Introduction to FRONT ARENA. Instruments

Responsible teacher: Anatoliy Malyarenko

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Abstract

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☞ FRONT ARENA architecture.
☞ The PRIME Session Manager.
☞ Instruments.
☞ Valuation: background.
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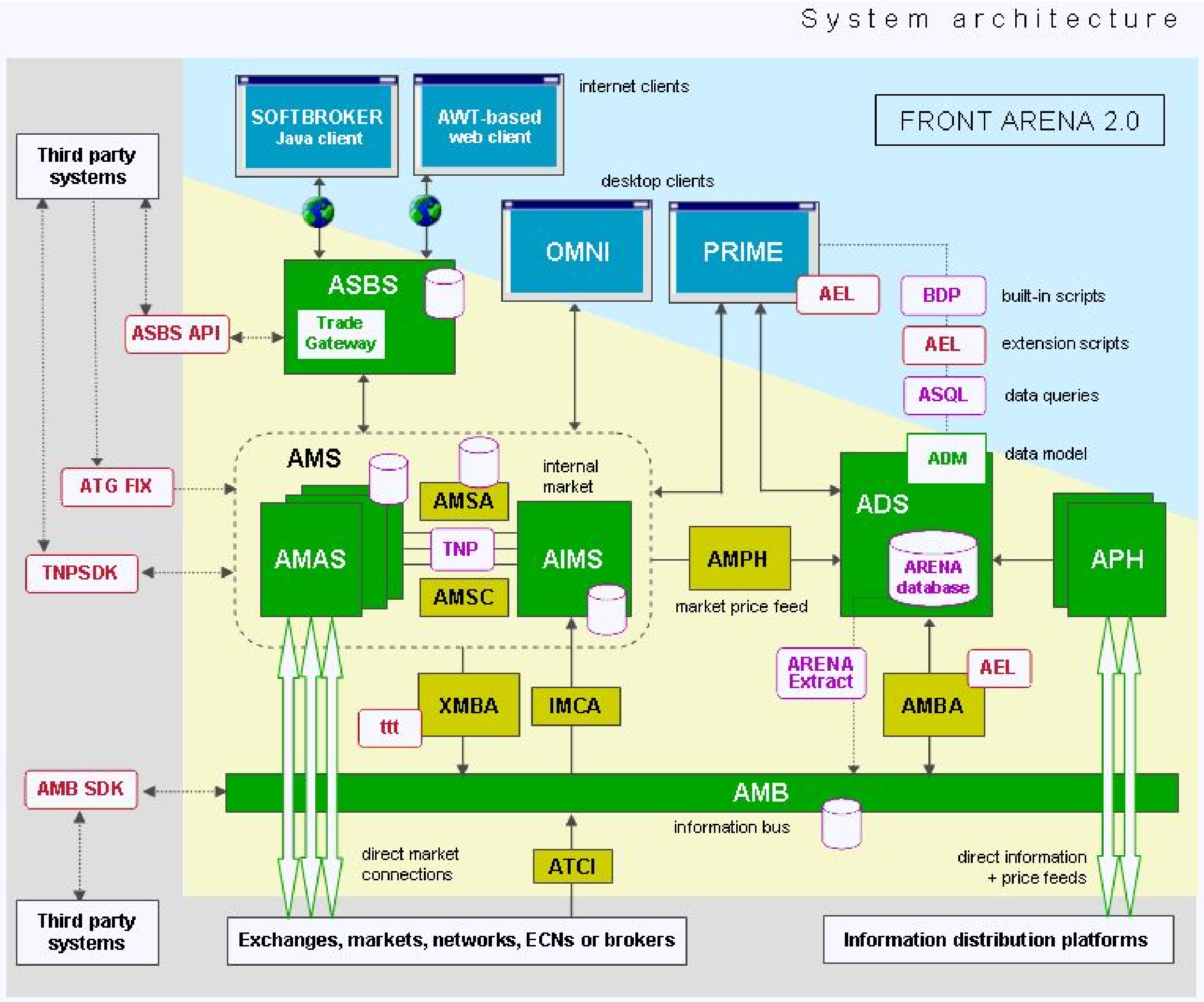
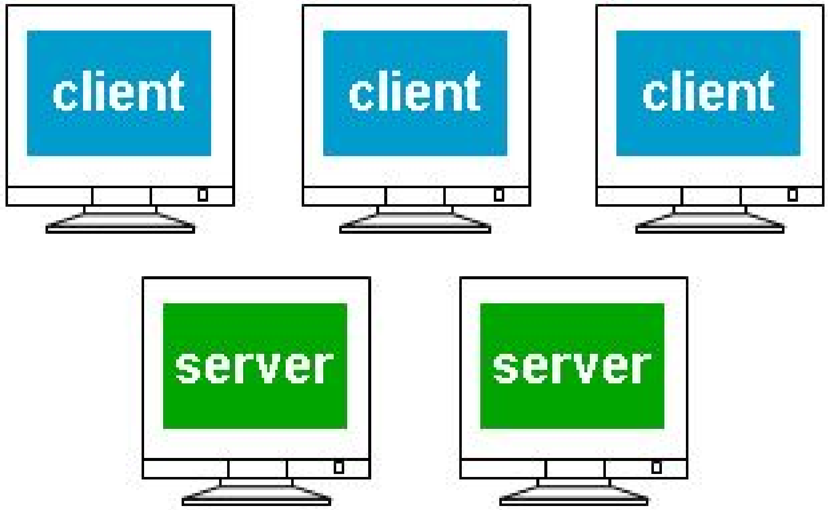
FRONT ARENA system architecture



FRONT ARENA is a software to support sales, trading and risk management in front, middle and back offices.

