# Data model standardization for real-time e-commerce ⋆

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**Abstract.** Real-time activity is important trend rising in e-commerce. Such kind of activity requires specialized, fully standardized and integrated market systems. In this paper we present and discuss basic requirements for real-time e-commerce systems. We also present $M^3$ – Open Multi-commodity Market Data Model, which may provide flexible and universal market data and communication models for wide range of markets, and thereby facilitate systems integration for real-time e-commerce purposes.

## 1 Introduction

Nowadays we observe continuous development and broaden application area of e-commerce. Companies want to realize more and more new individual targets using the Internet and thereby e-commerce. One of important trends in modern economy is to operate according to the *real-time requirements*, this means that some tasks have to be realized in guaranteed and as short as possible time. Under such circumstances commodities and services delivered or accomplished too late or in improper amount become worthless. Good example of such activity is company making short series of untypical custom-made equipment. Such enterprise has to ensure that all necessary materials will be delivered in proper amount and time, what usually means in the same time. Moreover company has to prepare its own resources and productive power to be available in adequate amount and time. If such a company has its own dependent deliverers these requirements may be not so difficult to meet, but if company operates on the free market and has to buy all components from independent entities this task become quite challenging and may require some special mechanisms to ensure success. These special mechanisms may be provided by creating special kind of

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market – *real-time market*, which should enable market entities to meet real-time requirements.

There exists a special group of commodities – non-storable goods, like electric energy [2], telecommunication bandwidth [5], transportation services [3], which require real-time market to ensure completely free and fluent trade. These goods have to be exactly balanced in each time moment and all unused resources physically disappear. In such a market entities trade by integrals of some time functions (e.g. function of electric power in time). In case of other commodities real-time market is not indispensable, but in some cases may be used to increase profits, better adjust to demand on the market and improve trade fluency. On the other hand "standard" commodities traded in the real-time market gain some features of non-storable goods. They are localized in time and space, become worthless if are delivered in improper time; storage may be very expensive and can not last too long. Moreover, delivery and other constraints (eg. limited transport capabilities) become much more critical.

## 2 Multicommodity real-time eMarket

Rise of *Business To Business – B2B* relations significance in e-commerce caused establishment of eMarketplaces [1]. They are trade platforms, which group in one place many customers and suppliers, and thereby allow to much more efficient offers matching, than in the case of bilateral trade, when suppliers and customers have to search each other in the whole Internet. EMarketplaces enable also to partially automate processes of transaction conclusion, best offers searching and demand examination.

Standard eMarketplaces work fine in traditional e-commerce, but real-time markets cause new demands. One of the most important problems is necessity of synchronization of deliveries from various suppliers. Buyer has to have a guarantee that he gets all needed commodities in proper amount and time. Very often some goods are complementary, what means that one good without the other is worthless for customer (eg. all raw materials necessary to produce final product), therefore market entity has to get all needed commodities in certain amount proportions and in the same time. In some cases there is also additional demand of exact goods balance without storage possibilities. All these demands may be easily met using the multicommodity turnover model [12], which allows market entities to trade in bundled packages of goods.

On real-time markets offers may be submitted or changed in short time before their realization time. A possibility has to exist to react for these events within adequate time, therefore all market procedures should be automated and take place without necessity of direct human interference. All operation should be performed by inteligent agents, whose targets and parameters are defined by a human.

Traditional e-commerce mechanisms are insufficient for real-time markets, therefore we propose idea of *Multicommodity real-time eMarket – RTeMarket*. Such a market should enable market entities to trade respecting real-time requirements. This is enabled by possibility of complex commodities definition (in particular commodities may be precisely located in time and space), possibility of submitting complex multicommodity offers for bundled packages of goods, standardized data and communication model, which enables system integration and trade process automation, possibility of precise entities structure and infrastructure description. We try to facilitate meeting this requirements by developing an Open Multi-commodity Market Data Model – $M^3$ [7], which allows to integrate market data from multiple distributed sources in diverse systems and normalize market procedures and data modeling form market entity as well as from market processes point of view.

