QuantLib User Meeting
30 November 2017

Deriscope

by
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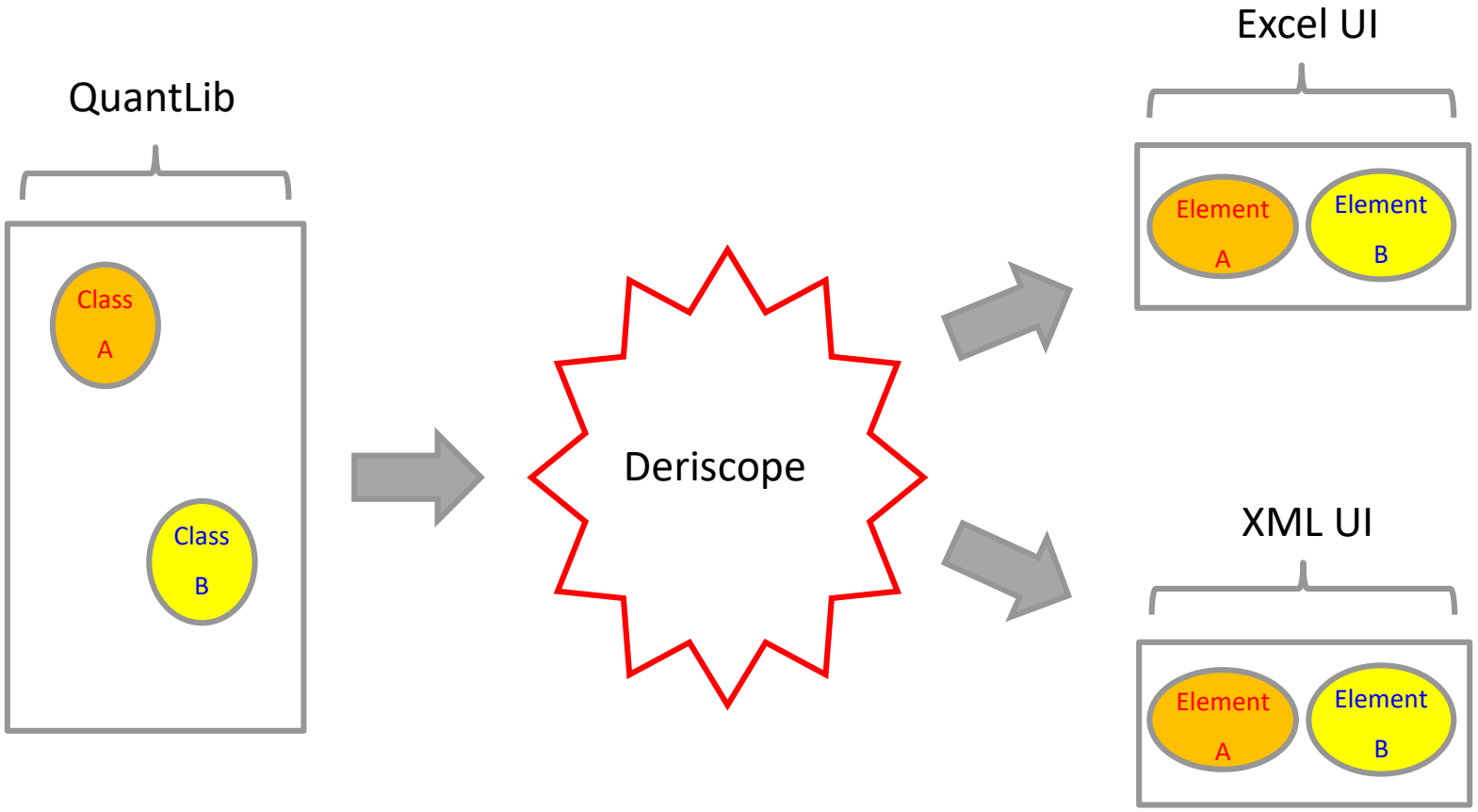
Part 1
Architecture

The grand idea

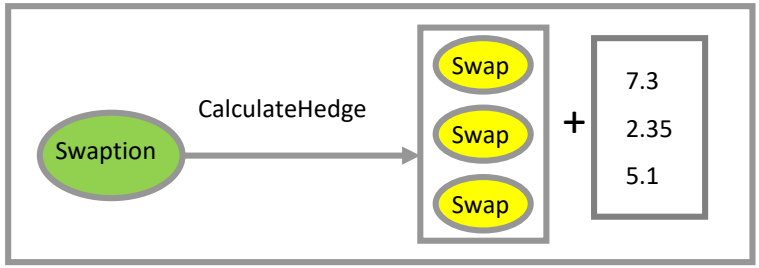
- Map the compile-time C++ classes and respective run-time objects to User Interface compatible elements



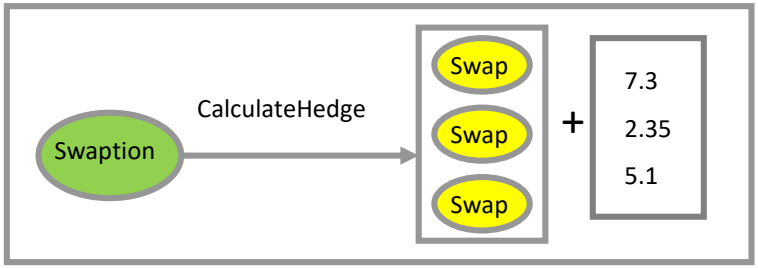
The grand idea (example)

- A **QuantLib developer** has just implemented a new class called "**Swaption**" that has a method called "**CalculateHedge**" which returns a vector of **Swap** instruments plus a vector of notionals
- An **Excel user** who accesses QuantLib through Deriscope will see in the wizard a new type called "**Swaption**" that has the method "**CalculateHedge"**, which produces two columns of data:
- One column containing objects of type **Swap** and one column containing plain numbers (*)

C++ World

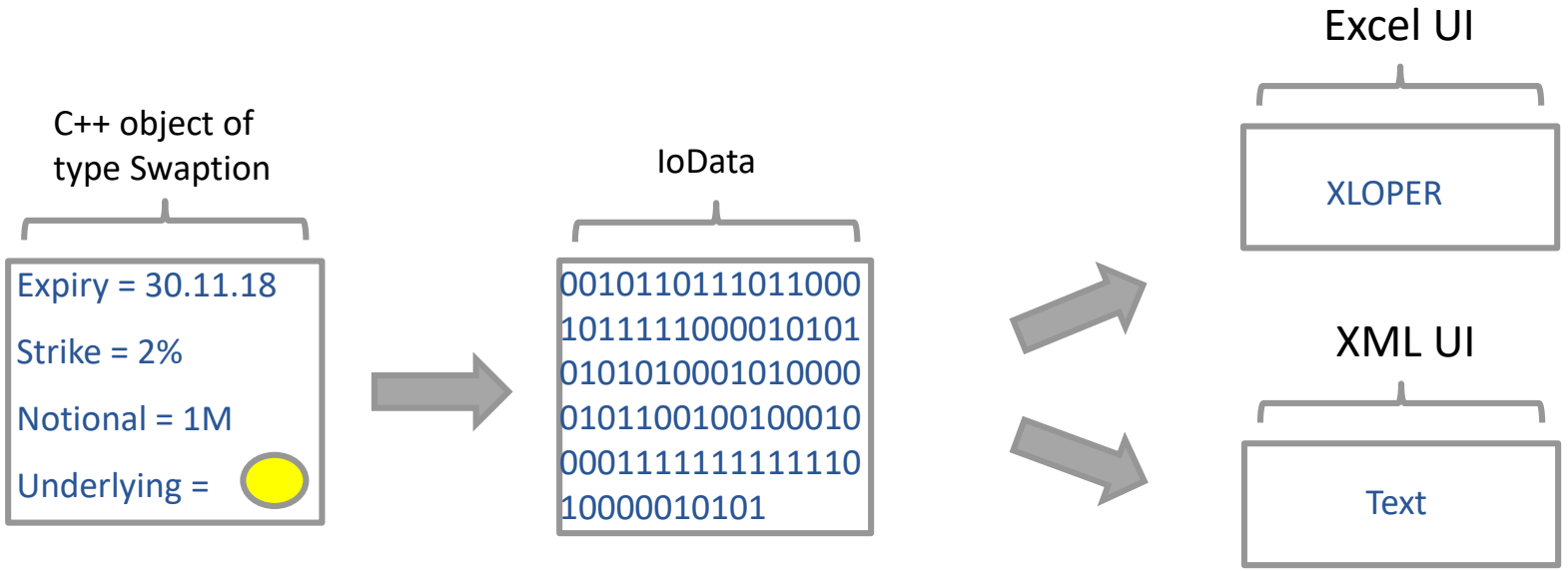


Excel World (generated by Deriscope from the C++ world)



