

Qt Model-View Architecture

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2025

Overview

Qt
Model-View
Architecture

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Model/View
Architecture

Using
predefined
classes

Implementing
custom
models

Implementing
custom
delegates

- 1 Model/View Architecture
- 2 Using predefined classes
- 3 Implementing custom models
- 4 Implementing custom delegates

Qt Item based widgets I

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- QListWidget, QTableWidget, QTreeWidget
- Item widgets are populated with the entire content of a data set.
- Searches, edits are performed on the data held in the widgets.
- The data needs to be synchronized, written back to the data source (file, database, network).

Qt Item based widgets II

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Advantages

- easy to understand;
- simple to use.

Drawbacks

- does not scale well with very large data sets;
- does not work if we have multiple views of the same data set;
- requires data duplication.

Model-View-Controller (MVC) I

Is a flexible approach to visualizing large data sets.

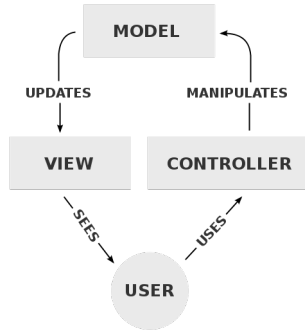


Figure source: [Model-View-Controller \(Wikipedia\)](#)

Model-View-Controller (MVC) II

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"MVC consists of three kinds of objects. The Model is the application object, the View is its screen presentation, and the Controller defines the way the user interface reacts to user input. Before MVC, user interface designs tended to lump these objects together. MVC decouples them to increase flexibility and reuse."

(Gamma, E., Helm, R., Johnson, R., Vlissides, J., Patterns, D. (1995). Elements of Reusable Object-Oriented Software. Design Patterns.)

Model-View-Controller (MVC) III

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Model

- Represents and manages the data of the application domain.
- Is responsible for:
 - fetching the data that is needed for view;
 - writing back any changes (requests which come from the controller).

Model-View-Controller (MVC) IV

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View

- Presents the data to the user.
- Even if we have a large dataset, only a limited amount of data is visible. That is the only data that is requested by the view.

Controller

- Mediates between the user and the view.
- Interprets user input and commands the model or the view to change as appropriate.
- Converts user actions (which come from the view) into requests to navigate or edit data.

Model/View Architecture in Qt I

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- Model/View is a technology used to separate data from their visual representation (views).
- This separation makes the components independent for development, testing and maintenance.
- The view and controller objects from MVC are combined.
- The way the data is stored is separated from the way the data is presented to the user.

Model/View Architecture in Qt II

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- Allows displaying the same data in different views.
- Implementing new types of views is possible, without changing the underlying data structures.
- You can find a more detailed tutorial at: <https://doc.qt.io/qt-6/modelview.html>.

Model/View Architecture in Qt III

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Components

- *Model* - represents the data (interface to the data structure).
- *View* - displays the data.
- *Delegate* - renders single data and assists in data editing.

Basic concepts in the Model-View Infrastructure

- *Item* - a unit of data in the model.
- *Index* - a unique identifier to locate the data within the model.

Model/View Architecture in Qt IV

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- Model/view architecture is very suitable for handling large data sets, complex data items, database integration, multiple data views.
- User input is handled with [delegates](#).
- The *delegate* is used to provide fine control over how items are rendered and edited.
- Qt provides a default delegate for every type of view (which is sufficient for most applications).

Model/View Architecture in Qt V

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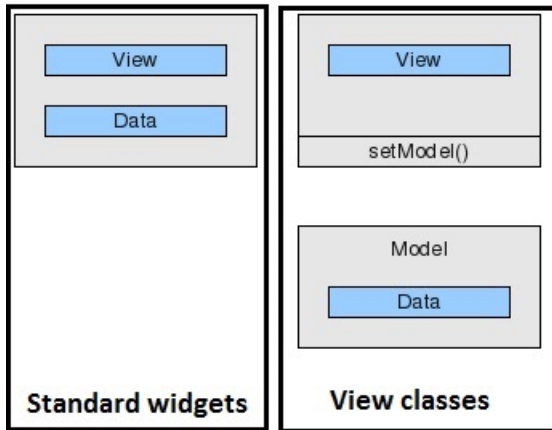


Figure source: [Qt6 - Model/View Tutorial](#).

Model/View Architecture in Qt VI

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How does it work?

- The model communicates with a source of data.
- The model must provide an *interface* for the views.
- The view obtains *model indexes* from the model - references to items of data.
- The delegate renders the items of data and communicates with the model when the data is edited.

Model/View Architecture in Qt VII

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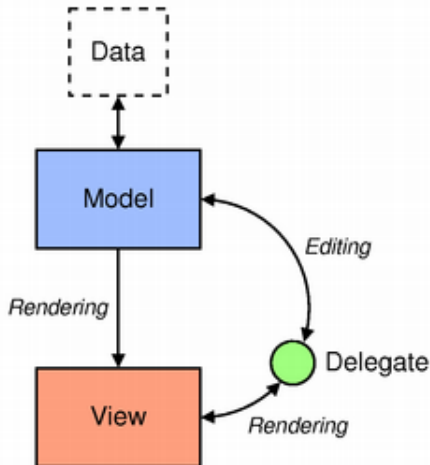


Figure source: [Qt6 - Model/View Tutorial](#).