Client/server architecture

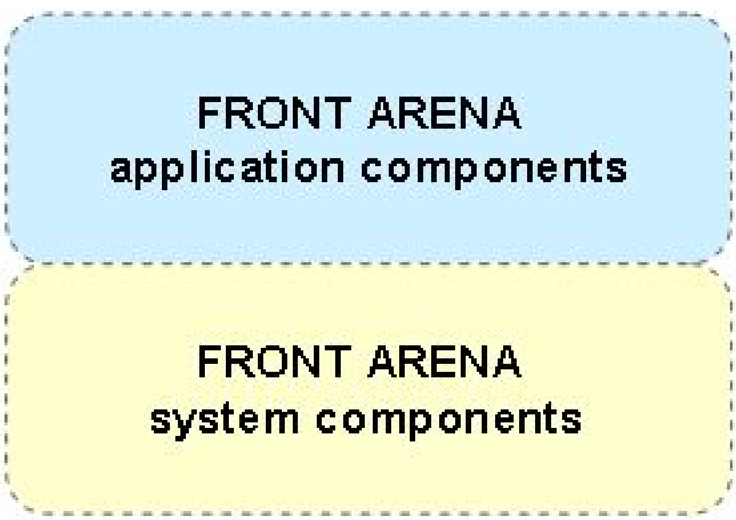


FRONT ARENA is based on **client/server architecture**.

Servers take care of central tasks such as external connections, data storage and external logging.

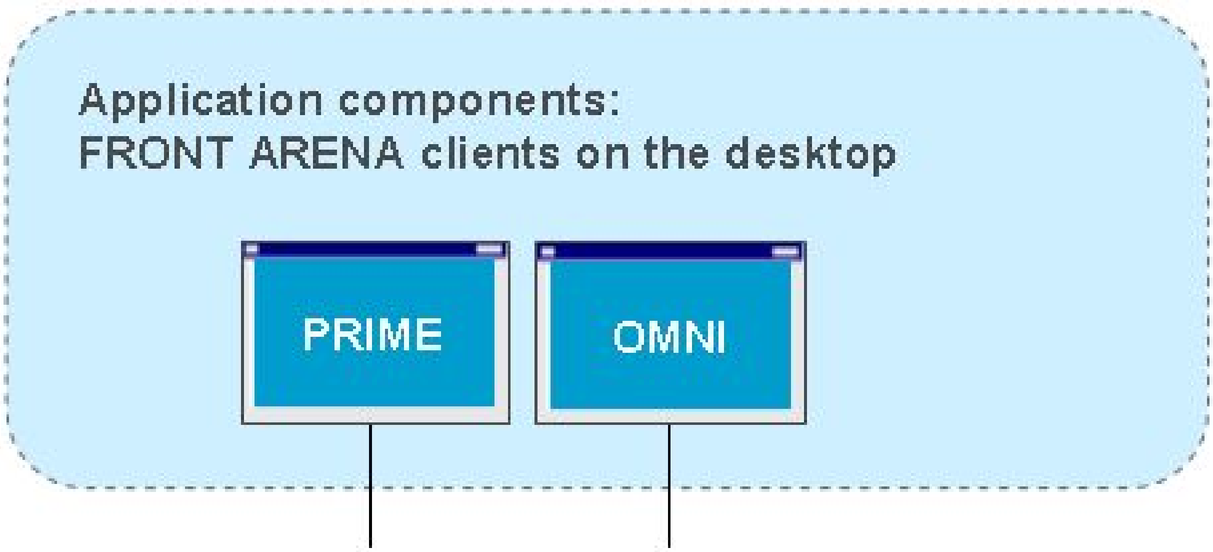
Clients contain the end-user interfaces and sufficient business logic to reduce the processing load on the servers. This *distributed processing* allows reports, calculations and data simulations to be handled locally. Data is received from the servers in real time and cached where appropriate.

Application components, system components



Another distinction is between **application components** and **system components**. The application components are the FRONT ARENA clients. The system components are the various FRONT ARENA servers together with other components used to achieve integration within FRONT ARENA and with third party systems.

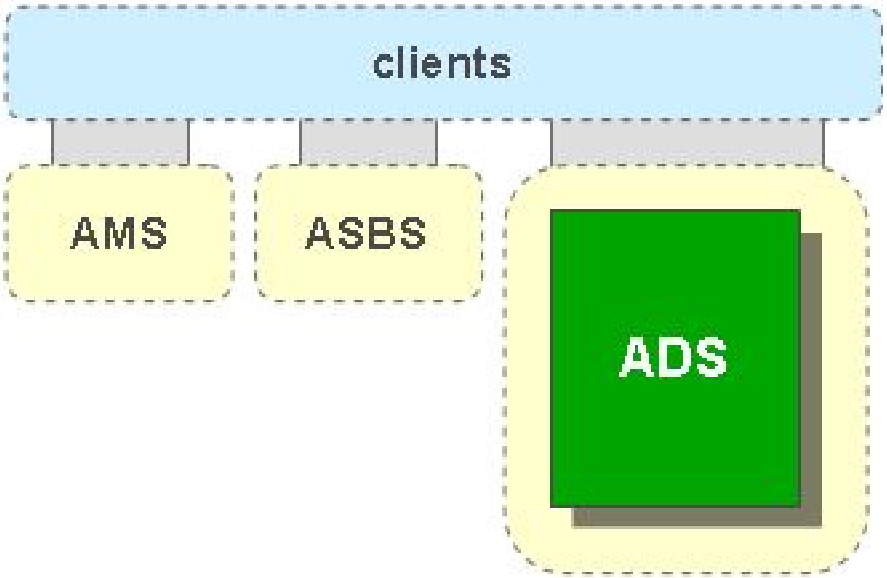
FRONT ARENA clients: PRIME and OMNI



PRIME is the main client in FRONT ARENA. It is used for trading, position keeping and risk management.

