Qt Creator Manual > Using Debugging Helpers

Using Debugging Helpers

Structured data, such as objects of `class`, `struct`, or `union` types, is displayed in the **Locals** and **Expressions** views as part of a tree. To access sub-structures of the objects, expand the tree nodes. The sub-structures are presented in their in-memory order, unless the **Sort Members of Classes and Structs Alphabetically** option from the context menu is selected.

Similarly, pointers are displayed as a tree item with a single child item representing the target of the pointer. In case the context menu item **Dereference Pointers Automatically** is selected, the pointer and the target are combined into a single entry, showing the name and the type of the pointer and the value of the target.

This standard representation is good enough for the examination of simple structures, but it does usually not give enough insight into more complex structures, such as `QObjects` or associative containers. These items are internally represented by a complex arrangement of pointers, often highly optimized, with part of the data not directly accessible through neither sub-structures nor pointers.

To give the user simple access also to these items, Qt Creator employs Python scripts that are called *debugging helpers*. Debugging helpers are always automatically used. To force a plain C-like display of structures, select **Edit** > **Preferences** > **Debugger** > **Locals & Expressions**, and then deselect the **Use Debugging Helpers** check box. This will still use the Python scripts, but generate more basic output. To force the plain display for a single object or for all objects of a given type, select the corresponding option from the context menu.

Qt Creator ships with debugging helpers for more than 200 of the most popular Qt classes, standard C++ containers, and smart pointers, covering the usual needs of a C++ application developer out-of-the-box.

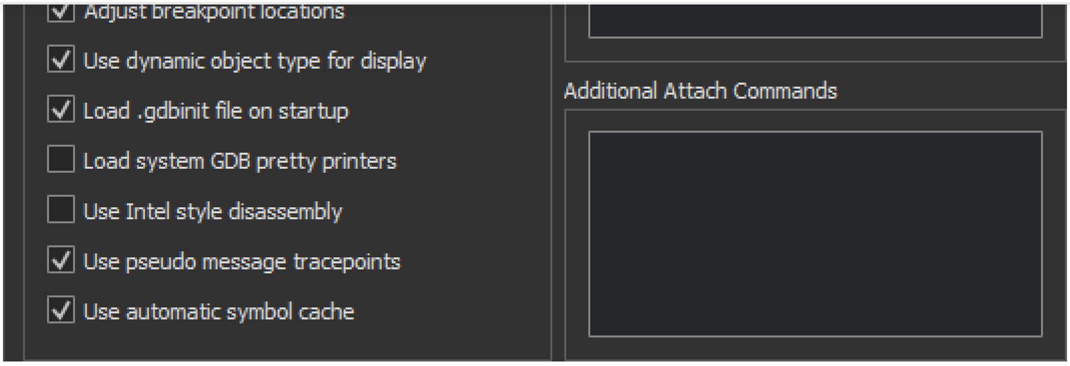
Extending Debugging Helpers

Qt Creator uses Python scripts to translate raw memory contents and type information data from native debugger backends (GDB, LLDB, and CDB are currently supported) into the form presented to the user in the **Locals** and **Expressions** views.

Unlike GDB's pretty printers and LLDB's data formatters, Qt Creator's debugging helpers are independent of the native debugging backend. That is, the same code can be used with GDB on Linux, LLDB on macOS, and CDB on Windows, or any other platform on which at least one of the three supported backends is available.

To use the default GDB pretty printers installed in your system or linked to the libraries your application uses, select **Preferences** > **Debugger** > **GDB** > **Load system GDB pretty printers**. For more information, see Specifying GDB Settings.