Predefined classes for models, views, delegates

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- Models, views and delegates are defined by *abstract classes* that provide common interfaces and sometimes default implementations.
- These abstract classes should be subclassed for specialised components.
- Models, views, and delegates communicate with each other using signals and slots.

Models I

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- [QAbstractItemModel](#) is the class that defines an interface used by views and delegates to access data.
- All item models are based on this abstract class.
- This class provides a flexible interface, which can be used with views that represent data in the form of tables, lists, and trees.
- There are also [QAbstractListModel](#) and [QAbstractTableModel](#), which are more appropriate for models representing list of table-like data structures.

Models II

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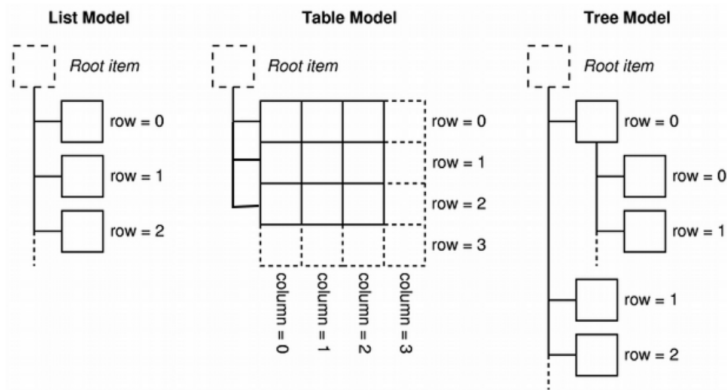


Figure source: [Qt6 - Model/View Tutorial](#).

Predefined models

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Qt provides several predefined models for use with the view classes:

- [QStringListModel](#) - stores a list of strings.
- [QStandardItemModel](#) - stores arbitrary hierarchical data.
- [QFileSystemModel](#) - encapsulates the local file system.
- [QSqlQueryModel](#) - encapsulates an SQL result set.
- [QSqlTableModel](#) - encapsulates an SQL table.
- [QSortFilterProxyModel](#) - sorts and/or filters another model.

Views I

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- `QAbstractItemView` is the abstract base class for views.
- There are complete implementations for the following types of views:
 - `QListView` - displays a list of items.
 - `QTableView` - displays data from a model in a table.
 - `QTreeView` - shows model items of data in a hierarchical list.

Views II

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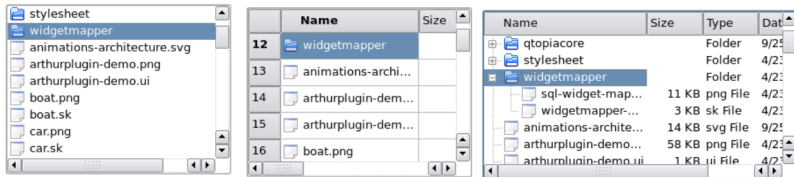


Figure source: [Qt6 - Model/View Tutorial](#).

Genes List

- Displaying a list of genes using a list widget and then a list view with a predefined model ([QStringListModel](#)).
- Large data sets are displayed faster.

DEMO

Using predefined models - genes list (*Lecture11_genes*).

Directory Tree View

- Recursively displaying the sub-folders of a folder using the predefined view `QTreeView` and the predefined model `QDirModel`.

DEMO

Using predefined models - directory tree view (*Lecture11_genes - main.cpp - directory tree*).

Custom models I

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- [QAbstractItemModel](#) is the class representing the model for any Qt Item View Class.
- This is able to represent list data (rows), table data (rows, columns) or hierarchical data (tree structure: parents, children).
- To create a custom model, create a new class, which extends the appropriate Qt model class ([QAbstractItemModel](#) or [QAbstractListModel](#) or [QAbstractTableModel](#)).

Custom models II

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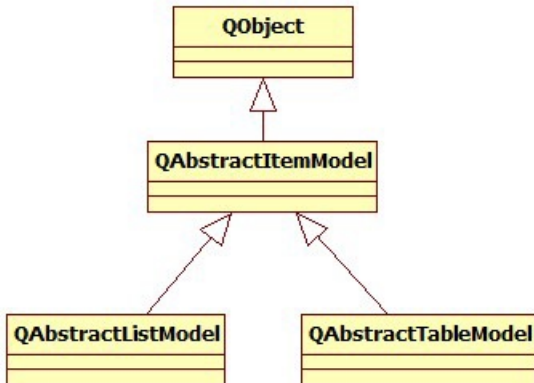
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Example - genes table model I

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- Inherit from `QAbstractTableModel`.
- Provide implementation for at least the following three functions: `rowCount`, `columnCount`, `data`.
- The `QModelIndex`
 - is used to locate data in a model;
 - it is an index which refers to an item in a model and is used by views;
 - each index is located in a given row and column, and may have a parent index.