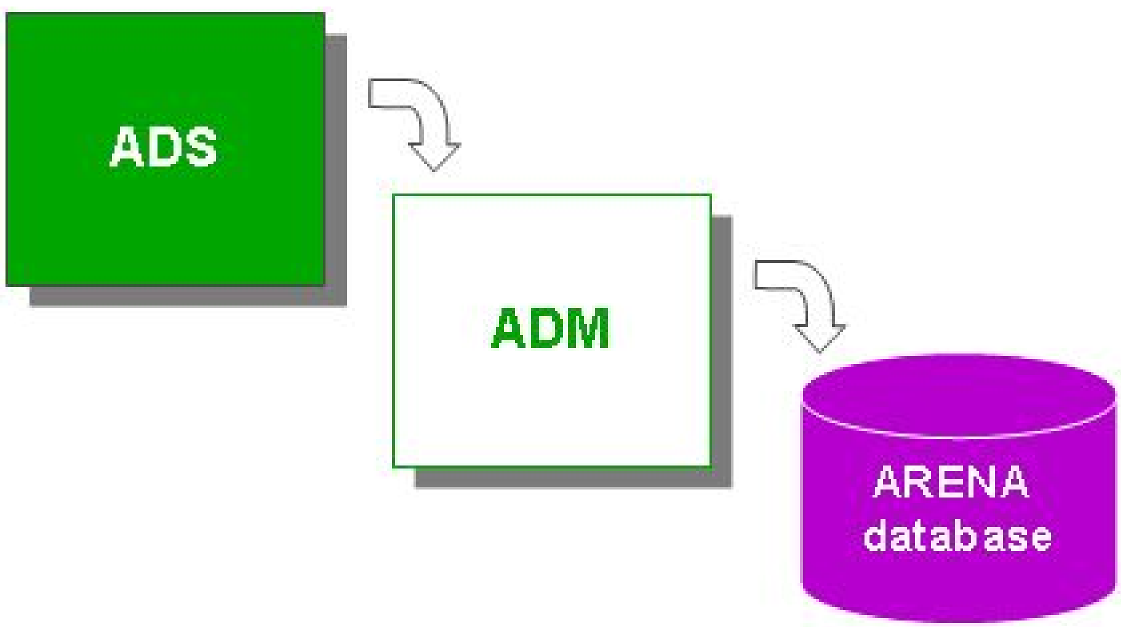
OMNI is an alternative client for exchange-based equities trading.

ARENA Data Server (ADS)



The **ARENA Data Server (ADS)** provides database services to the main FRONT ARENA client(PRIME), including data storage and a **transaction log**. PRIME subscribes to ADS for real-time data updates.