GDB timeout: 20sec



☑ Adjust breakpoint locations

☑ Use dynamic object type for display

☑ Load .gdbinit file on startup

□ Load system GDB pretty printers

□ Use Intel style disassembly

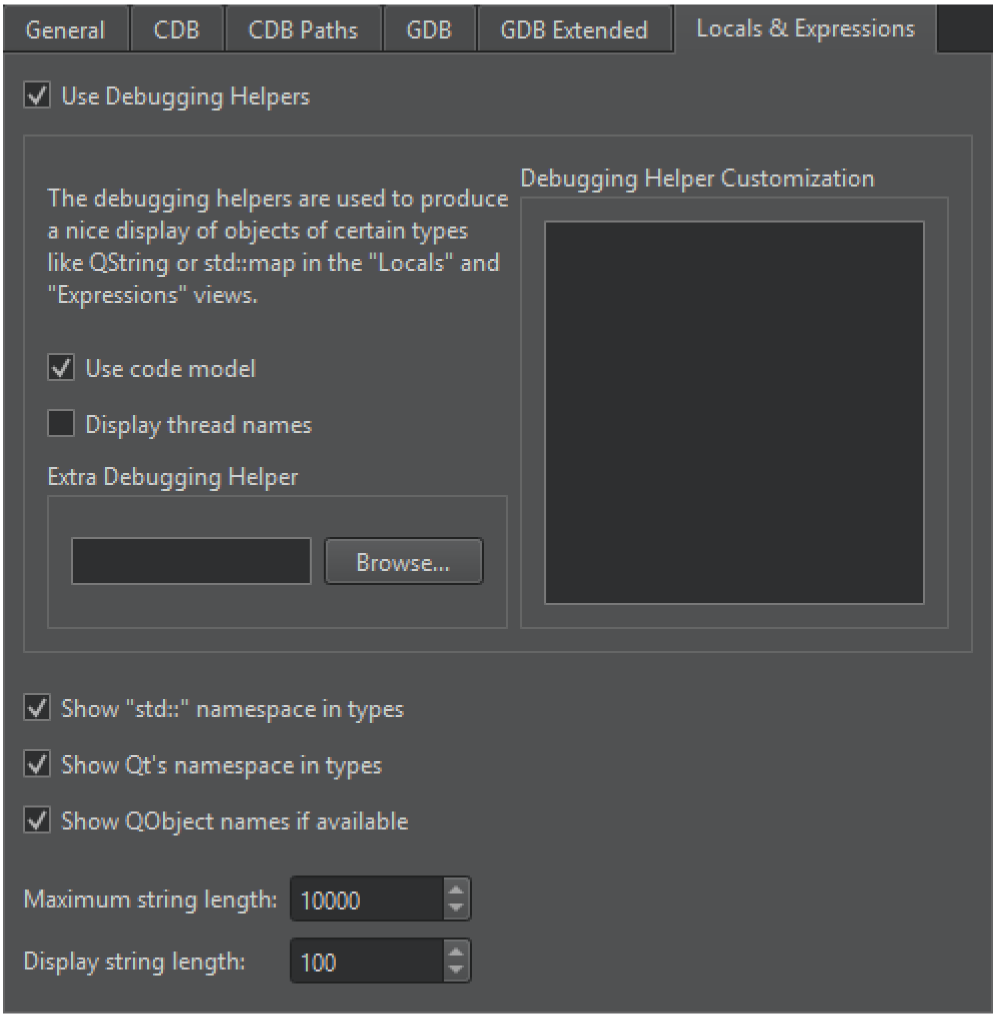
☑ Use pseudo message tracepoints

☑ Use automatic symbol cache

Additional Attach Commands

Customizing Built-In Debugging Helpers

You can have commands executed after built-in debugging helpers have been loaded and fully initialized. To load additional debugging helpers or modify existing ones, select **Edit** > **Preferences** > **Debugger** > **Locals & Expressions**, and enter the commands in the **Debugging Helper Customization** field.



☑ Use Debugging Helpers

The debugging helpers are used to produce a nice display of objects of certain types like QString or std::map in the "Locals" and "Expressions" views.

☑ Use code model

□ Display thread names

Extra Debugging Helper

Debugging Helper Customization

☑ Show "std::" namespace in types

☑ Show Qt's namespace in types

☑ Show QObject names if available

Maximum string length: 10000

Display string length: 100

If you receive error messages about receiving signals when using GDB, you can specify GDB commands for handling the signals. For example, you can tell GDB to ignore the `SIGSTOP` signal if you receive the following error message: `The inferior stopped because it received a signal from the operating system. Signal name: SIGSTOP`.

To stop GDB from handling the `SIGSTOP` signal, add the following commands to the **Debugging Helper Customization** field:

To display a message box as soon as your application receives a signal during debugging, select **Edit** > **Preferences** > **Debugger** > **GDB** > **Show a message box when receiving a signal**.

Adding Custom Debugging Helpers

To add debugging helpers for your own types, no compilation is required, just adding a few lines of Python. The scripts can address multiple versions of Qt, or of your own library, at the same time.

