PRACTICAL APPROACH FOR ENERGY MARKET TRADING SIMULATOR

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Abstract. *This paper presents the implementation of an energy market simulator that is developed under a research grant. In the introduction there are mentioned several other software simulators available on the market or as research proposals (CrocodileAgent 2012, Market Coupling Simulator and Algo Trader), and also the main characteristics for these types of applications. The system's architecture and the used technologies are shown in chapter 2, while the implementation of the two main modules is in the following chapters. The application is developed in JDeveloper using PL/SQL web services, jsf pages and an Oracle database. The first application module refers to interfaces for the simulator's inputs following the flow: Offers – Packages – Bids – Contracts – Settlements – Invoices – Encashments. The second application module is developed for virtually trading on the wholesale electricity markets in Romania: the Market for Bilateral Contracts, the Day-Ahead Market and the Balancing Market. Most examples in this paper are provided for the Market for Bilateral Contracts' web page.*

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JEL classification: O13, O30

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1. Introduction

Paper [1] describes how their proposed simulator for distributing energy resources in the balancing market has three layers: Bidding and dispatching layer, Market layer and Physical layer. The first layer contains the software routines that are used for aggregating or disaggregating the power flexibility, the second layer contains the market routines that are used for optimizing the bids, while the last layer is used for network transmission and distribution.

A simulation model for local markets in Portugal with the perspective of a licensed municipal entity participation is presented in work [2]. There are two approaches for the implementation of this simulator: in the first one, the municipal entity restricts the participation of the players in the market, and in the other approach, the market is more freely developed.

Also, a patent can be accessed at [3], regarding a tool for a stakeholder market simulator for energy delivery. The license belongs to Siemens and claims to obtain optimal prices and schedules for stakeholder's resources.

According to [4], CrocodileAgent 2012 is an intelligent software developed by a team from the University of Zagreb, which participated in the Power TAC competition ([5]) in 2012. It has a modular design specific to the TAC platform in which it was integrated. CrocodileAgent 2012 focuses on developing the logic of the brokers module that participate in the customer market and the wholesale market.

CrocodileAgent 2012 models the energy consumption for all types of customers (i.e. C1 - consumption, C2 - production, C3 - interruption), as follows:

$$\text{EnergyConsumption (C1)} = f(\delta, \theta) \quad (1)$$

$$\text{EnergyConsumption (C2)} = f(\delta, \theta) \quad (2)$$

$$\text{EnergyConsumption (C3)} = f(\delta, \vartheta, \sigma) \quad (3)$$

Where δ is about the weather, ϑ offers information about the trading interval, and σ is the percentage of the controllable capacity offered by consumers. In the wholesale market, the brokers buy and sell energy with a negotiated price, called the market clearing price and can be expressed like this:

$$\text{Price (T}_i) = f(\vec{\phi}_i, \vec{\chi}_i, [\psi_i]) \quad (4)$$

Where T_i is the serial number of a TAC hour for which the trading window is opened, $\vec{\phi}_i$ is the offer price vector, $\vec{\chi}_i$ is the demand price vector and $[\psi_i]$ is the supply and demand energy matrix for each contract offered by each i . The wholesale market is a periodic double auction that is reset every TAC hour (trading interval).

Market Coupling Simulator (MaCSim – can be seen in resource [6]) is a web-based software for simulating the coupling of European prices on the electricity Day-Ahead Market. The main capabilities of MaCSim include: market areas are customizable, the user can have multiple roles, the orders can be for an hour or for a block, it integrates the energy markets and offers a mechanism for trading the electricity, and a mechanism for allocating cross-border capacity.

Algo Trader (presented in [7]) enables fast transactions by automating complex trading strategies on the intraday market, including EPEX Spot, Nord Pool and other markets using open APIs. Powel Algo Trader is a complete SaaS (Software as a Service) solution hosted as a Cloud service.

Details about the components of the wholesale electricity market in Romania are offered in [8]. These markets are the Centralized Market for universal service (CMUS), the Market for Bilateral Contracts (Central Market with continuous double negotiation of bilateral electric energy contracts (CM - OTC), the Centralized Market for bilateral electric energy contracts), the Day-Ahead Market (DAM), the Inter-Daily Market (IM), the Balancing Market (BM). Also diagrams with the main business processes are detailed in the referred paper.

2. System architecture and technologies

The system contains two modules: one for accessing the information of the main entities of the system (Offers, Packages, Bids, Contracts, Settlements, Invoices, Encashments) and one for the actual trading simulator that allows the user to see historical data and to simulate the trading process on the Market for Bilateral Contracts (MBC), the Day-Ahead Market (DAM) and the Balancing Market (BM). Both modules are developed in JDeveloper, using PL/SQL web services and SQL user-defined views.

JDeveloper is part of Oracle Fusion Middleware, which can offer complete software support for developing, implementing and managing applications in Service-Oriented Architecture (SOA). Aspects regarding SOA security like confidentiality, integrity and availability are handled in [9], while SOA in constrained environments is presented in the PhD thesis [10].