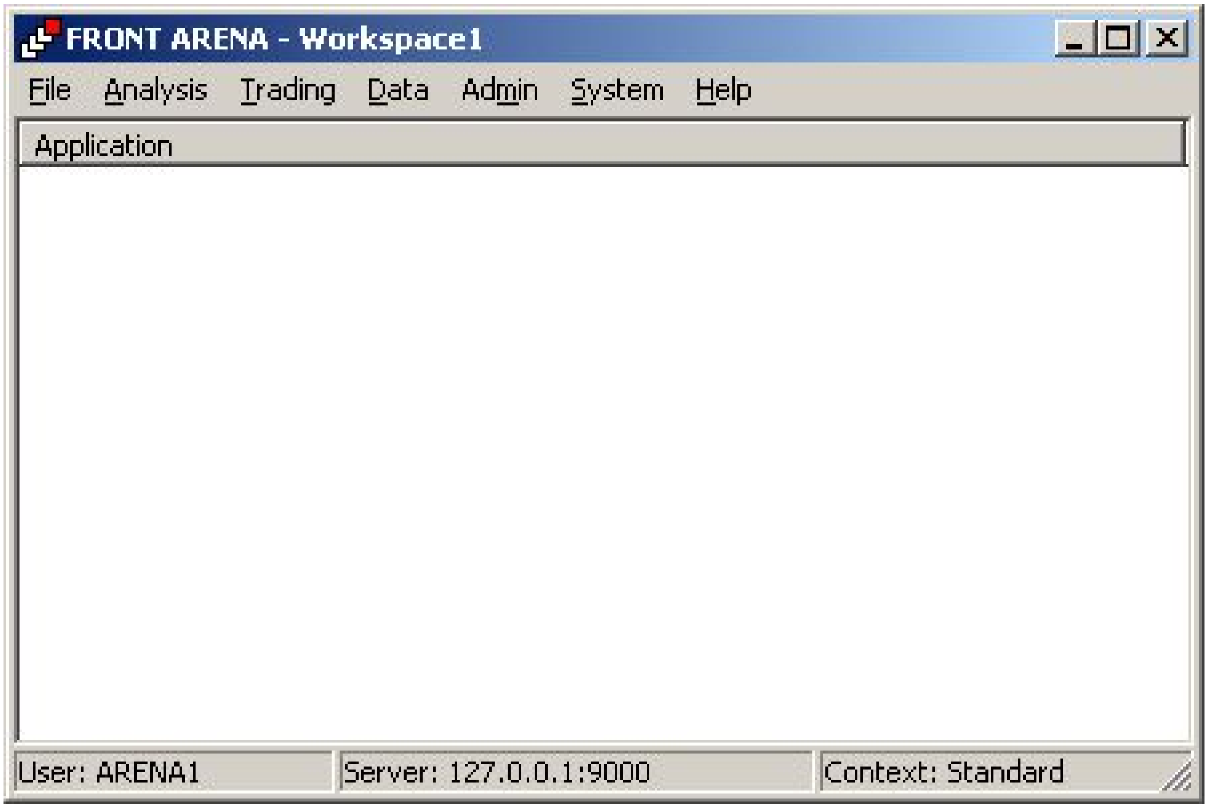
ADS, ADM, and the ARENA database



ADS is a general database service provider. In theory it could connect any relational database. In practice, it is used to connect to the **ARENA database**, the main database in FRONT ARENA.

To work with a database, ADS needs to know about the tables, fields, and relationships in the database. For the ARENA database, this is defined in the **ARENA Data Model (ADM)**. The SQL scripts that defined the ADM are packaged into a separate component, also called ADM.

The PRIME Session Manager



The PRIME Session Manager is the main control for a PRIME Session connected to the ARENA database. From here you can manage you workspace:

- Open other windows.
- Save and retrieve Workspaces.

From the various menus on the PRIME Session Manager you can open other windows. Each window offers different features and functionality to help you carry out your work.

File Session administration.

Analysis Pricing, position management, and risk management.

Trading Define instruments and execute trades.

Data Valuation parameters and portfolio definition.

Admin Reporting and static data.

System System management.

Help Help and About.

Workspaces

Normally when a user starts PRIME for the first time, only the Session Manager will be displayed. Then the user should open various windows that can be used to carry out business tasks. Creating and saving a Workspace is the method to store a desktop layout that can easily be retrieved later so the user does not have to manually re-open windows every time PRIME is started.

The user can save a workspace, that is the position and contents of the opened windows, by selecting **File** → **Save as** and then saving with an appropriate name. You can save as many workspaces as you like.

If you already have a previously saved workspace and wish to save it with a different configuration, you can do this by selecting **File** → **Save** and the workspace will be defined with the current settings.

You can open an existing workspace by selecting **File** → **Open** from the Session Manager, selecting the workspace that you want to open, then clicking **OK**. The current workspace will be replaced with the one selected.

The default Workspace opens automatically when PRIME is started. Each user can have an individual default Workspace. To make the current Workspace the default, select **File** → **Save As Default** from the Session Manager.

Instruments: traditional classification

The convention in financial markets is to divide instruments according to the following sectors.

① *Fixed income instruments*: interbank certificate of deposits (CD), deposits, commercial papers (CP), banker's acceptances, and Treasury bills.

② *Equities*: various types of stock issued by public companies.

③ *Currencies* and *commodities*.

④ *Derivatives*: interest rate, equity, currency, and commodity derivatives.

⑤ *Credit instruments*: high-yield bonds, corporate bonds, credit derivatives, and various guarantees.

Instruments: classification in FRONT ARENA

For valuation purposes, PRIME divides instruments into two categories, *cash flow instruments* and *derivative instruments*. Examples of each type are as follows:

Cash flow instruments: swaps, currency swaps, caps/floors, deposit/loans bills, bonds, FRNs, promissory loans, CD's, rate indices.

Derivative instruments: futures, forwards, options.

Applications for defining new instruments are found in the **Trading** menu in the Session Manager. These applications are also used for the retrieval of previously defined instruments that have been stored in the database. Each instrument type has its own application. The overall structure of an individual cash flow instrument is defined in the instrument definition application. Each single cash flow belonging to that instrument can then be edited in terms of amount, rate, dates, and so on. Cash flows can also be removed or added.

Valuation: background

PRIME estimates the value of instruments using two basic components:

☞ Yield curves.

☞ Volatility structures.

Current market conditions are represented through sets of benchmark instruments used when deriving the curves and volatility structures. All instruments are mapped to yield curves and, if applicable, to a volatility structure. The parameters that are derived from these curves are then used when valuing the instrument.

Zero coupon pricing

The concept behind zero coupon pricing is the evaluation of all individual cash flows as if they were zero coupon bonds. The evaluation is made using a yield curve or, alternatively, a discount function, which accurately describes current market conditions.

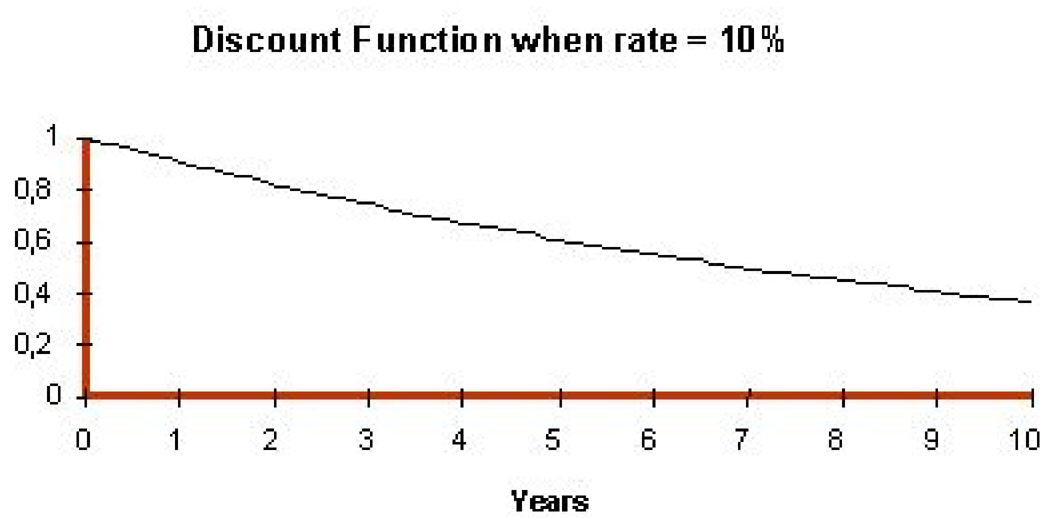
The pricing of liquid, standardised instruments is quite simple — the current market price is used.

