in sorted(qs.allKeys()):
6     print(k)
```

20.3 Barre degli strumenti

Remove toolbar

```
1 toolbar = iface.helpToolBar()
2 parent = toolbar.parentWidget()
3 parent.removeToolBar(toolbar)
4
5 # and add again
6 parent.addToolBar(toolbar)
```

Remove actions toolbar

```
actions = iface.attributesToolBar().actions()
iface.attributesToolBar().clear()
iface.attributesToolBar().addAction(actions[4])
iface.attributesToolBar().addAction(actions[3])
```

20.4 Menus

Remove menu

```
1 # for example Help Menu
2 menu = iface.helpMenu()
3 menubar = menu.parentWidget()
4 menubar.removeAction(menu.menuAction())
5
6 # and add again
7 menubar.addAction(menu.menuAction())
```

20.5 Canvas

Access canvas

```
canvas = iface.mapCanvas()
```

Change canvas color

```
from qgis.PyQt.QtCore import Qt

iface.mapCanvas().setCanvasColor(Qt.black)
iface.mapCanvas().refresh()
```

Map Update interval

```
from qgis.core import QgsSettings
# Set milliseconds (150 milliseconds)
QgsSettings().setValue("/qgis/map_update_interval", 150)
```


20.6 Layer

Add vector layer

```
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

```
layer = iface.activeLayer()
```

List all layers

```
from qgis.core import QgsProject

QgsProject.instance().mapLayers().values()
```

Obtain layers name

```
1 from qgis.core import QgsVectorLayer
2 layer = QgsVectorLayer("Point?crs=EPSG:4326", "layer name you like", "memory")
3 QgsProject.instance().addMapLayer(layer)
4
5 layers_names = []
6 for layer in QgsProject.instance().mapLayers().values():
7     layers_names.append(layer.name())
8
9 print("layers TOC = {}".format(layers_names))
```

```
layers TOC = ['layer name you like']
```

Otherwise

```
layers_names = [layer.name() for layer in QgsProject.instance().mapLayers().
↳values()]
print("layers TOC = {}".format(layers_names))
```

```
layers TOC = ['layer name you like']
```

Find layer by name

```
from qgis.core import QgsProject

layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
print(layer.name())
```

```
layer name you like
```

Set active layer

```
from qgis.core import QgsProject

layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
iface.setActiveLayer(layer)
```

Refresh layer at interval

```
1 from qgis.core import QgsProject
2
```

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```
3 layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
4 # Set seconds (5 seconds)
5 layer.setAutoRefreshInterval(5000)
6 # Enable auto refresh
7 layer.setAutoRefreshEnabled(True)
```

Show methods

```
dir(layer)
```

Adding new feature with feature form

```
1 from qgis.core import QgsFeature, QgsGeometry
2
3 feat = QgsFeature()
4 geom = QgsGeometry()
5 feat.setGeometry(geom)
6 feat.setFields(layer.fields())
7
8 iface.openFeatureForm(layer, feat, False)
```

Adding new feature without feature form

```
1 from qgis.core import QgsGeometry, QgsPointXY, QgsFeature
2
3 pr = layer.dataProvider()
4 feat = QgsFeature()
5 feat.setGeometry(QgsGeometry.fromPointXY(QgsPointXY(10,10)))
6 pr.addFeatures([feat])
```

Get features

```
for f in layer.getFeatures():
    print(f)
```

```
<qgis._core.QgsFeature object at 0x7f45cc64b678>
```

Get selected features

```
for f in layer.selectedFeatures():
    print(f)
```

Get selected features Ids

```
selected_ids = layer.selectedFeatureIds()
print(selected_ids)
```

Create a memory layer from selected features Ids

```
from qgis.core import QgsFeatureRequest

memory_layer = layer.materialize(QgsFeatureRequest().setFilterFids(layer.
    ↳selectedFeatureIds()))
QgsProject.instance().addMapLayer(memory_layer)
```

Get geometry

```
# Point layer
for f in layer.getFeatures():
    geom = f.geometry()
    print('%f, %f' % (geom.asPoint().y(), geom.asPoint().x()))
```

