

# Object-Oriented Programming

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# Overview

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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 view 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 view 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.

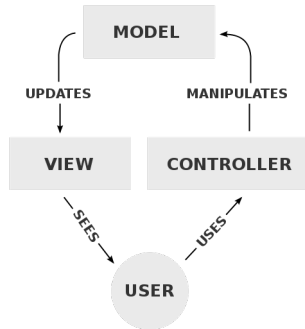


Figure source: <https://en.wikipedia.org/wiki/Model-view-controller#/media/File:MVC-Process.svg>

# Model-View-Controller (MVC) II

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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) III

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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).
- 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:  
<http://doc.qt.io/qt-5/modelview.html>.

# Model/View Architecture in Qt III

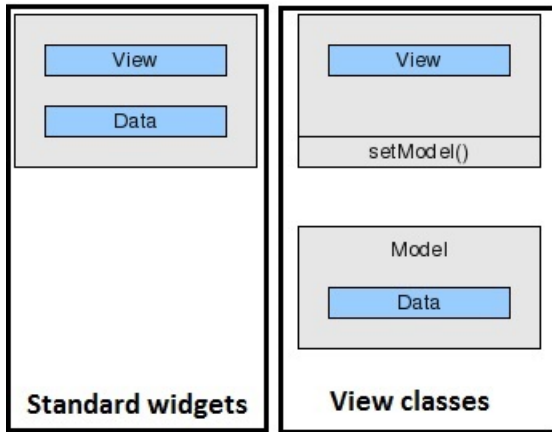


Figure source: <http://doc.qt.io/qt-5.6/modelview.html>

# 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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## 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 VI

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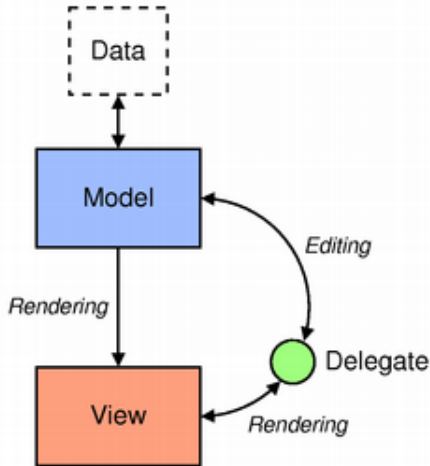


Figure source: <http://doc.qt.io/qt-5.6/modelview.html>

# 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 specialized components.
- Models, views, and delegates communicate with each other using signals and slots.

# Models

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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.

# 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.
- **QDirModel** - encapsulates the local file system.
- **QSqlQueryModel** - encapsulates an SQL result set.
- **QSqlTableModel** - encapsulates an SQL table.
- **QSqlRelationalTableModel** - encapsulates an SQL table with foreign keys.
- **QSortFilterProxyModel** - sorts and/or filters another model.



# Views

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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.

## 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 much faster.
- For  $\sim 21000$  genes: the list widget needs  $\sim 9$  seconds, while the view needs  $\sim 2$  seconds.

### DEMO

Using predefined models - genes list (*Lecture11\_demo\_predefined\_models*).

## 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\_demo - 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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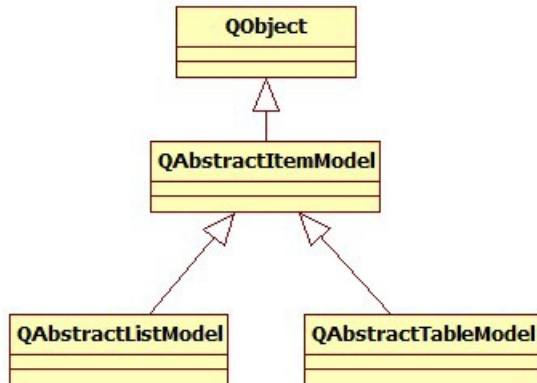
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# Example - genes table model I

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

# 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\_demo\_custom\_models*).

# 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\_demo\_custom\_models*).

# 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\_demo\_custom\_models*).

# 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\_demo\_custom\_models*).

# 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\_demo\_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\_demo\_custom\_models* - Picture-Delegate).