The zero coupon pricing methodology becomes important when pricing instruments, for which no market prices are available. It is also needed for pricing standardised instruments which do not have reliable market prices. In this case, zero coupon pricing will be used to price these instruments consistently alongside the liquid instruments. This is a kind of relative pricing where user preferences only need to be taken account of to a small extent.

The discount function

The discount function describes the present value at time t_0 of a unit cash flow at time t: $P(t_0, t)$.

In most cases, t_0 is the current date and is sometimes dropped for notational convenience. The remaining variable t then refers to the time between t_0 and t.



At $t = 0$, the discount function always has the value 1. The discount function is monotonically decreasing, which corresponds to stipulation that interest rates are always positive. It never reaches zero since all cash flows, no matter how far in the future they are paid, are always worth more than nothing.

The discount function has a mathematical relationship to the spot yield curve, although the “yield curve” is not a well-defined concept. The relationship between the discount function $P(t)$ and different yield curves $r(t)$, using a day count convention that reflects the actual time between time t_0 and t measured in years, can be written as:

Discount Rates	$P(t) = 1 - tr_d(t)$
Simple Rates	$P(t) = (1 + tr_s(t))^{-1}$
Annual Rates	$P(t) = (1 + r_1(t))^{-t}$
Semiannual Rates:	$P(t) = \left(1 + \frac{r_2(t)}{2}\right)^{2t}$
N-annual Rates:	$P(t) = \left(1 + \frac{r_N(t)}{N}\right)^{Nt}$
Continuous Rates:	$P(t) = e^{-tr_c(t)}$

Each of these formulae can be inverted. For example: $r_1(t) = P(t)^{-1/t} - 1$.

Day count conventions

When using the discount function to express yield or interest rates, the day count convention must be taken into consideration. The day count convention is a user-defined, instrument-specific parameter and is used when valuing that particular instrument.

The alternative day count conventions supported by PRIME are as follows:

- ☞ **30/360**
- ☞ **30E/360**
- ☞ **Act/360**
- ☞ **Act/365**
- ☞ **NL/365**
- ☞ **Act/ActISDA**
- ☞ **Act/ActISMA**
- ☞ **Act/ActAFB**

The meaning of the abbreviations used in the naming of the above conventions is as follows:

- **Act** Actual number of calendar days.
- **NL** Actual number of calendar days.
  - ✔ Exception: If the year is a leap year then February is considered to have 28 days (instead of 29).
- **30** Each month is considered to have 30 days.
  - ✔ Exception: If the later date is the last day of February, that month is considered to have its actual number of days.
  - ✔ Exception: When the later date of the period is the 31st and the first day is not the 30th or the 31st, the month that includes the later date is considered to have its actual number of days.
- **30E** Each month has 30 days.
  - ✔ If the later date is the last day of the month of February, that month is considered to have its actual number of days.
- **ActISDA** Actual number of calendar days. This ISDA method can be used for all instrument types.
- **ActISMA** Actual number of calendar days. This convention is recommended by ISMA for euro denominated bonds (also the US treasury convention).
- **ActAFB** Actual number of calendar days. This convention is recommended for French Government Bonds.

Interest rates are typically expressed for annual periods. The time period measured in years between two dates, t, is described as the fraction of the number of days between two dates, t_d, and the number of days in a year, t_y:

$$t = \frac{t_d}{t_y},$$

where t_d and t_y are determined according to the specified day count convention.

Forward rates

From the yield curve describing the interest rates that apply between the current date and a future date, it is possible to determine an implied forward rate, i.e. the rate that “should” apply between two future dates.

The formula for implied forward rates is based on an arbitrage argument, where the rate for a specific nominal amount between two future dates can be locked in by borrowing and lending at the current rates to the future dates.

The arbitrage condition can be expressed in terms of the discount function as:

$$P(t_0, t_2) = P(t_0, t_1)Q(t_0, t_1, t_2),$$

where $Q(t_0, t_1, t_2)$ is the implied discount factor at time t_0 between time t_1 and t_2. This relationship simply states that the present value at t_0 of a unit cash flow at time t_2 must equal the present value of a cash flow at time t_2, which is first discounted to t_1 and then discounted to t_0.

The implied forward discount factor is obtained from this relationship:

$$Q(t_0, t_1, t_2) = \frac{P(t_0, t_2)}{P(t_0, t_1)}.$$

The formula for implied forward rates has the same relationship to the implied forward discount function as spot rates have to the discount function.

All "floating" cash flows in the system are estimated using implied forward rates. "Floating" means that the actual interest rate is not fixed at the outset, but determined on the basis of an index on a particular date before the interest rate period.