To add debugging helpers for custom types, add debugging helper implementations to the startup file of the native debuggers (for example, `~/.gdbinit` or `~/.lldbinit`) or specify them directly in the **Additional Startup Commands** in **Edit** > **Preferences** > **Debugger** > **GDB**.

To get started with implementing debugging helpers for your own data types, you can put their implementation into the file `share/qtcreator/debugger/personaltypes.py` in your Qt installation or stand-alone Qt Creator installation. On macOS, the file is bundled into the Qt Creator application package, where it is located in the `Contents/resources/debugger` folder.

The `personaltypes.py` file contains one example implementation:

```
# def qdump__MapNode(d, value):
#    d.putValue("This is the value column contents")
#    d.putExpandable()
#    if d.isExpanded():
#        with Children(d):
#            # Compact simple case.
#            d.putSubItem("key", value["key"])
#            # Same effect, with more customization possibilities.
#            with SubItem(d, "data")
#                d.putItem("data", value["data"])
```

To add debugging helpers:

1. Open the `share/qtcreator/debugger/personaltypes.py` file for editing. For example, if your Qt installation is located in the `Qt5` directory on Windows, look in `C:\Qt5\Tools\QtCreator\share\qtcreator\debugger`. On macOS, look in `Qt5/Qt Creator.app/Contents/resources/debugger`.
2. Add your dumper implementation to the end of the `personaltypes.py` file. For more information about implementing debugging helpers, see the following sections.
3. To prevent `personaltypes.py` from being overwritten when you update your Qt Creator installation (when updating your Qt installation, for example), copy it to a safe location outside the Qt Creator installation in your file system and specify the location in **Edit** > **Preferences** > **Debugger** > **Locals & Expressions** > **Extra Debugging Helper**.

The custom debugging helpers will be automatically picked up from `personaltypes.py` when you start a debugging session in Qt Creator or select **Reload Debugging Helpers** from the context menu of the **Debugger Log** view.

Debugging Helper Overview

The implementation of a debugging helper typically consists of a single Python function, which needs to be named `qdump__NS__Foo`, where `NS::Foo` is the class or class template to be examined. Note that the `::` scope

Examples:

- The name for the function implementing a debugging helper for the type namespace Project { template<typename T> struct Foo {... } } is qdump__Project__Foo.
- The name for the function implementing a debugging helper for the type std::__1::vector<T>::iterator is qdump__std____1__vector__iterator.

Qt Creator's debugger plugin calls this function whenever you want to display an object of this type. The function is passed the following parameters:

- d of type Dumper, an object containing the current settings and providing facilities to build up an object representing a part of the **Locals** and **Expressions** views.
- value of type Value, wrapping either a gdb.Value or an lldb.SBValue.

The qdump__* function has to feed the Dumper object with certain information that is used to build up the object and its children's display in the **Locals** and **Expressions** views.

Example:

```
def qdump__QFiniteStack(d, value):
    alloc = value["_alloc"].integer()
    size = value["_size"].integer()
    d.putItemCount(size)
    if d.isExpanded():
        d.putArrayData(value["_array"], size, value.type[0])
```

> **Note:** To create dumper functions usable with both LLDB and GDB backends, avoid direct access to the gdb.* and lldb.* namespaces and use the functions of the Dumper class instead.

To get to the base instance of the object in the debugging helper, use the value.base() function or the following example code:

```
def qdump__A(d, value):
   t = value.members(True)[0].type
   dptr, base_v = value.split('p{%s}' % t.name)
   d.putItem(base_v)
```

Debugging helpers can be set up to be called whenever a type name matches a regular expression. To do so, the debugging helper's function name must begin with qdump__ (with two underscore characters). In addition, the function needs to have a third parameter called regex with a default value that specifies the regular expression that the type name should match.

For example, the Nim 0.12 compiler assigns artificial names, such as TY1 and TY2, to all generic sequences it compiles. To visualize these in Qt Creator, the following debugging helper may be used:

```
def qdump__NimGenericSequence__(d, value, regex = "^TY.*$"):
    size = value["Sup"]["len"]
```

```
       d.putArrayData(base, size, typeobj)
```

Debugging Helper Implementation

A debugging helper creates a description of the displayed data item in a format that is similar to GDB/MI and JSON.

For each line in the **Locals** and **Expressions** views, a string like the following needs to be created and channeled to the debugger plugin.