```
10.000000, 10.000000
```

Move geometry

```
1 from qgis.core import QgsFeature, QgsGeometry
2 poly = QgsFeature()
3 geom = QgsGeometry.fromWkt("POINT(7 45)")
4 geom.translate(1, 1)
5 poly.setGeometry(geom)
6 print(poly.geometry())
```

```
<QgsGeometry: Point (8 46)>
```

Set the CRS

```
from qgis.core import QgsProject, QgsCoordinateReferenceSystem

for layer in QgsProject.instance().mapLayers().values():
    layer.setCrs(QgsCoordinateReferenceSystem('EPSG:4326'))
```

See the CRS

```
1 from qgis.core import QgsProject
2
3 for layer in QgsProject.instance().mapLayers().values():
4     crs = layer.crs().authid()
5     layer.setName('{} ({}).format(layer.name(), crs))
```

Hide a field column

```
1 from qgis.core import QgsEditorWidgetSetup
2
3 def fieldVisibility (layer, fname):
4     setup = QgsEditorWidgetSetup('Hidden', {})
5     for i, column in enumerate(layer.fields()):
6         if column.name() == fname:
7             layer.setEditorWidgetSetup(i, setup)
8             break
9     else:
10        continue
```

Layer from WKT

```
1 from qgis.core import QgsVectorLayer, QgsFeature, QgsGeometry, QgsProject
2
3 layer = QgsVectorLayer('Polygon?crs=epsg:4326', 'Mississippi', 'memory')
4 pr = layer.dataProvider()
5 poly = QgsFeature()
6 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))")
7 poly.setGeometry(geom)
8 pr.addFeatures([poly])
9 layer.updateExtents()
10 QgsProject.instance().addMapLayers([layer])
```

Load all vector layers from GeoPackage

```
1 from qgis.core import QgsDataProvider
2
3 fileName = "testdata/sublayers.gpkg"
```

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```

4 layer = QgsVectorLayer(fileName, "test", "ogr")
5 subLayers = layer.dataProvider().subLayers()
6
7 for subLayer in subLayers:
8     name = subLayer.split(QgsDataProvider.SUBLAYER_SEPARATOR)[1]
9     uri = "%s|layername=%s" % (fileName, name,)
10    # Create layer
11    sub_vlayer = QgsVectorLayer(uri, name, 'ogr')
12    # Add layer to map
13    QgsProject.instance().addMapLayer(sub_vlayer)

```

Load tile layer (XYZ-Layer)

```

1 from qgis.core import QgsRasterLayer, QgsProject
2
3 def loadXYZ(url, name):
4     rasterLyr = QgsRasterLayer("type=xyz&url=" + url, name, "wms")
5     QgsProject.instance().addMapLayer(rasterLyr)
6
7 urlWithParams = 'https://tile.openstreetmap.org/%7Bz%7D/%7Bx%7D/%7By%7D.png&
8 ↪zmax=19&zmin=0&crs=EPSG3857'
9 loadXYZ(urlWithParams, 'OpenStreetMap')

```

Remove all layers

```
QgsProject.instance().removeAllMapLayers()
```

Remove all

```
QgsProject.instance().clear()
```

20.7 Table of contents

Access checked layers

```
iface.mapCanvas().layers()
```

Remove contextual menu

```

1 ltv = iface.layerTreeView()
2 mp = ltv.menuProvider()
3 ltv.setMenuProvider(None)
4 # Restore
5 ltv.setMenuProvider(mp)

```

20.8 Advanced TOC

Root node

```

1 from qgis.core import QgsVectorLayer, QgsProject, QgsLayerTreeLayer
2
3 root = QgsProject.instance().layerTreeRoot()
4 node_group = root.addGroup("My Group")
5
6 layer = QgsVectorLayer("Point?crs=EPSG:4326", "layer name you like", "memory")

```

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```

7 QgsProject.instance().addMapLayer(layer, False)
8
9 node_group.addLayer(layer)
10
11 print(root)
12 print(root.children())

```

Access the first child node

```

1 from qgis.core import QgsLayerTreeGroup, QgsLayerTreeLayer, QgsLayerTree
2
3 child0 = root.children()[0]
4 print (child0.name())
5 print (type(child0))
6 print (isinstance(child0, QgsLayerTreeLayer))
7 print (isinstance(child0.parent(), QgsLayerTree))

```

```

My Group
<class 'qgis._core.QgsLayerTreeGroup'>
False
True

```

Find groups and nodes