Definitions of cash flow instruments

A **bill** is an instrument where only the nominal amount is paid or received at expiry. The instrument is traded before expiry at a "discount" of the nominal amount and is a true zero-coupon instrument.

Bonds are contracts that promise the delivery of known cash flows, at known dates. In situations when a bond is traded between the end day and the pay day of a coupon, PRIME handles the cash flows as follows:

☞ For security instruments the cash flow is included in the trade if acquire day is before the end day of the cash flow.

☞ For non-security instruments the cash flow is included if acquire day is before the pay day of the cash flow.

An interest rate **cap** provides protection against the rate of interest on a floating rate loan going above some level. If the rate of interest goes above this rate the seller of the cap provides the difference between the interest on the loan and the interest that would be required if the strike rate applied. There is no valuation logic supported by PRIME core models for caps or floors with callable or putable features.

A **Certificate of Deposit (CD)** is a receipt for a deposit placed with an issuing bank.

A **convertible** is a bond that incorporates an option. At the maturity date, the principal can be paid as a predetermined number of stocks of the issuing company, if the bond holder so desires. Otherwise, the par value is received.

A **currency swap** has the following components. There are two currencies, say USD ($) and Euro (€). The swap is initiated at time t_0 and involves

① an exchange of a principal amount $N^{\$}$ against the principal $M^{€}$;

② a series of floating interest payments associated with the principals $N^{\$}$ and $M^{€}$, respectively.

Payments are settled at settlement dates, $\{t_1, t_2, \ldots, t_n\}$. One party will pay the floating payments $L^{\$}_{t_i} N^{\$} \delta_i$ and receive floating payments of size $L^{€}_{t_i} N^{€} \delta_i$, where δ_i is the day-count adjustment:

$$\delta = \frac{t_i - t_{i-1}}{D},$$

and D denotes the number of calendar days in the year according to the current day-count convention. The *two* Libor rates $L^{\$}_{t_i}$ and $L^{€}_{t_i}$ will be determined at *set dates* $\{t_1, t_2, \ldots, t_{n-1}\}$.

An interest rate **floor** provides protection against the rate of interest on a floating rate loan going below some level. If the rate of interest goes below this rate the seller of the floor provides the difference between the interest that would be required if the strike rate applied and the interest on the loan.

An **Forward Rate Agreement (FRA)** is a contract that specifies a nominal amount, N, the dates t_1 and t_2, and the “price” F_{t_0}. If the Libor rate L_{t_1} at time t_1 is greater than F_{t_0}, than the *purchaser* accepts the receipt of $(L_{t_1} - F_{t_0})\delta N$ at time t_2. On the other hand, if $L_{t_1} < F_{t_0}$ at date t_1, the purchaser pays $(F_{t_0} - L_{t_1})\delta N$.

A **Floating Rate Note (FRN)** is initiated at time t_0 and involves

① Buying the FRN at time t_0 for a fixed price N;

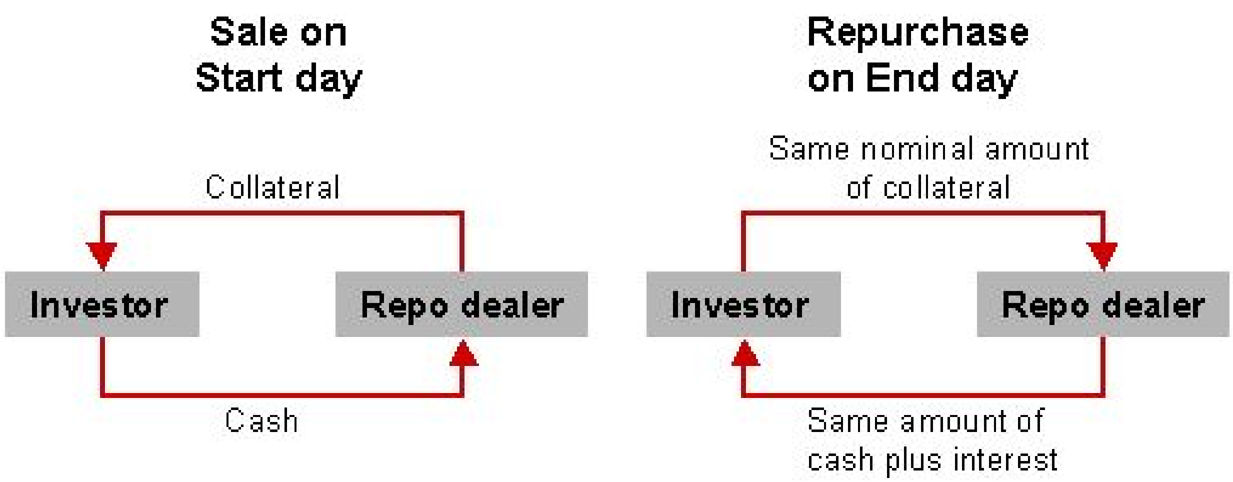
② a series of floating interest payments: L_{t_0} at time t_1, L_{t_1} at time t_2, …, $L_{t_{n-2}}$ at time t_{n-1}, $L_{t_{n-1}} + N$ at time t_n.

A **FX-swap** is made of a money market deposit and a money market loan in different currencies written on the same “ticket”.

A **Promissory Loan** has the property that the coupon is split between the historical owners of the security.