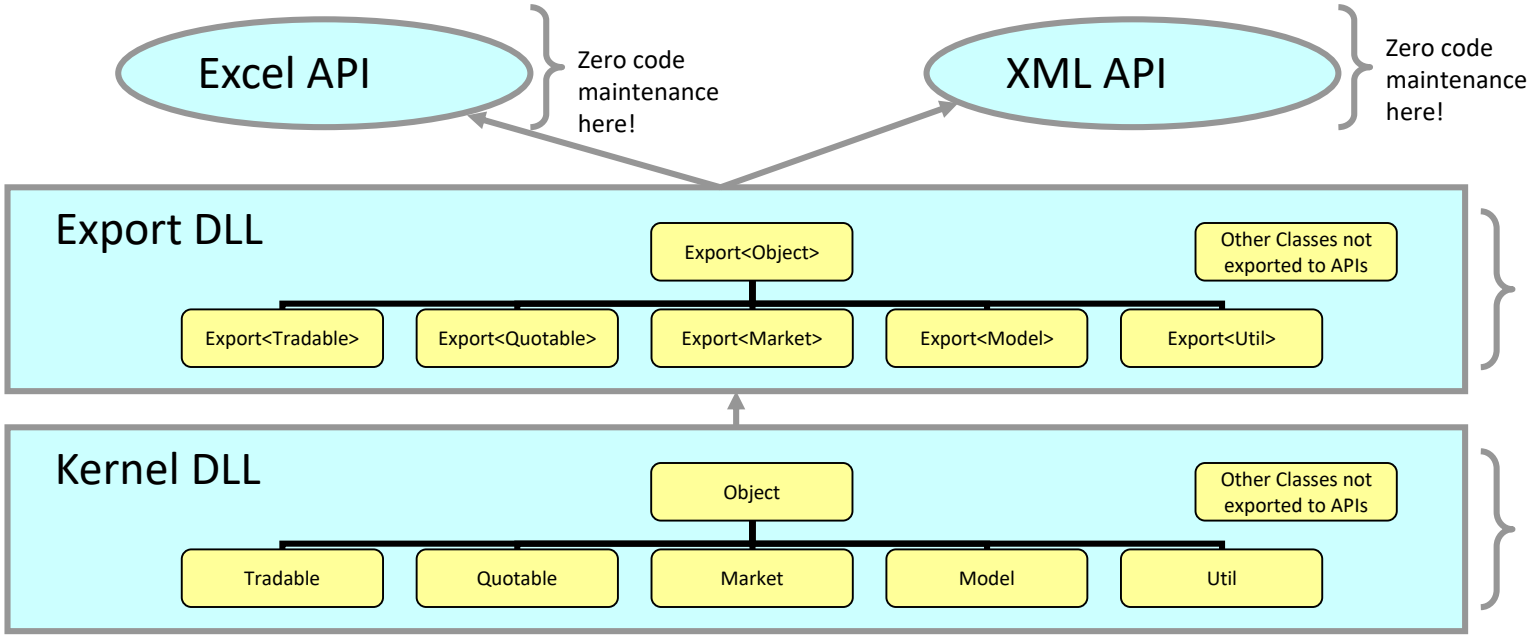
IoData: Bridge between C++ and UI

- C++ classes and data can be implemented in many different ways
- User Interfaces offer limited Data Representation
- Deriscope's trick:
  - **1.** Map from **C++** to special class called **IoData**
  - **2.** Map from **IoData** to each supported **User Interface** (*)



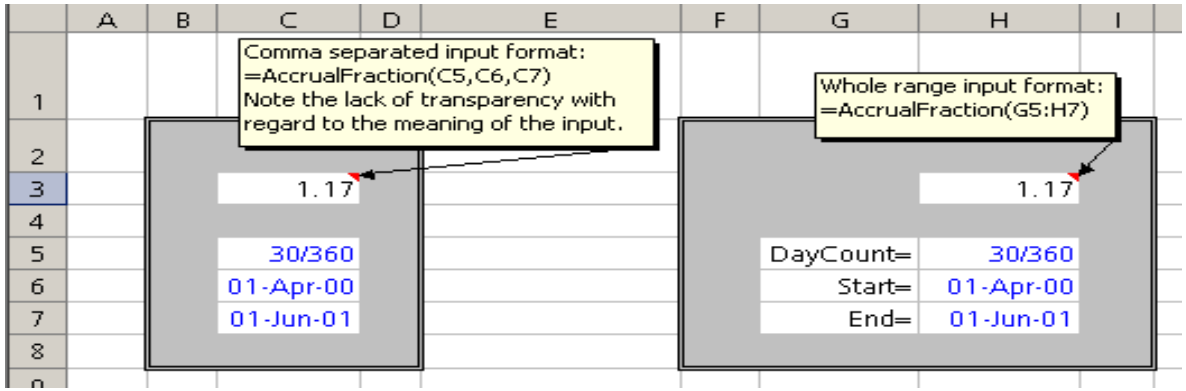
DLL & Class Structure

- Deriscope consists of two main Dlls: **Kernel** & **Export**
- The Kernel Dll contains all the analytics, including the QuantLib library
- The Export DLL contains classes Export<X>, where X is a Kernel class deriving from the root class Object (*)



Export DLL (IoData): Key-Value

- Input/output data are mostly expressed as **Key-Value pairs**
- **Key** = Text label
- **Value** = scalar, array, object or set of key/value pairs
- K**ey-Value pairs** may be dynamically declared as optional
- K**ey-Value pairs** apply to all User Interfaces (*)



Export DLL: Advantages

- Similar User Interface across Products and across APIs.
- APIs protected from Kernel changes.
- UI Type Inheritance mimics the C++ Type Inheritance
- C++ debugging transferred to the GUI level
- Hierarchical classification of exported Functions
- Overloading of exported Functions
- Efficient pool management (*)

UI Benefits from C++-level Reflection

- List of available exported classes
- List of available exported functions within a given class
- Required input data for a given function
- Detailed description of any class
- Detailed description of any function
- Detailed description of any key-value pair input (*)

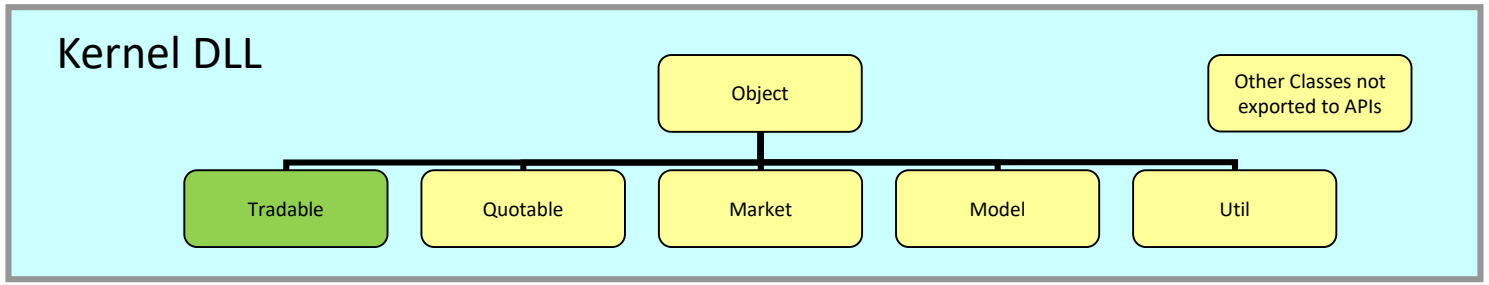
Drag & Drop across applications

- Any Deriscope object can be cast as an xml file and thus delivered to another application that can read such an XML file
- Effectively every object can be serialized in a recursive fashion so that all its dependencies are also serialized. The result is a stateless object in the form of a text file
- The reverse process is also possible. A properly formatted XML file can give rise to an object with a "state" in the pool of persistent objects maintained by the application that reads the XML file
- Drag & Drop is just a simple application of all this (*)

Kernel Architectural Aspects

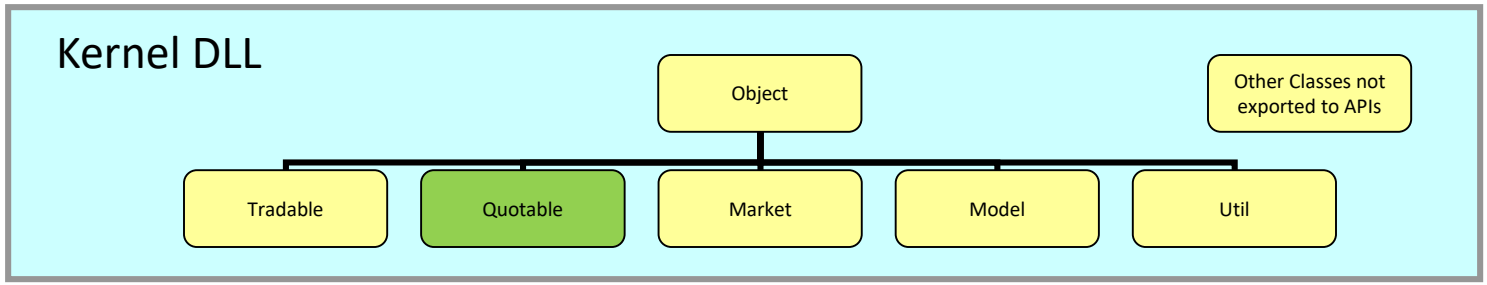
- **C++** with great emphasis on **Object Oriented** principles.
- Proprietary **smart pointer**
- **Reflexion** capabilities through template-based **metaprogramming**
- Definition of Concepts in terms of a few **orthogonal** concepts
- Deriscope has a relatively large number of pure header files (*)

Top Level Class Hierarchy - Tradable



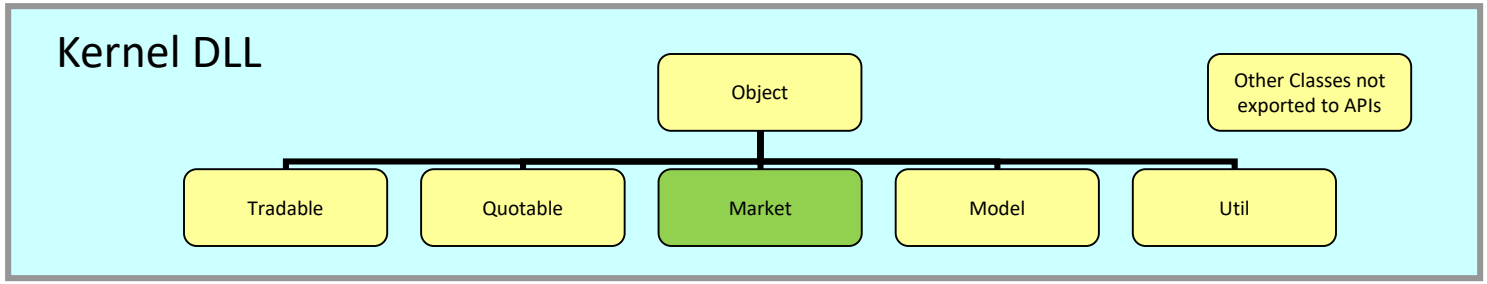
- Parent type of any object that describes a tradable instrument
- Examples of types deriving from **Tradable** are Bond, Stock, Swap etc
- The Market Price of a **Tradable A** with respect to another **Tradable B** at some time t is defined as the number of units of the **Tradable B** that are exchanged for one unit of the **Tradable A**
- The Theoretical Price of a **Tradable A** with respect to a **Tradable B** at some time t relies on additional objects of type Market and Model
- The landmark identifier of the **Tradable** class is its **"Price"** function (*)