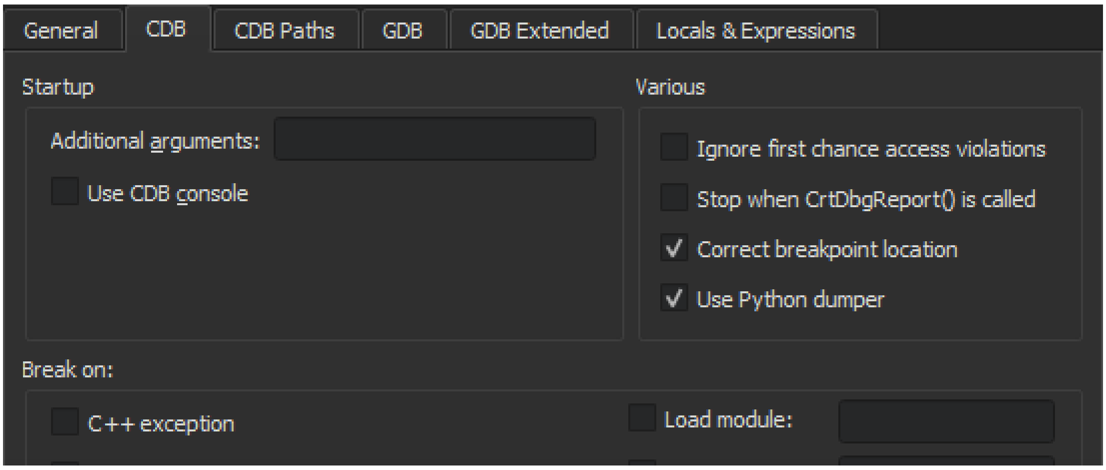
```
{ iname='some internal name',           # optional
  address='object address in memory',   # optional
  name='contents of the name column',   # optional
  value='contents of the value column',
  type='contents of the type column',
  numchild='number of children',        # zero/nonzero is sufficient
  children=[              # only needed if item is expanded in view
     {iname='internal name of first child',
       },
     {iname='internal name of second child',
       },

  ]}
```

The value of the `iname` field is the internal name of the object, which consists of a dot-separated list of identifiers, corresponding to the position of the object's representation in the view. If it is not present, it is generated by concatenating the parent object's `iname`, a dot, and a sequential number.

The value of the name field is displayed in the **Name** column of the view. If it is not specified, a simple number in brackets is used instead.

As the format is not guaranteed to be stable, it is strongly recommended not to generate the wire format directly, but to use the abstraction layer provided by the Python Dumper classes, specifically the `Dumper` class itself, and the `Dumper:Value` and `Dumper:Type` abstractions. These provide a complete framework to take care of the `iname` and `addr` fields, to handle children of simple types, references, pointers, enums, and known and unknown structs, as well as some convenience functions to handle common situations.

When using CDB as debugger backend, you can enable the Python dumper by selecting **Edit** > **Preferences** > **Debugger** > **CDB** > **Use Python dumper**.



Startup

Additional arguments:

☐ Use CDB console

Various

☐ Ignore first chance access violations

☐ Stop when CrtDbgReport() is called

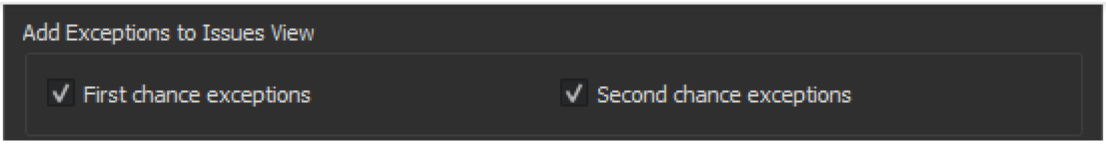
☑ Correct breakpoint location

☑ Use Python dumper

Break on:

☐ C++ exception

☐ Load module:



Add Exceptions to Issues View

☑ First chance exceptions ☑ Second chance exceptions

Dumper Class

The `Dumper` class contains generic bookkeeping, low-level, and convenience functions.

The member functions of the `Dumper` class are the following:

- `putItem(self, value)` - The *master function* that handles basic types, references, pointers, and enums directly, iterates over base classes and class members of compound types, and calls qdump__* functions when appropriate.
- `putIntItem(self, name, value)` - Equivalent to:

  ```
  with SubItem(self, name):
      self.putValue(value)
      self.putType("int")
  ```

- `putBoolItem(self, name, value)` - Equivalent to:

  ```
  with SubItem(self, name):
      self.putValue(value)
      self.putType("bool")
  ```

- `putCallItem(self, name, value, func, *args)` - Uses the native debugger backend to place the function call `func` on the value specified by *value* and output the resulting item.