At present, there are no general world-wide standards for market information interchange. In some industries there are data interchange mechanism, which can be acknowledged as local standards, for instance, RosettaNet standards in electronic industry, MDDL (Market Data Definition Language) in financial sector and other industries standards specified on the basis of open standards like ebXML (Electronic Business using eXtensible Markup Language) or XBRL (eXtensible Business Reporting Language) [14–16]. However, these standards are focused on electronic communication of business and financial data like invoices, offers, business partner information and so on. In energy sector – a typical infrastructure market – UCTE (Union for the Coordination of Transmission of Electricity) initiate initiative called Electronic Highway focuses only on transport layer and technical aspects of the communication network. It is clear that existing standards can not meet the needs of the real-time markets, where many specific elements, related to balancing of many commodities and services under constraints and other real-rime requirements, may play important roles. Heterogenous systems and absence of general mechanism for data interchange create barriers for mechanism integration and developments that are especially important for the European and world-wide market evolutions.

Apart from above mentioned requirements, real-time market demands also appropriately designed market process structure as well as balancing and pricing algorithms, but these problems are not subject of this paper. We only consider if using $M^3$ we may model all data necessary for these processes and ensure proper communication between them.

## 3 Systems integration for RTeMarkets

Efficient usage of real-time e-commerce requires standardized data exchange model and possibility of various systems integration. Market entity may trade on many platforms, changing them dynamically and even create new platforms and become their operator to realize its own targets. Market entity should have possibility to perform these changes freely, fluently and in some sense transparently. Therefore processes of offers submitting and searching, as well as transaction conclusion should be standardized not only within one platform but for all platforms in given market segment. These standardization should ensure that any rules' change in one platform will be invisible for market entity, which still should have possibility to efficiently operate on many trade platforms without changing anything in its software. Standardization and integration should also enable synchronization of trading using many platforms. Market entity should have possibility to buy or sell goods simultaneously in many platforms retaining guarantee of trade synchronization, balance and goods complementarity. All this requirements tends toward usage of inteligent automate agents, which should try to realize market entity targets in best possible way using simultaneously many trade platforms. Appropriate data model standardization may also allow to operate brokers, which group some eMarkets and are visible from outside as one "standard" trade platform.

### 3.1 M$^3$ approach

Although market balancing procedures on particular trade platforms may significantly vary, in case of practical used mechanisms there is usually possibility of determination some commonly used data and communication schemas. Proposed Open Multi-commodity Market Data Model (M$^3$ ) is flexible and universal solution, which allows to represent data concerning broad area of market system in standardized way, and thereby to easily integrate various trade platforms. M$^3$ treats elementary market balancing processes as a "black boxes" and take care only of their inputs and outputs, so it is independent from detailed market rules, as it was depicted on Fig. 1.

M$^3$ consists of several layers: formal mathematical model [7], conceptual data model, expressed in form of UML class diagrams [7, 6], exemplary relational database structure, XML schemas for static data [10], communication models [8, 9] and XML schemas for messages and Web Services definitions.

Conceptual data model, described in details in [7], consist of the following elements.

**Infrastructure (network)** – representing technical infrastructure required for the trade (eg. transportation network). During the balancing process, the infrastructure plays the role of a system of limited resources, and is a medium for delivery of commodities and services

**Market entities structure** – describing market players and relations between them. Market entities form a hierarchy, where given market entity may be composed of some other market entities, e.g. a corporation and subsidiaries.

**Time structure** – defining time periods used in balancing processes and relations between them. Well defined time structure is used to localize commodities in time and to organize market processes.

**Commodities** – describing goods traded on the market, which have specific type, parameters, and may be related to time structure and infrastructure

**Offers** – providing three types of offers: simple, integrated and grouping. Simple offer is described by admissible range of commodity volumes and a unit price. Integrated offer is a typical offer for multi-commodity turnover, where players trade with packages (or bundles) of commodities with fixed proportions of commodities in the offer. The most complex type of offers are grouping offers. Grouping offer aggregate a set of other simple or integrated offers and describes relation between these offers. Grouping offers allow the market entities to define individual constraints.

**Results** – describing current schedule of all commodities' delivery, which is called programme, and market prices.

Dependencies between $M^3$ data model elements and example of their possible usage on the electric power market was depicted on Fig. 2.