Top Level Class Hierarchy - Quotable



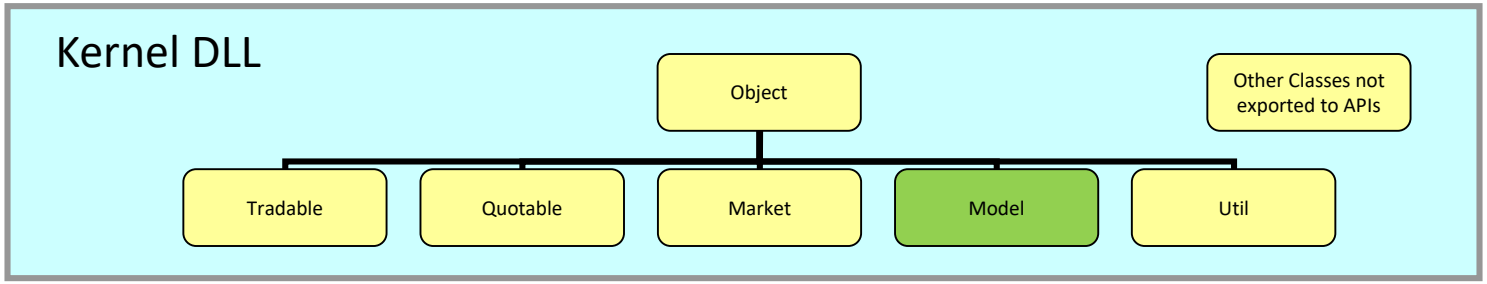
- Parent type of any object that describes a financial variable
- Examples of types deriving from **Quotable** are Stock Price, FX Rate
- The Value of a **Quotable** A at time t is a Measure
- For t = 0, the Measure typically collapses to a single number
- The Theoretical Value of a **Quotable** A with respect to a **Quotable** B at some time t relies on additional objects of type Market and Model
- The landmark identifier of the **Quotable** class is its **" Value "** function

Top Level Class Hierarchy - Market



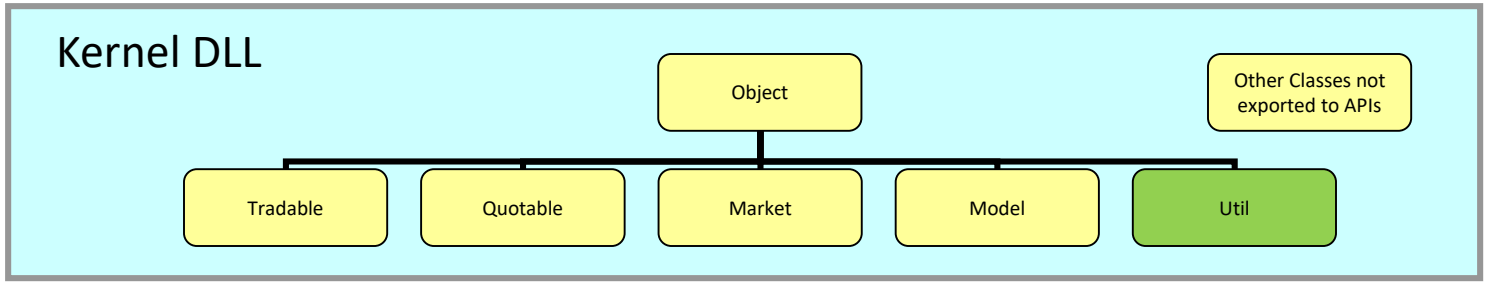
- This type serves as a container of "Market Data“, i.e. of the objective information that is available as of a given time t
- A **Market** object is defined as a collection of "**Valuation**" objects
- A “**Valuation**” object is a pair of a Quotable and its associated Value
- It is required **input** to the **Price** and **Value** functions
- It is also the **output** of the **Price** and **Value** functions! (*)

Top Level Class Hierarchy - Model



- This type serves to hold everything that can be seen as "subjective", i.e. information that can be potentially disputed
- **Model** objects hold assumptions, such as an assumed interpolation of zero rates or the Gaussian dynamics of a stock price
- Every Kernel class **X** can have a corresponding class **Model<X>**
- Deriscope discourages the creation of **Model** classes **M** that are not of the form **Model<X>** (*)

Top Level Class Hierarchy - Util



- This Type has a simple definition:
- It contains all those objects that do not already fall under any of Tradable, Quotable, Market, or Model (*)

Top Level Class Hierarchy Benefits

- Concept Orthogonalization makes the maintanance of a huge number of Classes possible
- Elimination of “orphan” classes
  - Class BlackScholes derives from Model<TradablePrice>
- Enhanced teamwork without overlap
- Single "Market" class
  - Additional inherited classes, such as YieldCurve, can be added for convenience but are not strictly necessary
- Automatic availability of "Model" classes: **T --> Model<T>** (*)

Run-time Composition of Dynamic Types

- Synthesize new types out of old ones during run time
- There are certain classes that make this possible. Two important such classes are described below:
- **Tradable Price**
  - Manufactures a **Quotable** object that represents the "**ratio**" of two given **Tradable** objects
  - Example: **Discount Factor** type created by “dividing” a **Zero Bond** with its own **Currency**
- **Quotable Group**
  - Manufactures a **Quotable** object that represents the "**equivalence class**" defined through a given **Quotable** object plus an "**equivalence relationship**"
  - Example: “**Yield Curve**" type created out of a specific **Discount Factor** object and an "**equivalence relationship**" that regards two **Discount Factor** objects equivalent if they have the same currency (*)

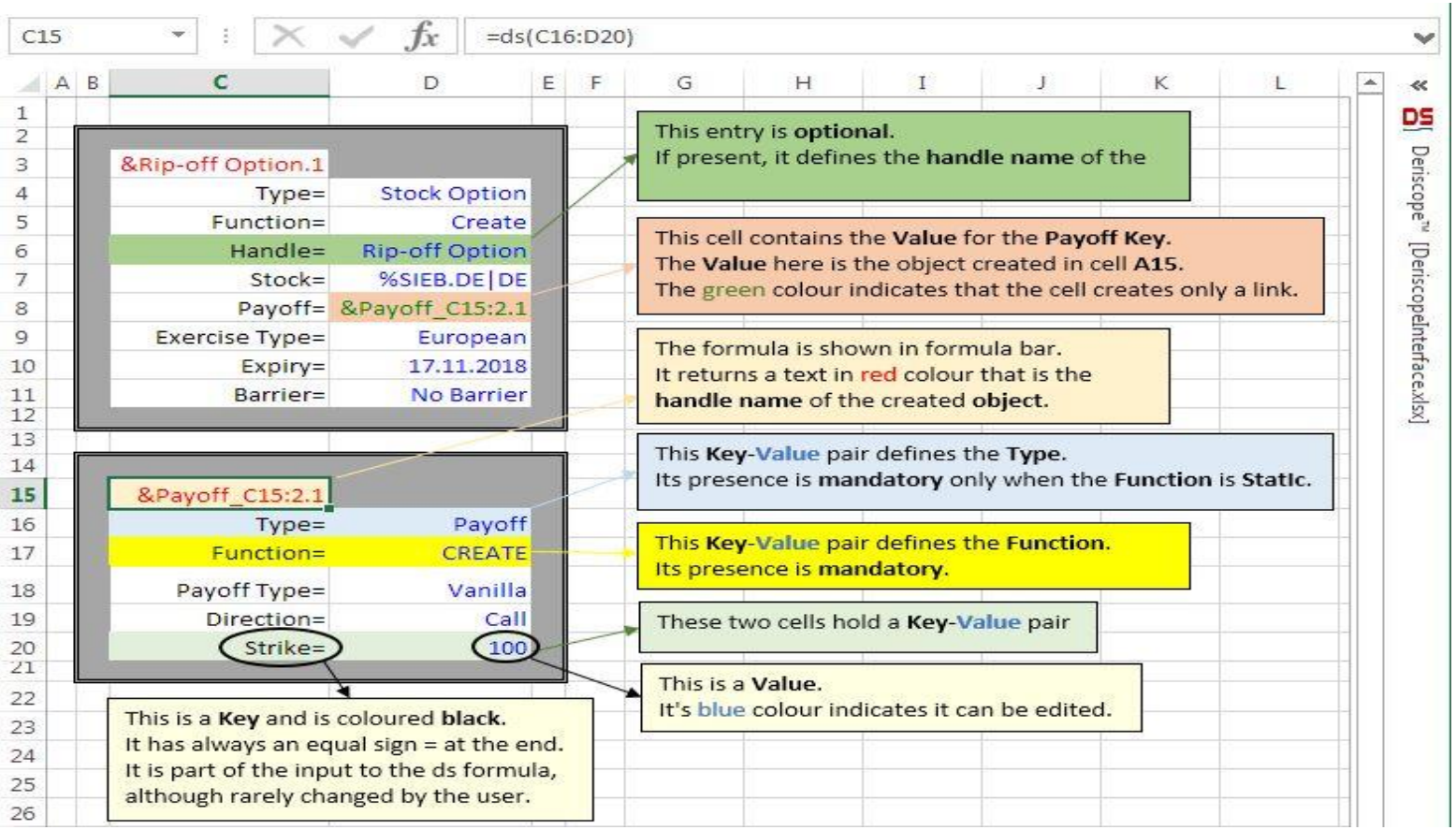
Part 2
User Interface

Overview

- **Deriscope** is an **Excel Add-In** that enables the user to work with QuantLib in Excel.
- **Deriscope** contains a **wizard** that allows the user to generate spreadsheet formulas by choosing predefined types and functions.
- **Deriscope** places full context-relevant **documentation** at the user's fingerprints. All relevant information is usually just a mouse click away.