Example - genes table model II

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```
class GenesTableModel: public QAbstractTableModel
{
public:
    GenesTableModel(QObject* parent = NULL);
    ~GenesTableModel();

    // number of rows
    int rowCount(const QModelIndex &parent = QModelIndex
                { }) const override;

    // number of columns
    int columnCount(const QModelIndex &parent =
                    QModelIndex { }) const override;

    // Value at a given position
    QVariant data(const QModelIndex &index, int role = Qt
                  :: DisplayRole) const override;
};
```

Controlling the text appearance - item roles I

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- Items in a model can perform various *roles*.
- Each item in the model has a set of data elements associated with it, each with its own role.
- When asking for the item's data from a model, the role can be specified and thus we obtain the type of data that we want.
- There is a set of standard roles defined in [Qt::ItemDataRole](#), which cover the most common uses for item data.

Controlling the text appearance - item roles II

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enum Qt::ItemDataRole	Description	Type
Qt::DisplayRole	The data to be rendered in the form of text.	QString
Qt::EditRole	The data in a form suitable for editing in an editor.	QString
Qt::FontRole	The font used for items.	QFont
Qt::TextAlignmentRole	The alignment of the text.	Qt::AlignmentFlag
Qt::BackgroundRole	The background brush.	QBrush
Qt::ForegroundRole	The foreground brush (text colour).	QBrush

Table/Tree headers

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- The model also controls the headers for a table/tree view.
- For this, the function `headerData` must be implemented.
- The `QVariant` class acts like a union for the most common Qt data types. A `QVariant` object holds a single value of a single type at a time.

```
QVariant headerData(int section , Qt::Orientation  
                    orientation , int role = Qt::DisplayRole) const  
override;
```

Demo

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DEMO

Implementing a custom model (*Lecture11_genes_custom_model*).

Edit model values

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- Implement the methods `setData` (will be called when a cell is edited) and `flags` (returns the item flags for a given index).
- When the data has been set, the model must let the views know that some data has changed. This is done by emitting the `dataChanged()` signal.

DEMO

Implementing a custom model (*Lecture11_genes_custom_model*).

Inserting new rows/columns

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- Whenever new rows/columns need to be inserted into the model's underlying data store, the views must be notified in order to update accordingly.
- The insertion process must be wrapped between functions `beginInsertRows(...)/beginInsertColumns(...)` and `endInsertRows(...)/endInsertColumns(...)`.
- When such a function pair is called, the model emits the (private) `rowsAboutToBeInserted()` signal and thus the views will "know" that they must update and show the newly added rows/columns.

Multiple views for the same model

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- Multiple views attached to the same model allow the user to interact with the data in different ways.
- Qt automatically keeps multiple views in sync, reflecting changes in the model.
- If the underlying data is changed, only the model needs to be changed; the views will behave correctly.
- Demo below: 3 different views (list view, table view, tree view) using the same model.

DEMO

Implementing a custom model (*Lecture11_genes_custom_model*).

Filtering and sorting I

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- The `QSortFilterProxyModel` class provides support for sorting and filtering data passed between another model and a view.
- The structure of the source model is transformed by mapping the model's indexes to new indexes.
- The given source model is restructured, without requiring transformations on the underlying data, and without duplicating the data in memory.

Filtering and sorting II

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- After an object `QSortFilterProxyModel` is created, use the `setSourceModel()` and set the `QSortFilterProxyModel` on the view.
- Use the `sortingEnabled` property of the `QTableView` and `QTreeView` to activate sorting by clicking on the header.

DEMO

Sorting (*Lecture11_genes_custom_model*).

Populating models incrementally

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- For large data sets, items should be added to the model in batches and only when they are needed by the view.
- Reimplement the methods `fetchMore()` and `canFetchMore()` from `QAbstractItemModel`.
- `canFetchMore()` is called by the view when it needs more items.

DEMO

Sorting (*Lecture11_genes_custom_models* - class `PaginatedGenesTableModel`).

Delegates

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- Delegates are used to render and edit individual items.
- They provide input capabilities and are also responsible for rendering individual items in some views.
- Usually, the default delegate is sufficient.
- However, the way that items of data are rendered and edited can be customized by using custom delegates.

Defining custom delegates

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- We can create our own delegate class and set it on the view that is supposed to use it.
- The standard interface for controlling delegates is defined in the [QAbstractItemDelegate](#) class.
- The default delegate implementation that is used by Qt's standard views is [QStyledItemDelegate](#). This should be used as base class when implementing custom delegates.

DEMO

Custom delegates (*Lecture11_genes_custom_model* - PictureDelegate).

Summary

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- The model/view architecture allows displaying the same data, in different views, without changing the underlying data structure.
- It is very suitable for handling large data sets, complex data items, database integration, multiple data views.
- The model communicates with a source of data and provides an interface for the views.
- The view obtains model indexes from the model.
- The delegate renders the items of data and communicates with the model when the data is edited.
- Qt offers predefined classes for models, views and delegates and we can also implement custom ones.