This SOA application uses PL/SQL web services and their fundamentals are approached in papers [11] and [12]. The first one is Oracle documentation, while the second paper is a CERN presentation of different techniques used in technology transfer database, product management tools or software for physics events handling, all of them having security as the main issue.

The interfaces for managing offers, bids, contracts, settlement notes, invoices and encashments are all made in JDeveloper through six web pages that interact with the Home page, as shown in the following figure.

Figure 1. Architecture of the first module in faces-config.xml file

The module for participating on electricity markets contains five main pages, as shown in the Figure 2. The general settings are made in the first page (general_module). From here the user navigates to the page for transactions on the MCB (PCCB page), then on the DAM (PZU page), then establishes the reserves, and finally, on the BM (PE page), where one can directly navigate from the PCCB page.

Figure 2. Architecture of the second module in faces-config.xml file

3. Implementation of the interfaces

For the T_MARKET_OFFERS and T_MARKET_OFFER_PACKAGES tables we have created a Master-Detail interface with a form for the offer and a table for the associated packages. On the two elements of the page the user can perform update operations (insert, update, delete) with database commit. There are lists of values (LOV) defined based on custom

SQL Query virtual tables for the OfferType and OfferCategory fields, as well as LOV for links to other tables (the IdParticipant field). The code for creating the view on which the LOV the trading interval is created is:

```
SELECT
    distinct T_MARKET_BIDS.TRADING_INTERVAL TRADING_INTERVAL
FROM
    T_MARKET_BIDS order by 1
```

Status	TradingSession	Type	Quantity	Price	Formula	IdMarket	IdProduct	IdPartici
closed		PCCB	1.94	208.13		1 PCCB	P20 FWG-A-AN	P3 Prod

Figure3. Implementing LOV with values from tables

All the pages from this module have similar functionalities.

4. Implementation of the Simulator

In order to manage the parameters entered by the users from the keyboard, a Java class (general_module.java) is created in which the parameter constructors are created. Sales / purchase transactions can take place on the PCCB page. The trader chooses the type of product that can be traded from the available list. The list is populated with the names of the products that meet the criterion regarding the simulation period, selected in the main module. Depending on the product chosen, its description is displayed. If sales occur, the available hourly power is displayed, starting from the value entered in the previous page.

Contract forward pentru energie electrică livrată în orele de vârf de sarcină (06:00 – 22:00 CET de luni până vineri) pe perioadă de o lună calendaristică. Denumirea instrumentului cuprinde date privind denumirea lunii din an (NL) și ultimele două cifre ale anului în care are loc livrarea (AN).

The desired quantity to be contracted [MW] 6

Financial loss from imbalances [%] 10

Hourly price negotiated for this type of product

[RON] 0

Start date 04-04-2017

End date 01-05-2020

Historical monthly average price for this type of product

[RON] 208.17

Figure4. PCCB page

In order to generate the list of products that meet the criterion of the selected period, a parameter view with the following source code is created:

Select

```

T_Market_Products.Id_Product Id_Product,
T_Market_Products.Name Name,
T_Market_Products.Type Type,
T_Market_Products.Description Description,
T_Market_Products.Characteristics Characteristics,
T_Market_Products.Availability Availability
From
    T_Market_Products
Where
    Substr(Characteristics, 1, 1) <= Substr(:P_Characteristic, 1, 1)
Order By Characteristics;

```

A virtual table is also created to display the product description according to its ID transmitted as a parameter. The virtual table code is as follows:

```

Select
    T_Market_Products.Description Description
From    T_Market_Products
Where    T_Market_Products.Id_Product = :Variable_Id;

```

The parameter for the product ID is passed through PageFlowScope considering the selection made in the list of the available products which is *selectOneChoice* type. By clicking "Historical monthly average price for this type of product" a web service is executed. It is based on the following PL/SQL function, placed in a package:

```

create or replace package package1 as
function price_pccb(product varchar2,date1 varchar2, date2 varchar2) return number;
end package1;
create or replace package body package1 as
function price_pccb(product varchar2,date1 varchar2, date2 varchar2) return number as
rez number(8,2);
date_1 date;
date_2 date;
begin
select to_date(date1,'dd-MM-yyyy') into date_1 from dual;
select to_date(date2,'dd-MM-yyyy') into date_2 from dual;
select nvl(round(avg(pret_tranzactie),2),0) into rez from t_pccb_nc_history where
substr(replace(instrument_tranzactionat,' ','-'), 1,6)= substr(replace(product,' ','-'),1,6) and
data_tranzactie between date_1 and date_2;
return rez;
end;
end package1;

```

When clicking "Hourly price negotiated for this type of product" a parameter query is executed. Its result is stored in a view that has the following code:

```

select nvl(round(avg(contract_price),2),0) from t_market_contract_line where id_product=:p

```

The events that take place after clicking the two previous presented buttons are:

```

actionListener="#{bindings.pricePccb.execute}"
actionListener="#{bindings.ExecuteWithParams.execute}"

```

Similarly, the other pages of the module were designed and implemented.

5. Conclusions

The developed application contains two modules corresponding to the interfaces for passing the input data into the system, and also to the simulator for trading on the electricity markets.

The technology used ensures the security and portability of the system on various work environments using JDeveloper as a development framework.

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