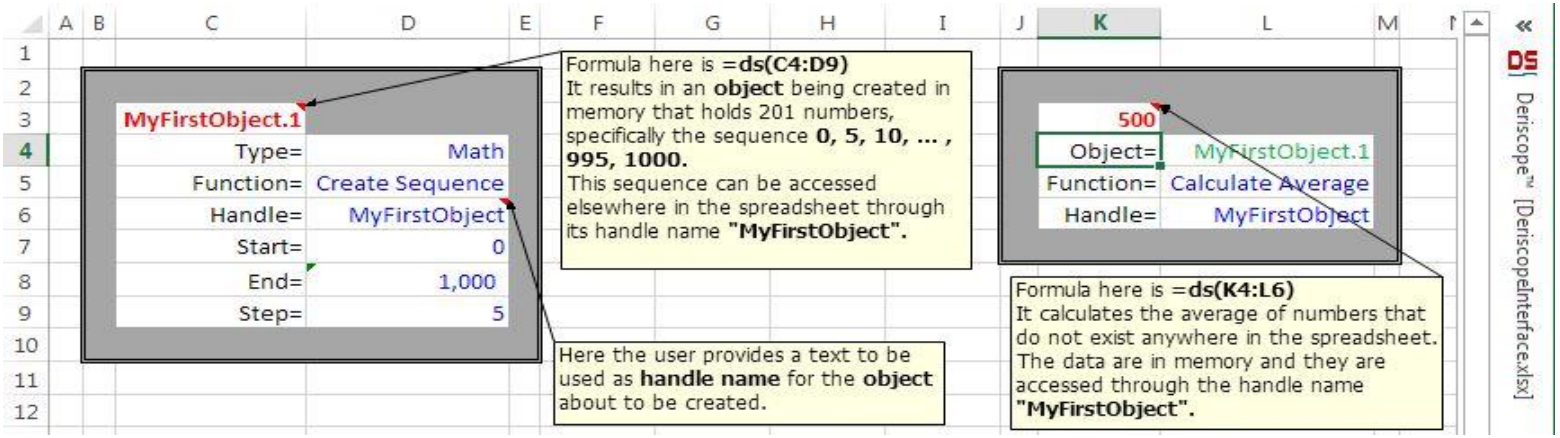
Spreadsheet Formatting and Data Input

- All formulas generated by *Deriscope* have a similar look:



About “Objects” and “Handle Names”

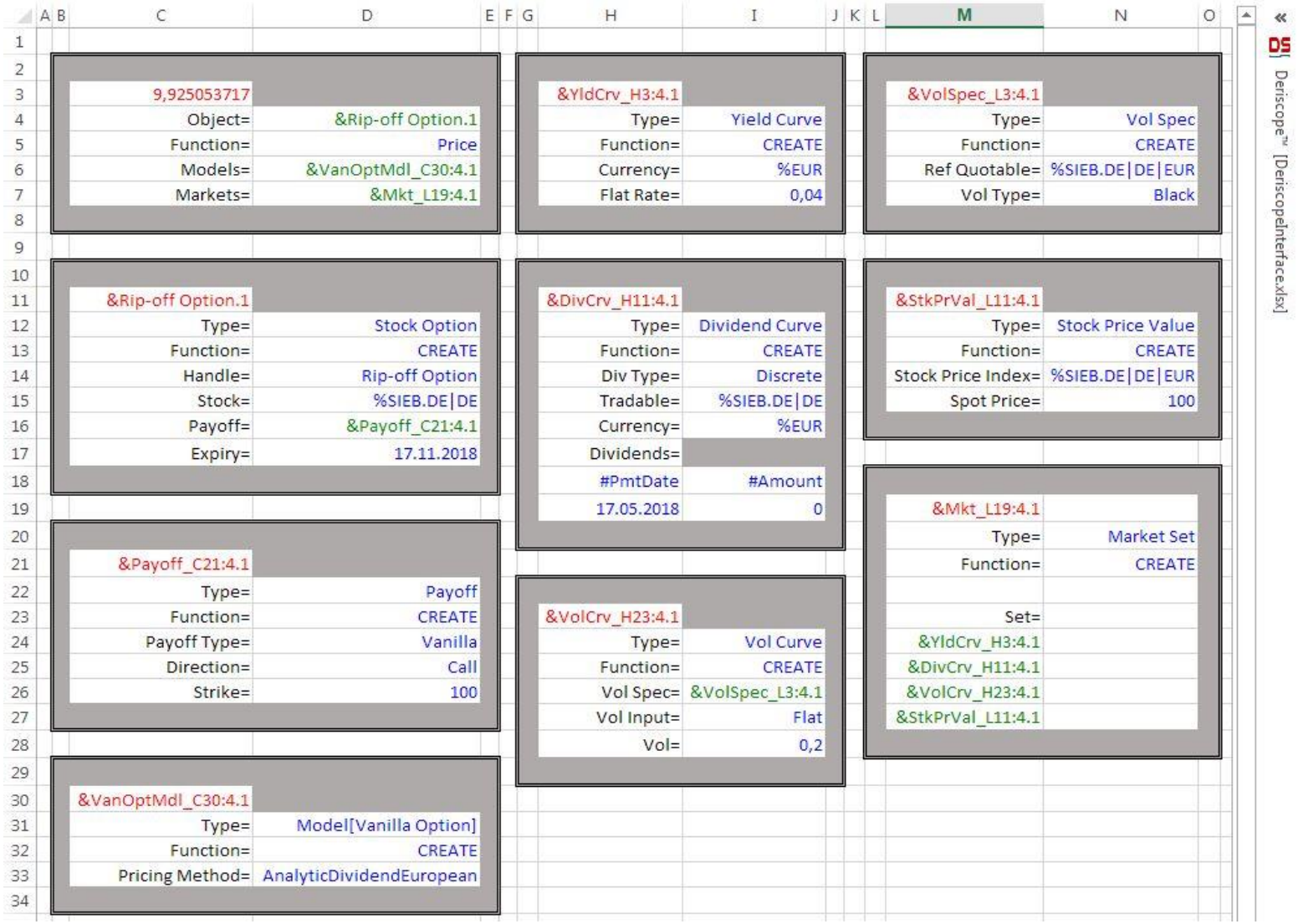
- In *Deriscope* almost everything is an **object**.
- By “**object**” we mean any set of data (i.e. numbers and text) held in memory that can be accessed through a unique text identifier.
- This unique identifier is referred as “**handle name**”.
- **Handle names** act in spreadsheet as pointers to the respective objects.



Deriscope's "building block" approach

- In *Deriscope* generally the user proceeds in two steps:
  - **1)** Build each required **object** separately.
  - **2)** Assemble the **objects** together and call the desired function.
- The next screen shows how a Stock Option is priced.

Stock Option Pricing Example



9,925053717	
Object=	&Rip-off Option.1
Function=	Price
Models=	&VanOptMdl_C30:4.1
Markets=	&Mkt_L19:4.1

&YldCrv_H3:4.1	
Type=	Yield Curve
Function=	CREATE
Currency=	%EUR
Flat Rate=	0,04

&VolSpec_L3:4.1	
Type=	Vol Spec
Function=	CREATE
Ref Quotable=	%SIEB.DE|DE|EUR
Vol Type=	Black

&Rip-off Option.1	
Type=	Stock Option
Function=	CREATE
Handle=	Rip-off Option
Stock=	%SIEB.DE|DE
Payoff=	&Payoff_C21:4.1
Expiry=	17.11.2018

&DivCrv_H11:4.1	
Type=	Dividend Curve
Function=	CREATE
Div Type=	Discrete
Tradable=	%SIEB.DE|DE
Currency=	%EUR
Dividends=	
#PmtDate	#Amount
17.05.2018	0

&StkPrVal_L11:4.1	
Type=	Stock Price Value
Function=	CREATE
Stock Price Index=	%SIEB.DE|DE|EUR
Spot Price=	100

&Payoff_C21:4.1	
Type=	Payoff
Function=	CREATE
Payoff Type=	Vanilla
Direction=	Call
Strike=	100

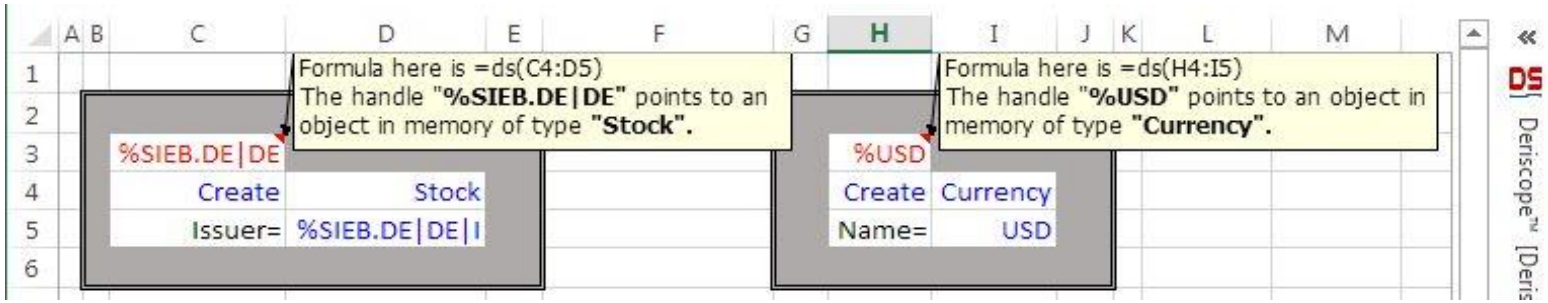
&VolCrv_H23:4.1	
Type=	Vol Curve
Function=	CREATE
Vol Spec=	&VolSpec_L3:4.1
Vol Input=	Flat
Vol=	0,2

&Mkt_L19:4.1	
Type=	Market Set
Function=	CREATE
Set=	
&YldCrv_H3:4.1	
&DivCrv_H11:4.1	
&VolCrv_H23:4.1	
&StkPrVal_L11:4.1	

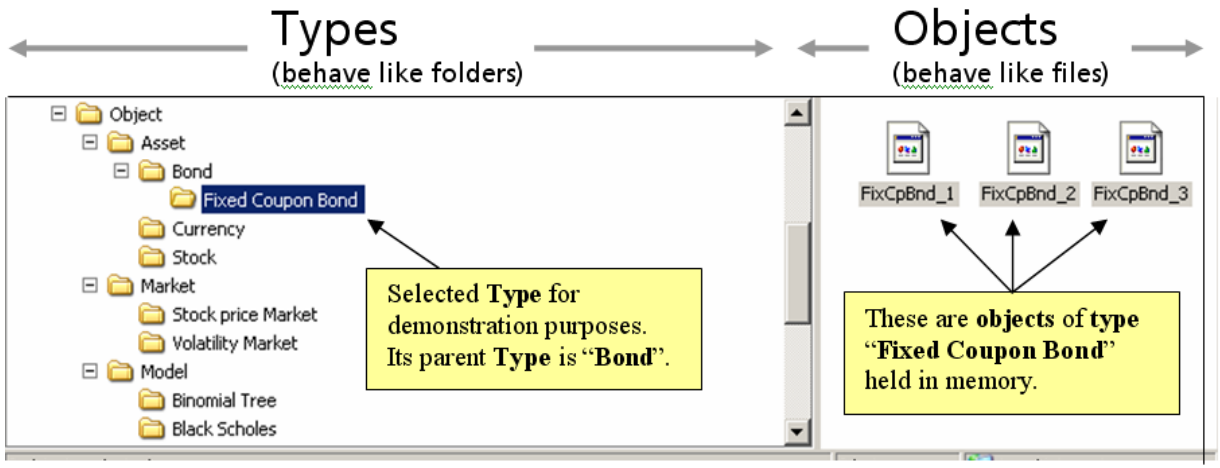
&VanOptMdl_C30:4.1	
Type=	Model[Vanilla Option]
Function=	CREATE
Pricing Method=	AnalyticDividendEuropean

About Types

- Every *Object* has a unique **Type** associated with it.