For example, assume yearly coupons and that Party A owns the security for the first nine months of the current cash flow period and then Party B buys the security and keeps it at least three months. 75% of the coupon will be paid out to Party A and 25% of the coupon will be paid out to Party B. Obviously, the size of the next coupon depends on the acquire day of the trade. The coupon cash flows for trades are presented exactly as they will be, taking the acquire day into account.

Rate indices are used as *benchmarks*. Foe example, Libor stands for London Interbank Offered Rate. It is an arithmetic average interest rate that measures the cost of borrowing from the point of view of a panel of preselected banks in London. Euribor (Brussel), Tibor (Tokyo), and Hibor (Hong Kong) are examples of other benchmarks.

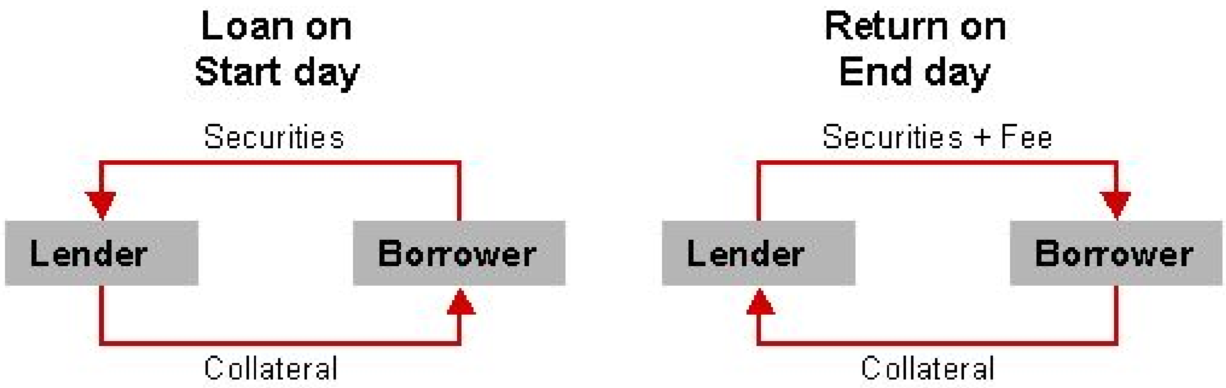


A **Repo/Reverse** involves the sale of assets and a simultaneous agreement to repurchase the same or similar equivalent assets at a future date or on demand for the original value plus a return on the use of the cash.

☞ A **Repo** involves lending securities with agreement to repurchase at some time in the future.

☞ A **Reverse** involves borrowing securities with an agreement to sell them back at some time in the future.

A **security loan** is a contract where a security is temporarily lent to a party. A lending fee is paid to the party that originally owned the security.



The lending fee payment is based on the lending rate, the day count method, and the time period. Coupons paid out during the life of the loan should be transferred to the original owner of the security.

A **swap** is a contract where two cash flow sequences are exchanged. The first sequence of cash flows starts at time t_1 and continues periodically at $t_2, t_3, \ldots, t_k$. There are k cash flows of different sizes denoted by $C(s_{t_0}, x_{t_1}), C(s_{t_0}, x_{t_2}), \ldots, C(s_{t_0}, x_{t_k})$. These cash flows depend on market or credit risk factors denoted by x_{t_i} and on s_{t_0}, a swap *spread*. By selecting the value of s_{t_0}, the initial value of the swap can be made zero.

The second sequence of cash flows, denoted by $B(y_{t_0}), B(y_{t_1}), \ldots, B(y_{t_k})$, depend potentially on some other risk factors denoted by y_{t_i}. The swap consists of exchanging the $C(s_{t_0}, x_{t_i})$ against $B(y_{t_i})$ at *settlement dates* t_i.

Valuation of cash flow instruments

- The appropriate yield curve is found.
- Floating cash flows are estimated using implied forward rates.
- Contingent cash flows are estimated using an option pricing model.
- All cash flows are discounted to the valuation date.
- All discounted values are summed.