```

1 from qgis.core import QgsLayerTreeGroup, QgsLayerTreeLayer
2
3 def get_group_layers(group):
4     print('- group: ' + group.name())
5     for child in group.children():
6         if isinstance(child, QgsLayerTreeGroup):
7             # Recursive call to get nested groups
8             get_group_layers(child)
9         else:
10            print(' - layer: ' + child.name())
11
12
13 root = QgsProject.instance().layerTreeRoot()
14 for child in root.children():
15     if isinstance(child, QgsLayerTreeGroup):
16         get_group_layers(child)
17     elif isinstance(child, QgsLayerTreeLayer):
18         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

```
1 from qgis.core import QgsVectorLayer, QgsProject
2
3 layer1 = QgsVectorLayer("Point?crs=EPSG:4326", "layer name you like 2", "memory")
4 QgsProject.instance().addMapLayer(layer1, False)
5 node_layer1 = root.addLayer(layer1)
6 # Remove it
7 QgsProject.instance().removeMapLayer(layer1)
```

Add group

```
1 from qgis.core import QgsLayerTreeGroup
2
3 node_group2 = QgsLayerTreeGroup("Group 2")
4 root.addChildNode(node_group2)
5 QgsProject.instance().mapLayersByName("layer name you like")[0]
```

Move loaded layer

```
1 layer = QgsProject.instance().mapLayersByName("layer name you like")[0]
2 root = QgsProject.instance().layerTreeRoot()
3
4 myLayer = root.findLayer(layer.id())
5 myClone = myLayer.clone()
6 parent = myLayer.parent()
7
8 myGroup = root.findGroup("My Group")
9 # Insert in first position
10 myGroup.insertChildNode(0, myClone)
11
12 parent.removeChildNode(myLayer)
```

Move loaded layer to a specific group

```
1 QgsProject.instance().addMapLayer(layer, False)
2
3 root = QgsProject.instance().layerTreeRoot()
4 myGroup = root.findGroup("My Group")
5 myOriginalLayer = root.findLayer(layer.id())
6 myLayer = myOriginalLayer.clone()
7 myGroup.insertChildNode(0, myLayer)
8 parent.removeChildNode(myOriginalLayer)
```

Changing visibility

```
myGroup.setItemVisibilityChecked(False)
myLayer.setItemVisibilityChecked(False)
```

Is group selected

```
1 def isMyGroupSelected( groupName ):
2     myGroup = QgsProject.instance().layerTreeRoot().findGroup( groupName )
3     return myGroup in iface.layerTreeView().selectedNodes()
4
5 print(isMyGroupSelected( 'my group name' ))
```

```
False
```

Expand node

```
print(myGroup.isExpanded())
myGroup.setExpanded(False)
```

Hidden node trick

```

1 from qgis.core import QgsProject
2
3 model = iface.layerTreeView().layerTreeModel()
4 ltv = iface.layerTreeView()
5 root = QgsProject.instance().layerTreeRoot()
6
7 layer = QgsProject.instance().mapLayersByName('layer name you like')[0]
8 node = root.findLayer(layer.id())
9
10 index = model.node2index(node)
11 ltv.setRowHidden(index.row(), index.parent(), True)
12 node.setCustomProperty('nodeHidden', 'true')
13 ltv.setCurrentIndex(model.node2index(root))

```

Node signals

```

1 def onWillAddChildren(node, indexFrom, indexTo):
2     print("WILL ADD", node, indexFrom, indexTo)
3
4 def onAddedChildren(node, indexFrom, indexTo):
5     print("ADDED", node, indexFrom, indexTo)
6
7 root.willAddChildren.connect(onWillAddChildren)
8 root.addedChildren.connect(onAddedChildren)

```

Remove layer

```
root.removeLayer(layer)
```

Remove group

```
root.removeChildNode(node_group2)
```

Create new table of contents (TOC)

```

1 root = QgsProject.instance().layerTreeRoot()
2 model = QgsLayerTreeModel(root)
3 view = QgsLayerTreeView()
4 view.setModel(model)
5 view.show()

```

Move node

```

cloned_group1 = node_group.clone()
root.insertChildNode(0, cloned_group1)
root.removeChildNode(node_group)

```

Rename node

```

cloned_group1.setName("Group X")
node_layer1.setName("Layer X")

```

20.9 Processing algorithms

Get algorithms list

```

1 from qgis.core import QgsApplication
2
3 for alg in QgsApplication.processingRegistry().algorithms():
4     if 'buffer' == alg.name():
5         print("{}: {} --> {}".format(alg.provider().name(), alg.name(), alg.
↳ displayName()))

```

```
QGIS (native c++):buffer --> Buffer
```

Get algorithms help

Random selection

```

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.