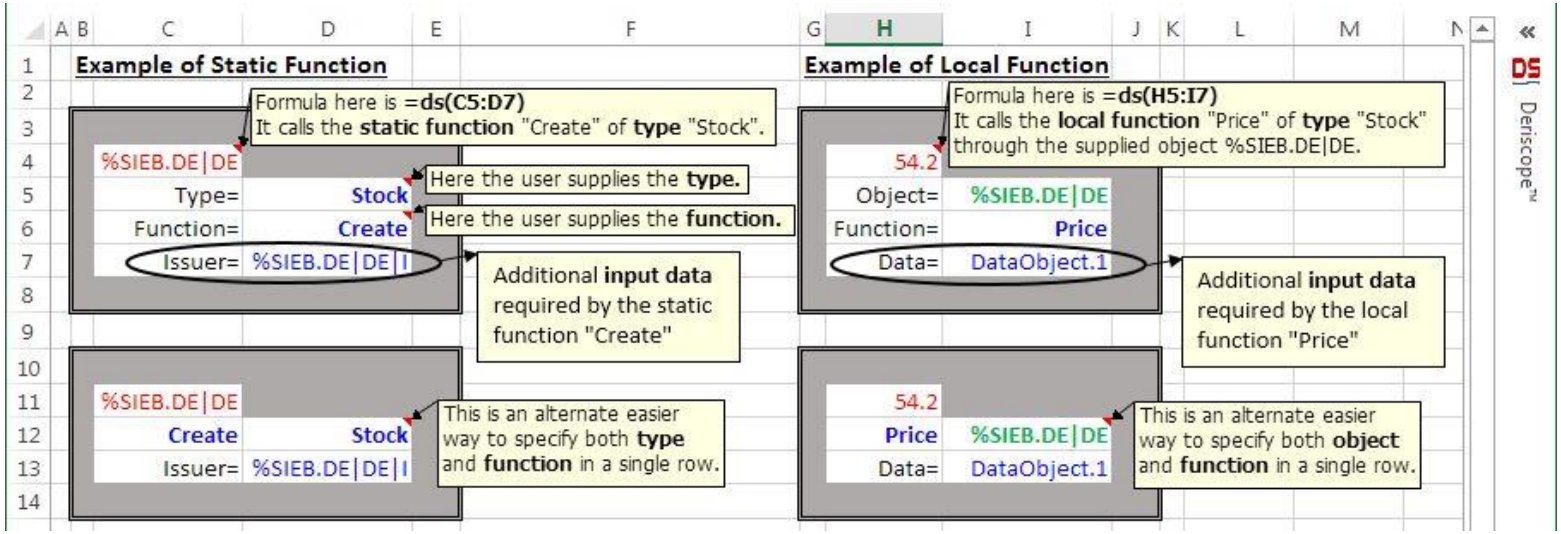


- So **Types** follow a hierarchy similar to the **folders** in a **file** structure.



About Functions

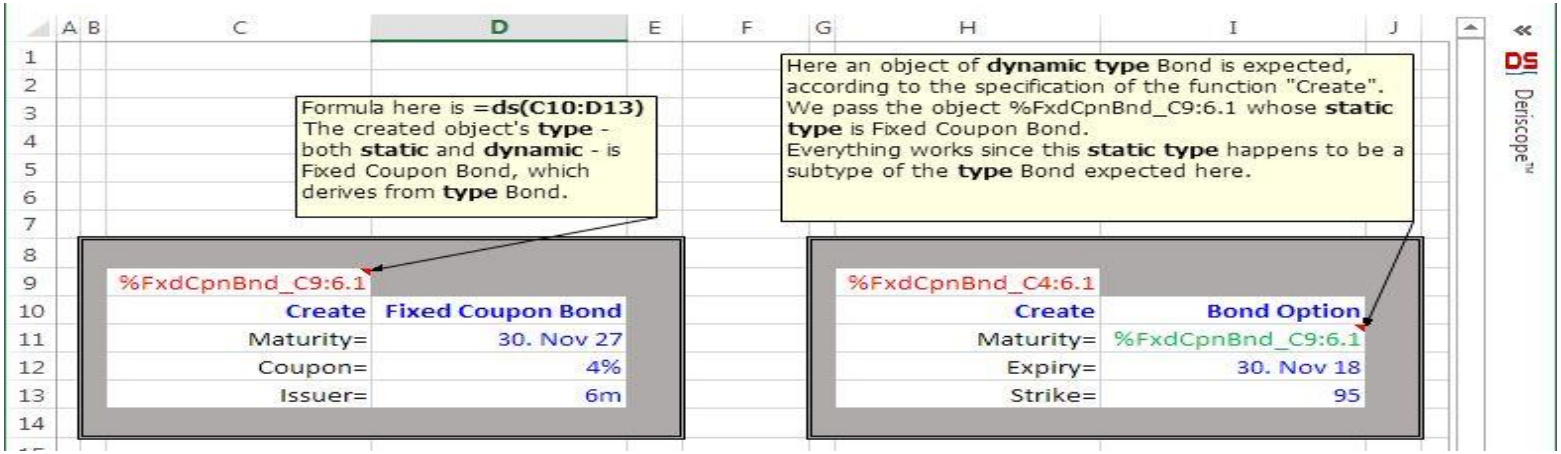
- Every *Type* has a set of predefined **Functions** associated with it.
- **Local Function:** If it is invoked by an already created *object*.
- **Static Function:** If it is invoked by a type.
- **Key-Value Pairs:** The typical form of a function's input data.



Spreadsheet C++

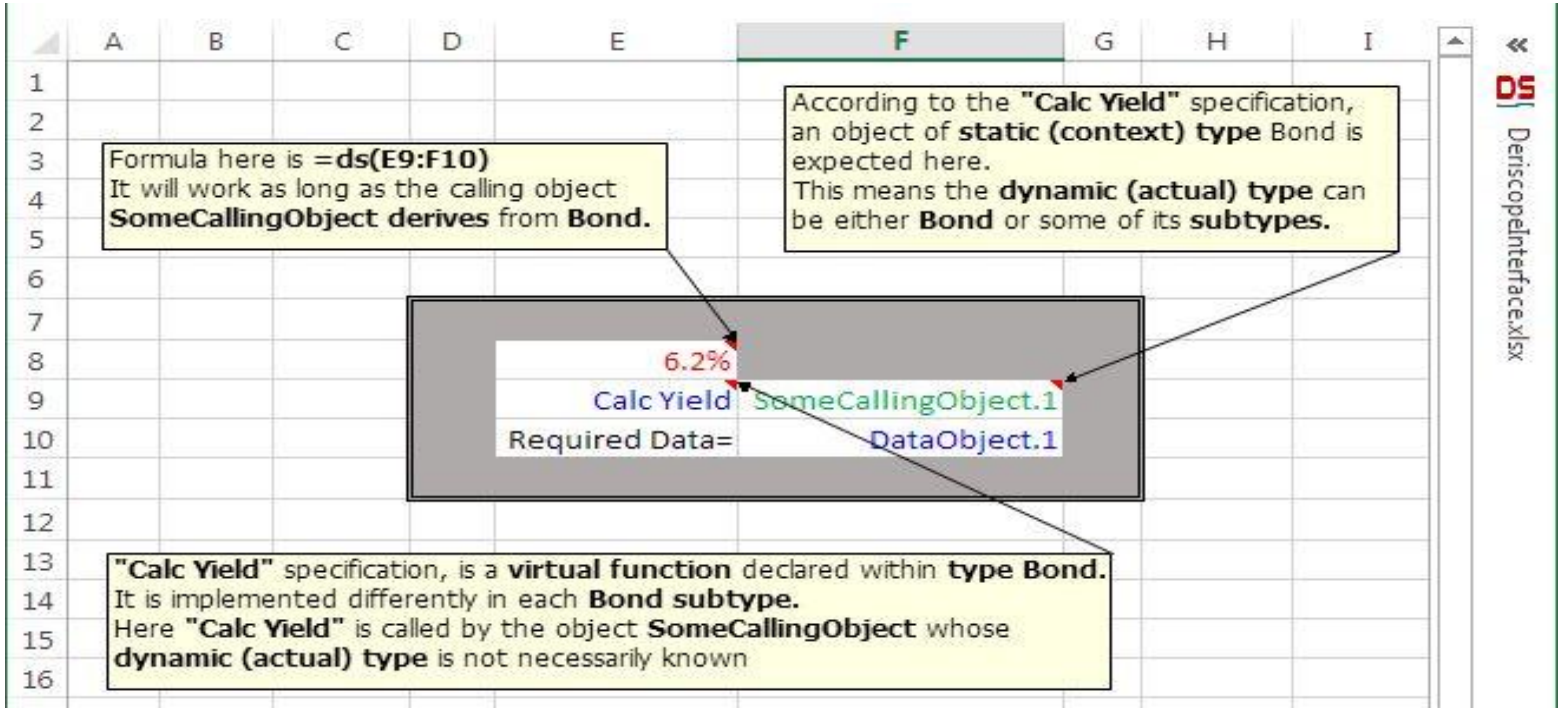
Inheritance , Subtypes, Dynamic and StaticTypes

- Deriscope supports **C++-**style "***inheritance***" at **spreadsheet level**.
- **Example:** An object of *type* "Fixed Coupon Bond" can be used in a context where an *object* of *type* "Bond" is required. In this case the *object's* ***dynamic (actual)*** *type* is "Fixed Coupon Bond", but its ***static (context)*** *type* is "Bond".
- **Language used:** *Type* "Fixed Coupon Bond" ***derives*** from *type* "Bond" or is a ***subtype*** of *type* "Bond".