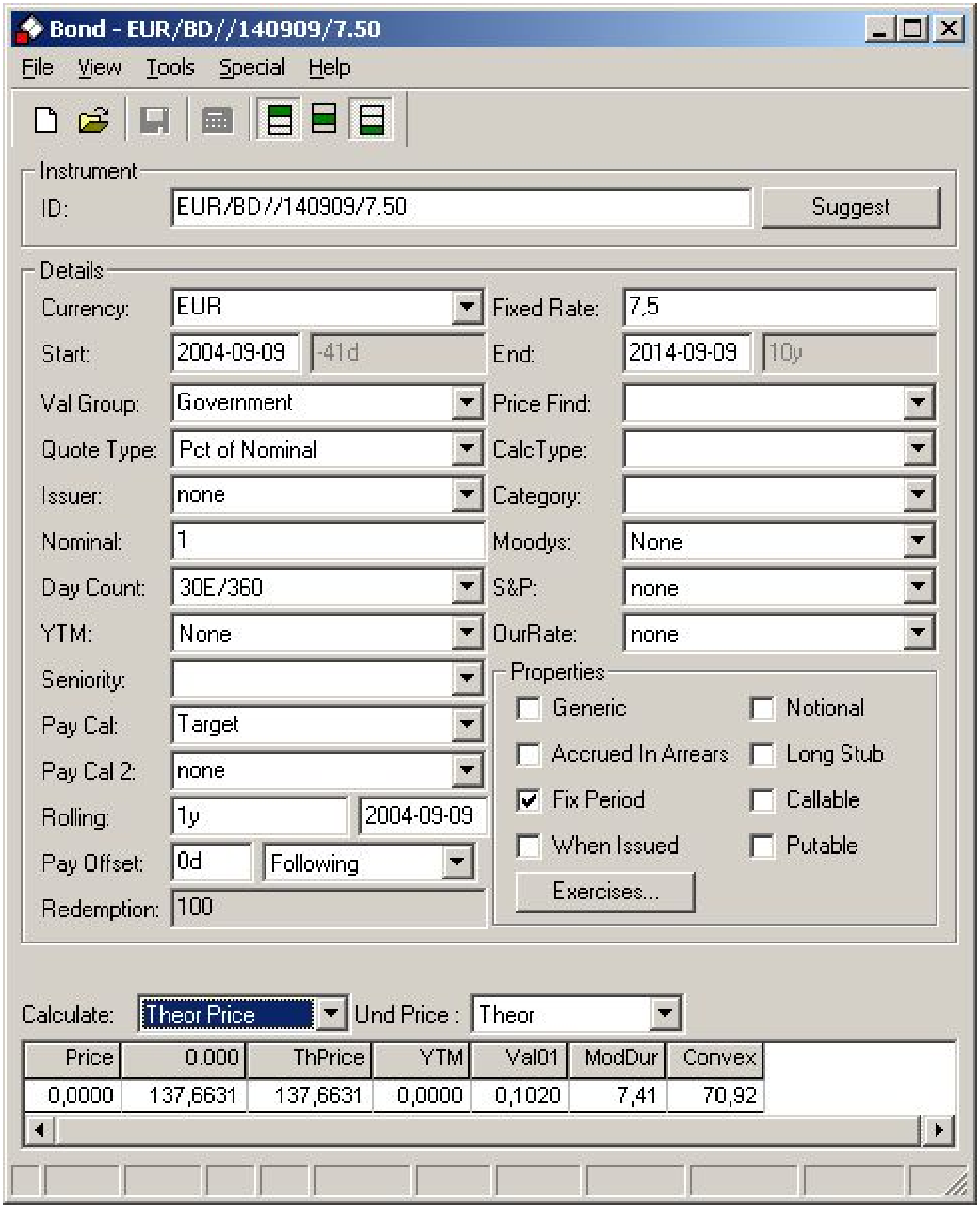
This gives us the present value.

Example: bond valuation

Today in November 2, 2004. We are going to calculate the theoretical price of a bond with the following instrument data:

Quote type:	*Pct of nominal*
Start day:	*2004-09-09*
End day:	*2014-09-09*
Fixed Rate:	*7.5*
Day count:	*30E/360*
Pay Method:	*Following*
Rolling Period:	*1y*
Rolling Base Day:	*2004-09-09*
Fix Period Dates:	*Yes*

In the PRIME Session Manager, choose **Trading** > **Bond**. In the **View** menu of the **Bond** application, make items **Instrument**, **Pricing**, and **Instrument Details** active. Input data, choose **File** > **Save New**. The theoretical price is 137.6631.


Bond - EUR/BD//140909/7.50
File View Tools Special Help
Instrument
ID: EUR/BD//140909/7.50
Suggest
Details
Currency: EUR
Fixed Rate: 7,5
Start: 2004-09-09 -41d
End: 2014-09-09 10y
Val Group: Government
Price Find:
Quote Type: Pct of Nominal
CalcType:
Issuer: none
Category:
Nominal: 1
Moodys: None
Day Count: 30E/360
S&P: none
YTM: None
OurRate: none
Seniority:
Pay Cal: Target
Pay Cal 2: none
Rolling: 1y 2004-09-09
Pay Offset: 0d Following
Redemption: 100
Properties
Generic
Notional
Accrued In Arrears
Long Stub
Fix Period
Callable
When Issued
Putable
Exercises...
Calculate: Theor Price
Und Price : Theor
Price 0.000 ThPrice YTM Val01 ModDur Convex
0,0000 137,6631 137,6631 0,0000 0,1020 7,41 70,92

Exercises

① Calculate the theoretical price of the promissory loan with the following instrument data.

Quote Type:	*Clean*
Nominal:	*1 000 000*
Start day:	*1995-07-24*
End day:	*2005-07-15*
Fixed Rate:	*7.5*
Day Count:	*30E/360*
Rolling Period:	*1 year*
Rolling Base Day:	*2005-07-15*
Fixed Period Dates:	*Yes*

② Calculate the theoretical price of the bill with the following instrument data.

Nominal:	*1 000 000*
Start:	*2004-11-05*
End day:	*2005-11-05*
Day Count:	*Act/360*

③ Calculate the modified duration and convexity of the bond with the following instrument data.

Quote Type:	*Clean*
Val Group:	*Government*
Nominal:	*2 000 000*
Start day:	*2004-11-08*
End day:	*2009-11-09*
Fixed Rate:	*12*
Day Count:	*Act/ActISMA*
YTM:	*None*
Rolling Period:	*1 year*
Rolling Base Day:	*2009-11-08*
Pay Offset	*0d*
Pay Method	*Following*
Notional:	*Yes*

④ Calculate the present value and vega of the cap with the following instrument data.

Start day:	*2004-11-05*
End day:	*2007-11-05*
Strike:	*5*
Day Count:	*Act/360*
Val Group:	*LMM*
Float Ref	*GBP-LIBOR-6M*
Pay Cal 1:	*Target*
Rolling:	*6m*
Rolling Base Day:	*2007-11-05*
Pay Offset	*0d*
Pay Method	*Mod.Following*
Exotic type:	*Chooser*
Exercises:	*3*