```

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?

```
len(QgsApplication.processingRegistry().algorithms())
```

How many providers are there?

```

from qgis.core import QgsApplication

len(QgsApplication.processingRegistry().providers())

```

How many expressions are there?

```

from qgis.core import QgsExpression

len(QgsExpression.Functions())

```

20.10 Decorators

CopyRight

```

1 from qgis.PyQt.Qt import QTextDocument
2 from qgis.PyQt.QtGui import QFont
3
4 mQFont = "Sans Serif"
5 mQFontSize = 9
6 mLabelQString = "© QGIS 2019"

```

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```

7 mMarginHorizontal = 0
8 mMarginVertical = 0
9 mLabelQColor = "#FF0000"
10
11 INCHES_TO_MM = 0.0393700787402 # 1 millimeter = 0.0393700787402 inches
12 case = 2
13
14 def add_copyright(p, text, xOffset, yOffset):
15     p.translate( xOffset , yOffset )
16     text.drawContents(p)
17     p.setWorldTransform( p.worldTransform() )
18
19 def _on_render_complete(p):
20     deviceHeight = p.device().height() # Get paint device height on which this_
↳painter is currently painting
21     deviceWidth = p.device().width() # Get paint device width on which this_
↳painter is currently painting
22     # Create new container for structured rich text
23     text = QTextDocument()
24     font = QFont()
25     font.setFamily(mQFont)
26     font.setPointSize(int(mQFontSize))
27     text.setDefaultFont(font)
28     style = "<style type=\"text/css\"> p {color: " + mLabelQColor + "}</style>"
29     text.setHtml( style + "<p>" + mLabelQString + "</p>" )
30     # Text Size
31     size = text.size()
32
33     # RenderMillimeters
34     pixelsInchX = p.device().logicalDpiX()
35     pixelsInchY = p.device().logicalDpiY()
36     xOffset = pixelsInchX * INCHES_TO_MM * int(mMarginHorizontal)
37     yOffset = pixelsInchY * INCHES_TO_MM * int(mMarginVertical)
38
39     # Calculate positions
40     if case == 0:
41         # Top Left
42         add_copyright(p, text, xOffset, yOffset)
43
44     elif case == 1:
45         # Bottom Left
46         yOffset = deviceHeight - yOffset - size.height()
47         add_copyright(p, text, xOffset, yOffset)
48
49     elif case == 2:
50         # Top Right
51         xOffset = deviceWidth - xOffset - size.width()
52         add_copyright(p, text, xOffset, yOffset)
53
54     elif case == 3:
55         # Bottom Right
56         yOffset = deviceHeight - yOffset - size.height()
57         xOffset = deviceWidth - xOffset - size.width()
58         add_copyright(p, text, xOffset, yOffset)
59
60     elif case == 4:
61         # Top Center
62         xOffset = deviceWidth / 2
63         add_copyright(p, text, xOffset, yOffset)
64
65     else:

```

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```
66     # Bottom Center
67     yOffset = deviceHeight - yOffset - size.height()
68     xOffset = deviceWidth / 2
69     add_copyright(p, text, xOffset, yOffset)
70
71     # Emitted when the canvas has rendered
72     iface.mapCanvas().renderComplete.connect(_on_render_complete)
73     # Repaint the canvas map
74     iface.mapCanvas().refresh()
```

20.11 Composer

Get print layout by name

```
1 composerTitle = 'MyComposer' # Name of the composer
2
3 project = QgsProject.instance()
4 projectLayoutManager = project.layoutManager()
5 layout = projectLayoutManager.layoutByName(composerTitle)
```

20.12 Sources

- [QGIS Python \(PyQGIS\) API](#)
- [QGIS C++ API](#)
- [StackOverFlow QGIS questions](#)
- [Script by Klas Karlsson](#)