Spreadsheet C++ (Virtual Functions)

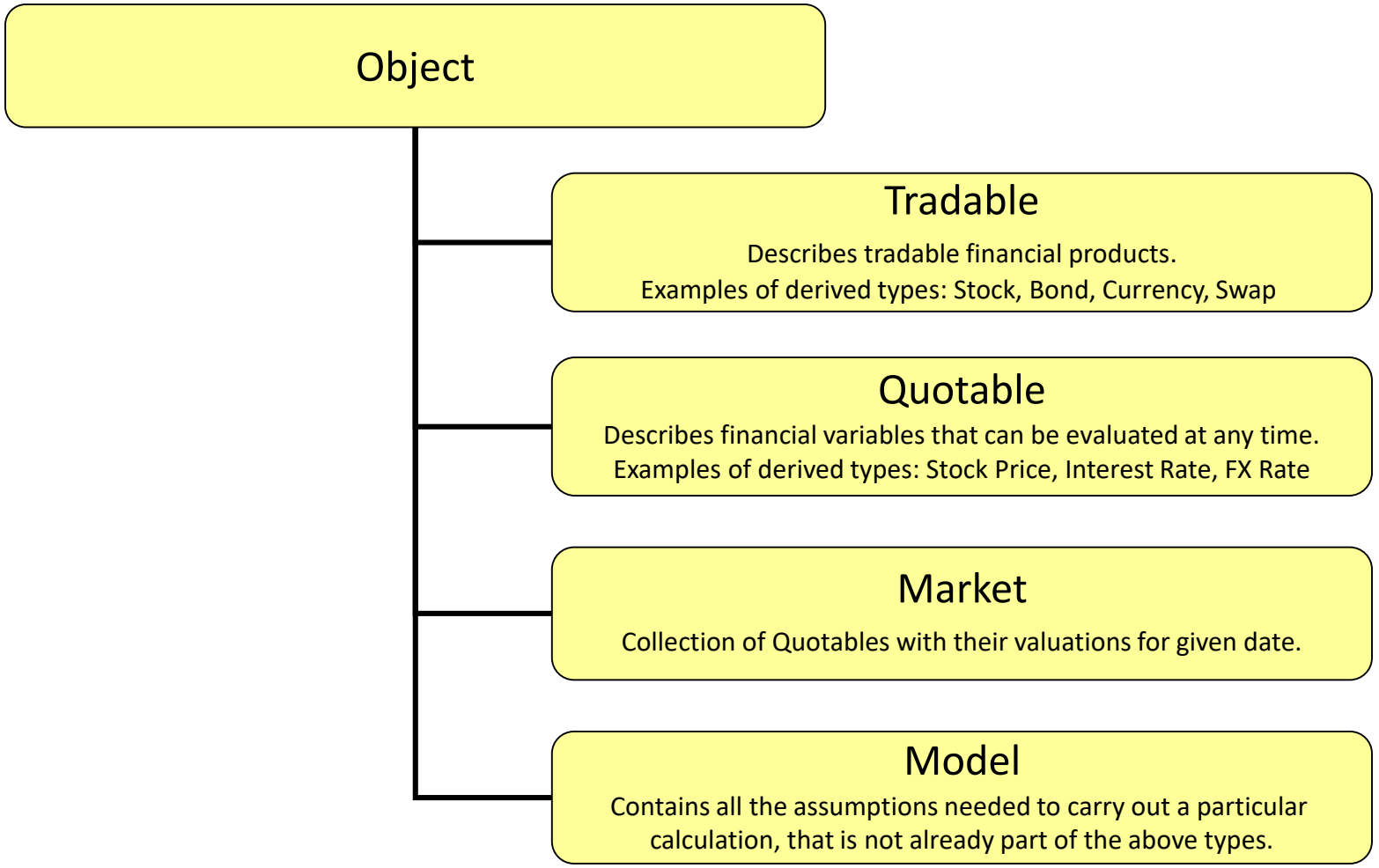
- *Functions* can also be ***virtual***!
- A ***virtual*** *function* can be used with an *object* of unknown *dynamic (actual) type*.



Spreadsheet C++ (Abstract Types)

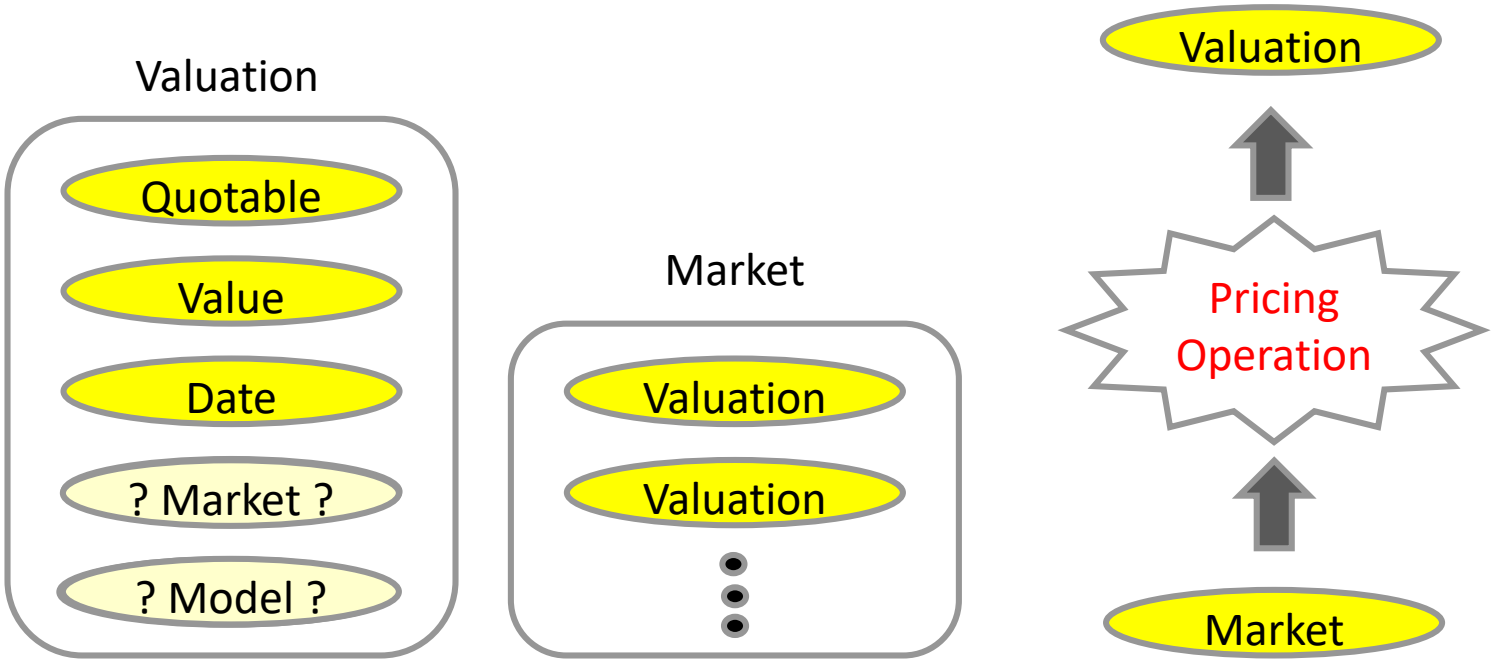
- Some *types* never have their own *objects*. They only have *subtypes*. These are called **abstract types**.
- The *type* "**Tradable**" is **abstract**. No *object* of *actual type* "**Tradable"** exists!
- The *type* "**Bond**", which derives from "**Tradable**", is also **abstract**. No *object* of *actual type* "**Bond"** exists!
- In the folder analogy an *abstract type* is equivalent to a folder that is restricted to contain only subfolders.

The fundamental Types in Deriscope

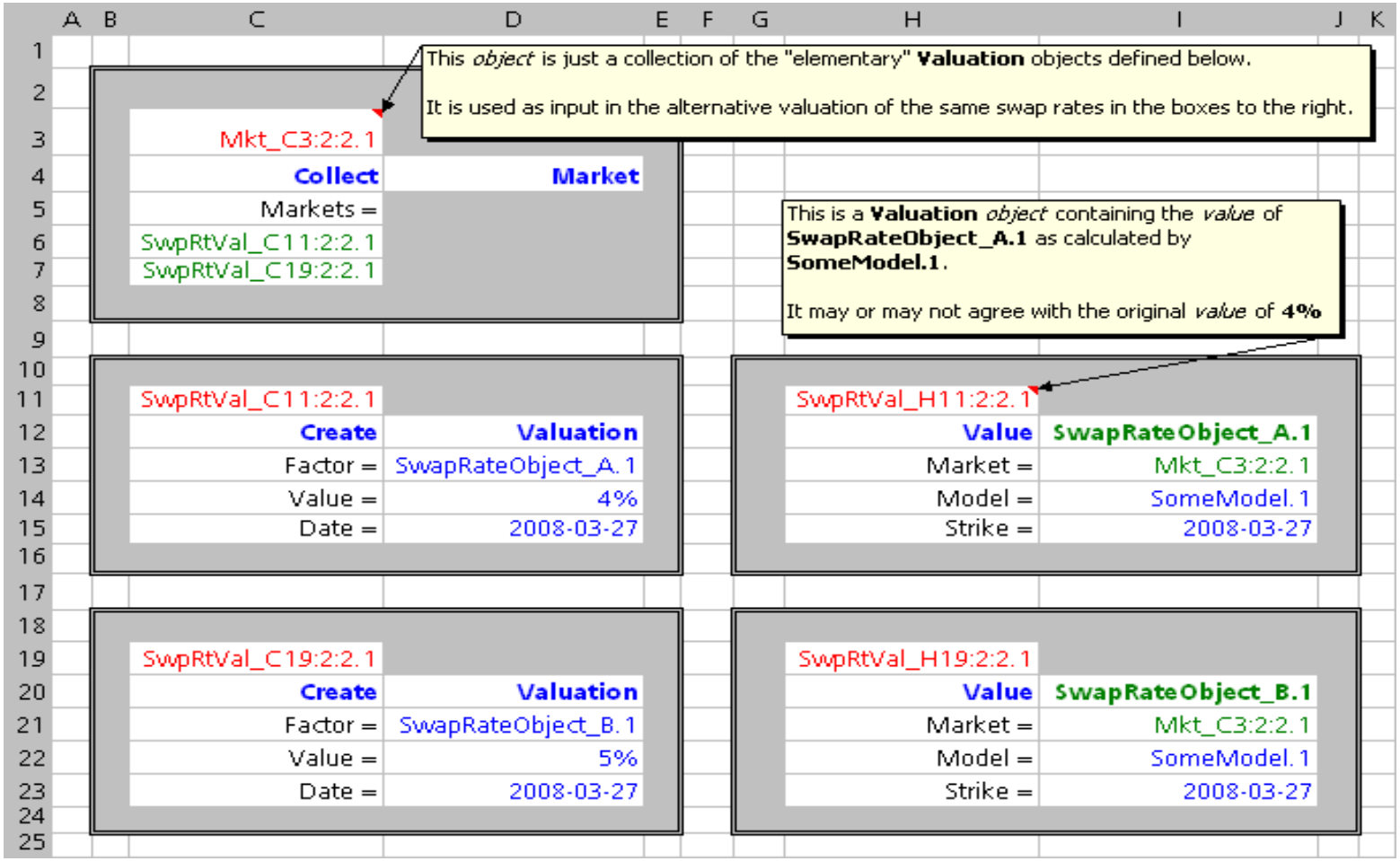


The “Valuation” Type

- The type “**Valuation**” derives from “Market”.
- A typical **Market** *object* is just a collection of **Valuation** *objects*.
- Pricing takes in **Valuation** objects and returns a **Valuation** *object*.