  Native calls are extremely powerful and can leverage existing debugging or logging facilities in the debugged process, for example. However, they should only be used in a controlled environment, and only if there is no other way to access the data, for the following reasons:

  - Direct execution of code is dangerous. It runs native code with the privileges of the debugged process, with the potential to not only corrupt the debugged process, but also to access the disk and network.
  - Calls cannot be executed when inspecting a core file.
  - Calls are expensive to set up and execute in the debugger.

- `putArrayData(self, address, itemCount, type)` - Creates the number of children specified by `itemCount` of the type `type` of an array-like object located at `address`.
- `putSubItem(self, component, value)` - Equivalent to:

  ```
  with SubItem(self, component):
      self.putItem(value)
  ```

  Exceptions raised by nested function calls are caught and all output produced by `putItem` is replaced by the output of:

```
except RuntimeError:
    d.put('value="<invalid>",type="<unknown>",numchild="0",')
```

- `put(self, value)` - A low-level function to directly append to the output string. That is also the fastest way to append output.
- `putField(self, name, value)` - Appends a `name='value'` field.
- `childRange(self)` - Returns the range of children specified in the current `Children` scope.
- `putItemCount(self, count)` - Appends the field `value='<%d items>'` to the output.
- `putName(self, name)` - Appends the `name=''` field.
- `putType(self, type, priority=0)` - Appends the field `type=''`, unless the *type* coincides with the parent's default child type or `putType` was already called for the current item with a higher value of `priority`.
- `putBetterType(self, type)` - Overrides the last recorded `type`.
- `putExpandable(self)` - Announces the existence of child items for the current value. The default are no children.
- `putNumChild(self, numchild)` - Announces the existence (`numchild` > 0) or non-existence of child items for the current value.
- `putValue(self, value, encoding = None)` - Appends the file `value=''`, optionally followed by the field `valueencoding=''`. The `value` needs to be convertible to a string entirely consisting of alphanumerical values. The `encoding` parameter can be used to specify the encoding in case the real value had to be encoded in some way to meet the alphanumerical-only requirement. The parameter `encoding` is either a string of the form `codec:itemsize:quote` where `codec` is any of `latin1`, `utf8`, `utf16`, `ucs4`, `int`, or `float`. `itemsize` gives the size of the basic component of the object if it is not implied by `codec` and `quote` specifies whether or not the value should be surrounded by quotes in the display.

  Example:

  ```
  # Safe transport of quirky data. Put quotes around the result.
  d.putValue(d.hexencode("ABC\"DEF"), "utf8:1:1")
  ```

- `putStringValue(self, value)` - Encodes a QString and calls `putValue` with the correct `encoding` setting.
- `putByteArrayValue(self, value)` - Encodes a QByteArray and calls `putValue` with the correct `encoding` setting.
- `isExpanded(self)` - Checks whether the current item is expanded in the view.
- `createType(self, pattern, size = None)` - Creates a `Dumper.Type` object. The exact operation depends on `pattern`.
  - If `pattern` matches the name of a well-known type, a `Dumper.Type` object describing this type is returned.
  - If `pattern` is the name of a type known to the native backend, the returned type describes the native type.
  - Otherwise, `pattern` is used to construct a type description by interpreting a sequence of items describing the field of a structure as follows. Field descriptions consist of one or more characters as follows:

- `i` - Signed 4-byte integral value
- `I` - Unsigned 4-byte integral value
- `h` - Signed 2-byte integral value
- `H` - Unsigned 2-byte integral value
- `b` - Signed 1-byte integral value
- `B` - Unsigned 1-byte integral value
- `d` - 8-byte IEEE 754 floating point value
- `f` - 4-byte IEEE 754 floating point value
- `p` - A pointer, that is, an unsigned integral value of suitable size according to the target architecture
- `@` - Suitable padding. The size is determined by the preceding and following field and the target architecture
- `<n>s` - A blob of <n> bytes, with implied alignment of 1
- `<typename>` - A blob of suitable size and suitable alignment determined by a `Dumper.Type` with the name `typename`

Dumper.Type Class

The `Dumper.Type` class describes the type of a piece of data, typically a C++ class or struct, a pointer to a struct, or a primitive type, such as an integral or floating point type.