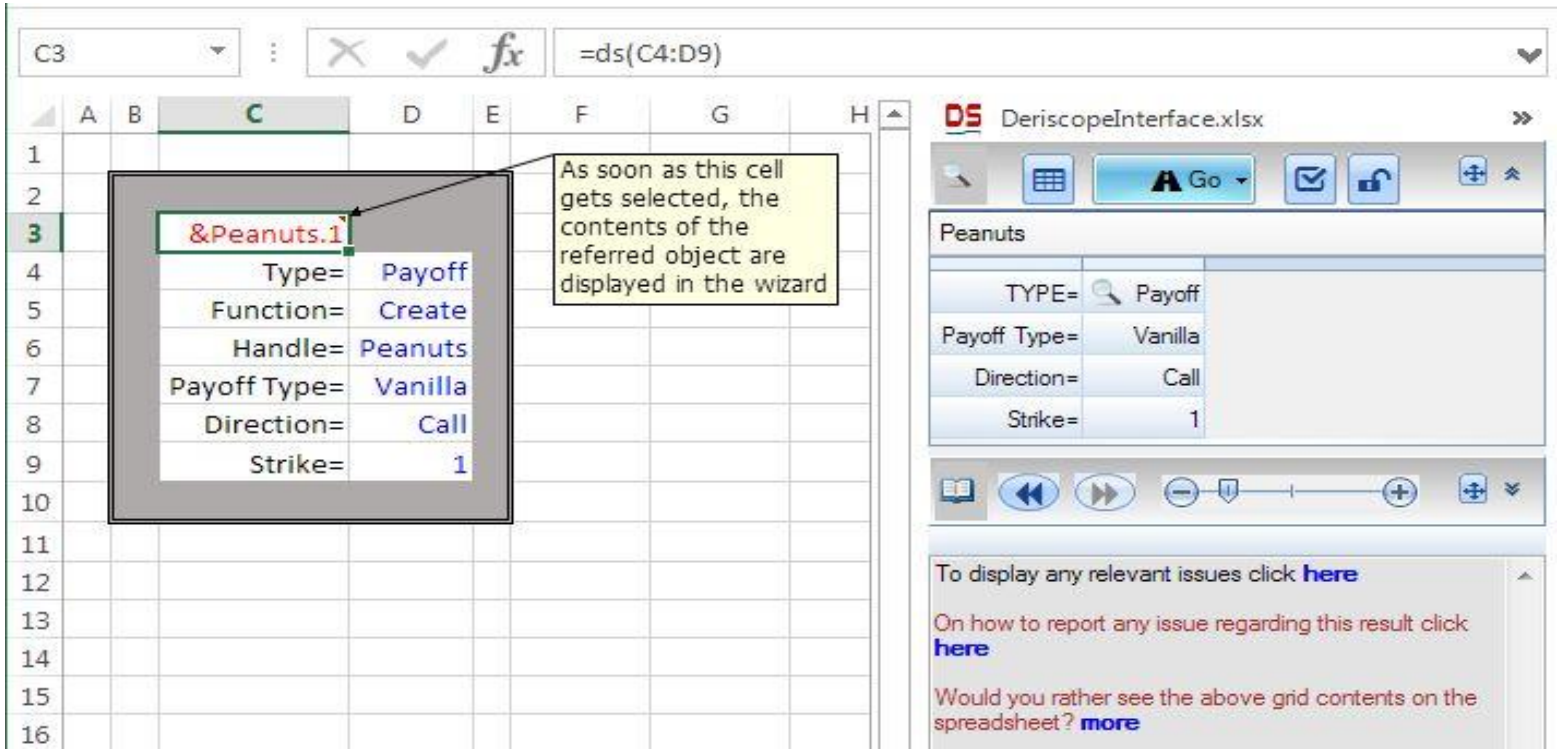


Using the “Valuation” Type

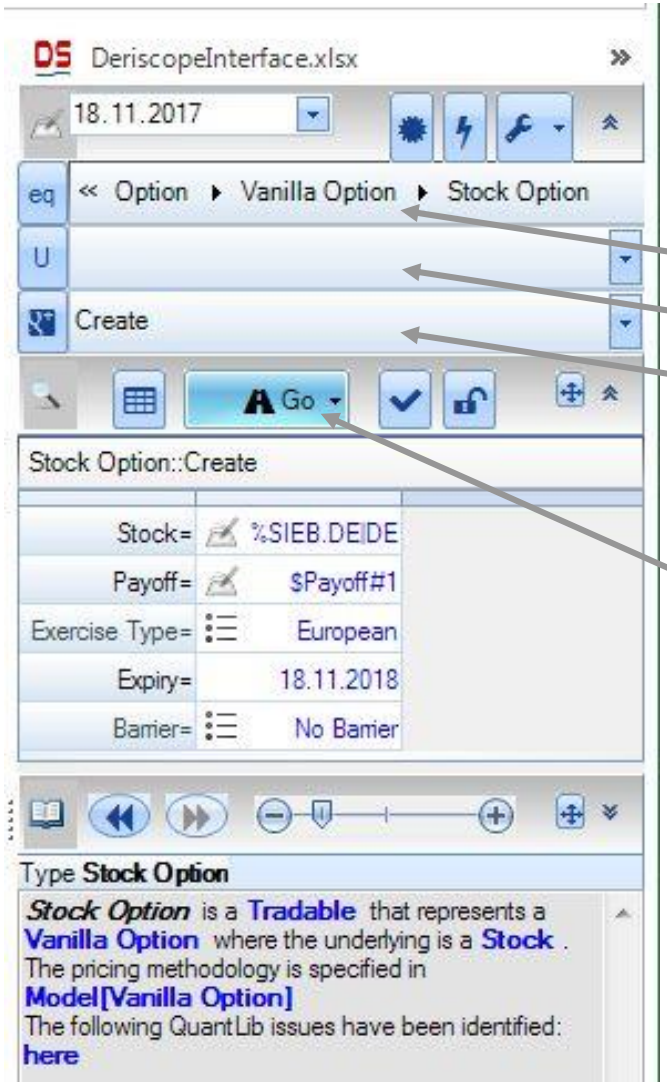


Using the Wizard to View an Object

- Click on  to view the contents of the object in that cell.
- Click on any cell to display relevant information within the wizard.



Using the Wizard to Create Formulas



Input Area

Type Selector

Object Selector

Function Selector

Browse Area

Press this Button to paste the selected function in the spreadsheet

Info Area

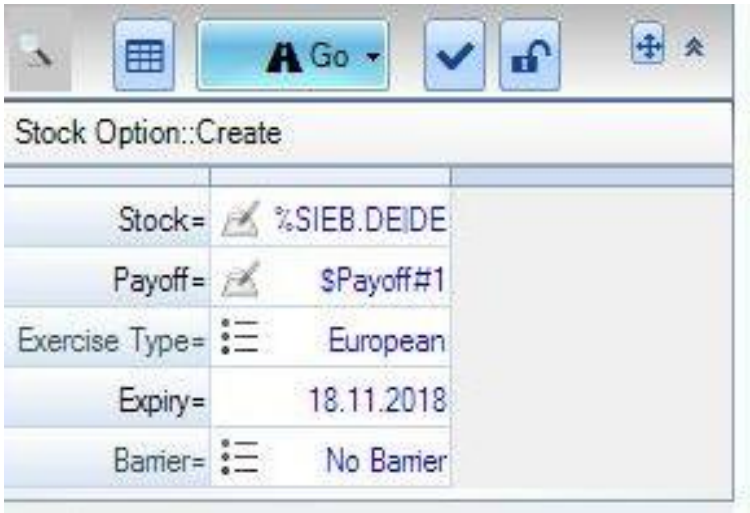
The Function Selector

Name	Origin	C	Vol
Create	Stock Option	S	NV
Get Settlement Date	Tradable	L	NV
Price	Tradable	L	NV
Implied Vol	Tradable	L	NV
Get Market Spot Price	Tradable	L	NV
Clone	Type	L	NV
Get Equivalent Tradable	Tradable	L	NV

- When clicked upon, the "**Fuction Selector**" displays all available **Functions.**
- **Origin** -> Type where function is defined
- **S** <-> **static** Functions
- **L** <-> **local** Functions
- NV <-> Non-Volatile

- All **concrete** types have a **Create** function
- All types deriving from **Tradable** have a **Price** function