Type objects, that is, instances of the `Dumper.Type` class, can be created by native debugger backends, usually by evaluating Debug Information built into or shipped alongside the debugged binary, or created on-the-fly by the debugging helper.

Qt Creator uses the possibility to provide type information on-the-fly for most Qt classes, obliterating the need to use *Debug* builds of Qt for the purpose of object introspection.

The member functions of the `Dumper.Type` class are the following:

- `name` - The name of this type as a string, or `None` if the type is anonymous.
- `size(self)` - Returns the size of an object of this type in bytes.
- `bitsize(self)` - Returns the size of an object of this type in bits.
- `alignment(self)` - Returns the required alignment for objects of this type in bytes.
- `deference(self)` - Returns the dereferences type for pointer type, `None` otherwise.
- `pointer(self)` - Returns a pointer type that can be dereferenced to this type.
- `target(self)` - A convenience function that returns the item type for array types and the dereferenced type for pointers and references.
- `stripTypedefs(self)` - Returns the underlying type if this type is an alias.
- `templateArgument(self, position, numeric = False)` - Returns the template parameter located at `position` if this is a templated type. If `numeric` is `True`, returns the parameter as an integral value.
- `fields(self)` - Returns a list of `Dumper:Fields` describing the base classes and data members of this type.

Dumper.Field Class

- `isBaseClass` - Distinguishes between base classes and data members.
- `fieldType(self)` - Returns the type of this base class or data member.
- `parentType(self)` - Returns the owning type.
- `bitsize(self)` - Returns the size of this field in bits.
- `bitpos(self)` - Returns the offset of this field in the owning type in bits.

Dumper.Value Class

The `Dumper.Value` class describes a piece of data, such as instances of C++ classes or primitive data types. It can also be used to describe artificial items that have no direct representation in memory, such as file contents, non-contiguous objects, or collections.

A `Dumper.Value` has always an associated `Dumper.Type`. The two main representations of the value's actual data are:

- Python object following the Python buffer protocol, such as a Python `memoryview`, or a `bytes` object. The `size()` should match the size of this value's type.
- An integral value representing a pointer to the begin of the object in the current address space. The size of the object is given by its type's `size()`.

Knowledge of the internal representation of a `Dumper.Value` is typically not required when creating a debugger helper for it.

The member function and properties of the `Dumper.Value` class are the following:

- `integer(self)` - Returns an interpretation of this value as a signed integral value of a suitable size.
- `pointer(self)` - Returns an interpretation of this value as a pointer in the current address space.
- `members(self, includeBases)` - Returns a list of `Dumper.Value` objects representing the base objects and data members of this value.
- `dereference(self)` - For values describing pointers, returns the dereferenced value, and None otherwise.
- `cast(self, type)` - Returns a value that has the same data as this value, but the type `type`.
- `address(self)` - Returns the address of this value if it consists of a contiguous region in the current address space, and None otherwise.
- `data(self)` - Returns the data of this value as a Python `bytes` object.
- `split(self, pattern)` - Returns a list of values created according to `pattern` from this value's data. Acceptable patterns are the same as for `Dumper.createType`.
- `dynamicTypeName(self)` - Tries to retrieve the name of the dynamic type of this value if this is a base class object. Returns None if that is not possible.

Children and SubItem Class

The attempt to create child items might lead to errors if data is uninitialized or corrupted. To gracefully recover in such situations, use `Children` and `SubItem` *Context Managers* to create the nested items.

The `Children` constructor `__init__(self, dumper, numChild = 1, childType = None, childNumChild = None, maxNumChild = None, addrBase = None, addrStep = None)` uses one mandatory argument and several optional arguments. The mandatory argument refers to the current `Dumper` object. The optional arguments can be used to specify the number `numChild` of children, with type `childType_` printing for the *n*th child item will be suppressed if its address equals with *addrBase* + *n* * *addrStep*.

Example:

```
if d.isExpanded():
    with Children(d):
        with SubItem(d):
            d.putName("key")
            d.putItem(key)
        with SubItem(d):
            d.putName("value")
            d.putItem(value)
```

Note that this can be written more conveniently as:

```
d.putNumChild(2)
if d.isExpanded():
    with Children(d):
        d.putSubItem("key", key)
        d.putSubItem("value", value)
```

‹ Interacting with the Debugger

Debugging Qt Quick Projects ›

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