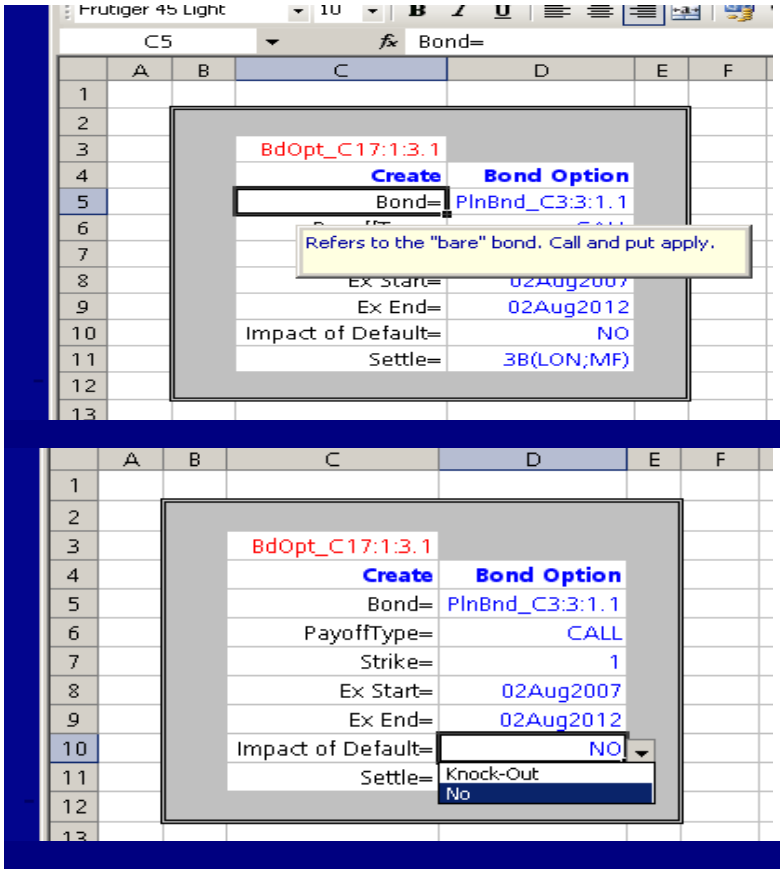
The Browse Area



- The symbol indicates that the input value is an object.
- Click on to display the object's contents and edit them.
- The symbol indicates that the input value can be any value out of an enumerated list of choices.
- Click on to display the choices and select one of them.
- Click on any element to display relevant information in the Info Area below.

Getting Information in Spreadsheet

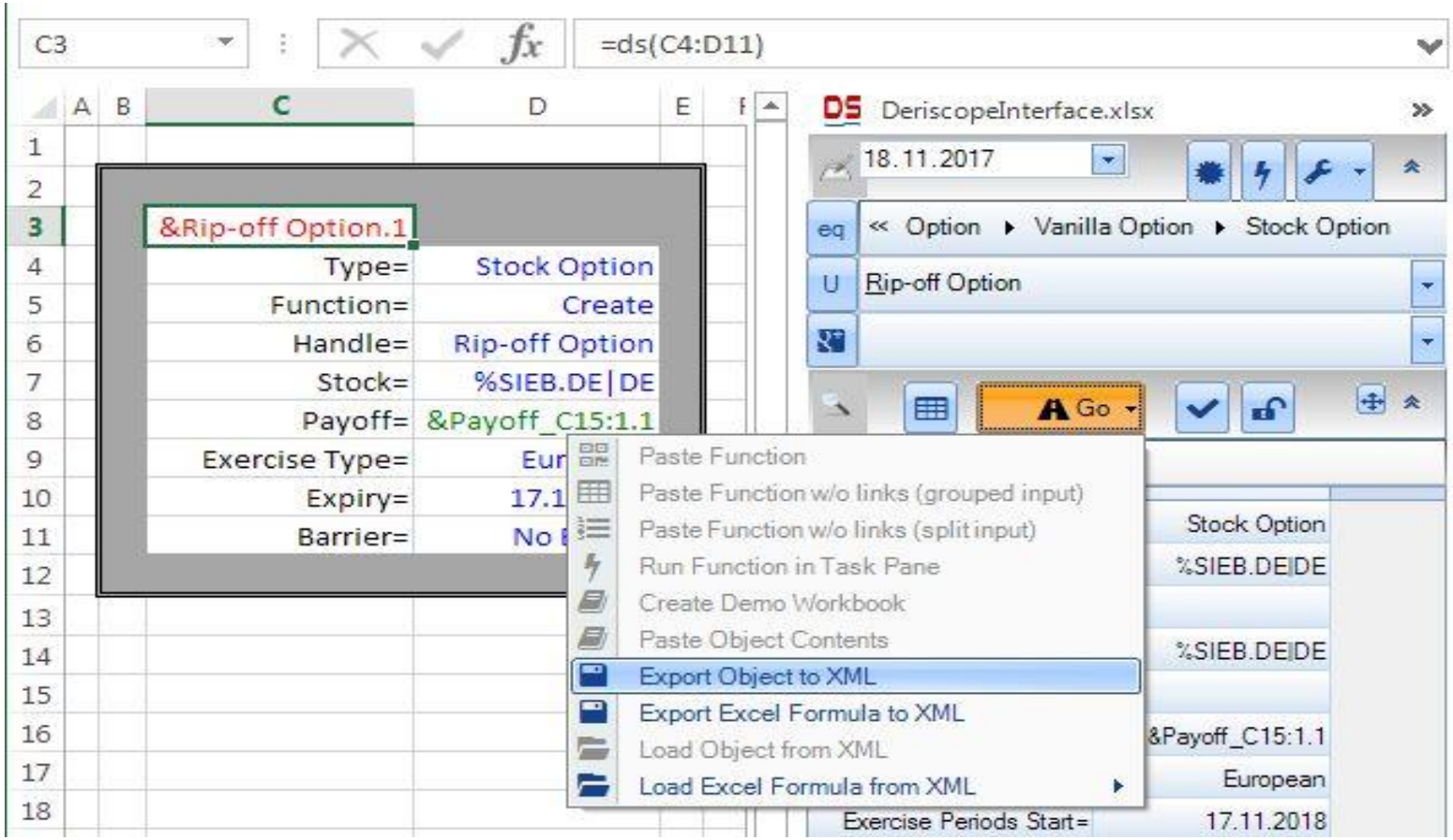
- No comments or dropdowns are needed within the spreadsheet!



- The user may ask for help by selecting any key
- … or get a dropdown with the possible values by selecting any value.

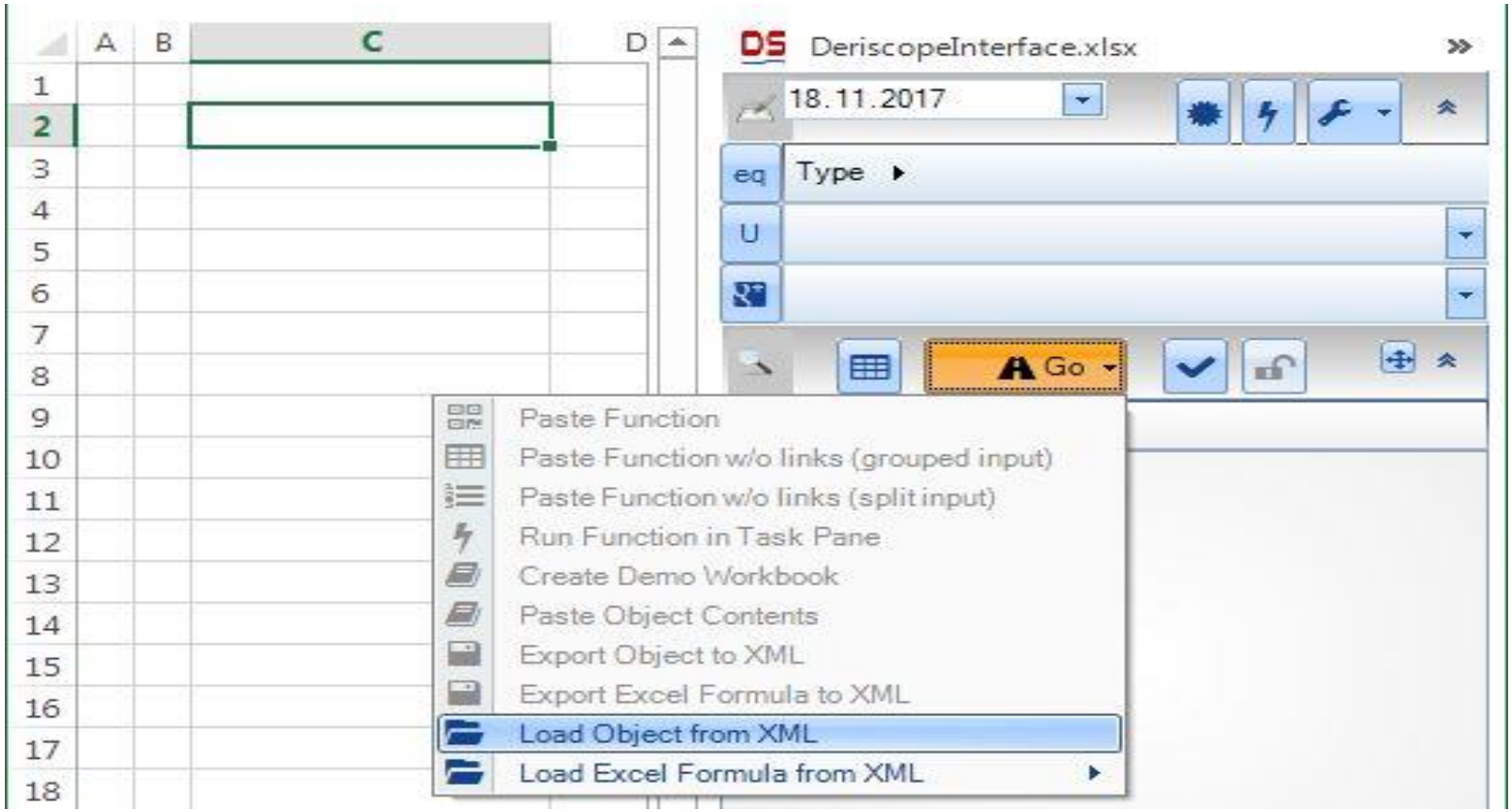
XML Export of Object

- Any *object* can be permanently stored (**exported**) as an xml file.



XML Import of Object

- Inversely an *object* may be created (**imported**) by reading a previously exported xml file.



XML Export of Deriscope Formula

- Any *Deriscope formula* can be permanently stored (**exported**) as an xml file and subsequently sent to a support person for analysis.
- If a comment is present, it will be also part of the xml file.
- This reduces the need for sending whole spreadsheets if issues arise.