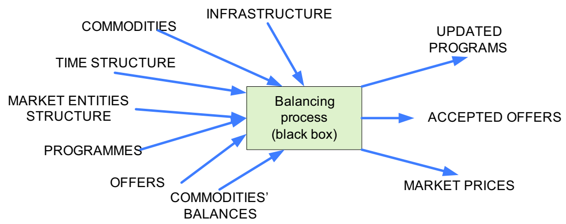


**Fig. 1.** Market balancing schema.

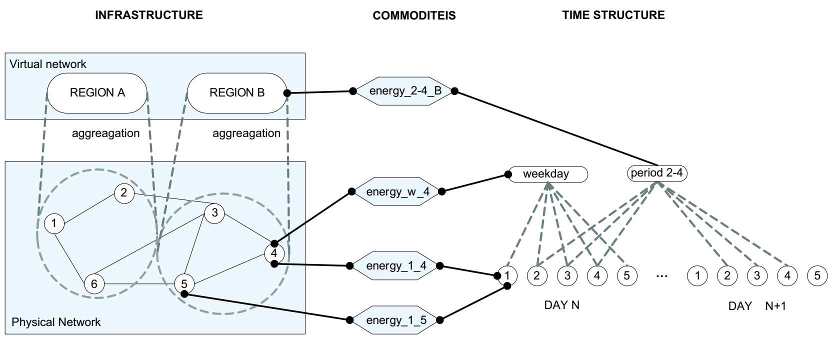


**Fig. 2.** $M^3$ elements dependencies and usage.

$M^3$ provides universal interface between market player and all trade platforms and balancing processes, as well as between various trade platforms. Moreover it may be used in data modeling and communication processes within one trade platform, e.g. in case of multistage balancing procedures. Apart from usage on real-world markets, $M^3$ may be used during research works to facilitate results obtained by different teams comparison as well as to facilitate simultaneous work within research team.

In $M^3$ data may be stored using XML files or a database. Information interchanged between market entities is to be expressed in XML, as a set of XML messages. All XML structures used in $M^3$ are defined using W3C XML Schema.

XML structures for static data [10] cover whole data model, and are designed mainly for data interchange between scientists and developers, who develop and test algorithms for balancing and optimizing turnover on multi-commodity markets. These structures may also be used – instead of a database – to store market data. XML messages, used in communication on the market, are composed of the same elements and types as used in the static data model. Messages schemas import necessary simple and complex types definitions, and global element declarations from static data schemas, and enclose them with an envelope containing communication details. Each message contains only those parts of static structures, which are necessary in particular data exchange process the message is designed for.

$M^3$ supports two topologies of communication on the market.

**Centralized** – where market participants communicate with one central entity, e.g. balancing operator. In this model, direct data interchange between participants is of course possible, but it is not covered by $M^3$ messages [8].

**Distributed** – where no central unit exists, and market participants directly communicate with each other using $M^3$ messages [9].

There exist, with respect to changeability, two categories of data. Current data, like offers, programmes, etc. – describing temporary market state; and metadata, like commodity kinds, market entities, networks, calendar, etc. – defining static objects appearing on the market, along with their identifiers. In both topologies, two models of message passing exist.

**Directional** – message is sent to one recipient or to explicitly listed group of recipients. This is a proper model for passing current market data, e.g. submitting offers, and for registering changes in metadata, e.g. introducing new entities or commodities to the central repository. In this model, each request should be individually replied. This communication model can be implemented by Simple Object Access Protocol (SOAP).

**Broadcast** – message is published to the public or to some group of entities (not explicitly listed). This model is appropriate for publishing market metadata, e.g. directories of market participants, catalogues of commodities, and for publishing results of balancing processes. This type of communication could be implemented by placing messages in some public repository (e.g. on public Web site), where every interested entity could withdraw them, or by constant polling a server by some client, more precisely by a software agent. The polling could be performed through SOAP protocol.

Messages designed for $M^3$ communication can be interchanged by any means, like ftp, e-mail, etc., but are especially suitable for use with SOAP and Web services. This is especially important in case of real-time market, where entities have to react immediately for incoming messages (eg. submitted offers or balancing results). Web services mechanism provides also immediate response for each request, which ensures sender that his message has been received by addressee and may inform if the message was accepted due to formal reasons (eg. if it is in proper format). Immediate response and confirmation is very important in real-time markets, because allows market entity to continuous control of market processes and to react immediately to various events including communication problems and formal mistakes.

## 4 $M^3$ applications in real-time e-commerce

### 4.1 E-supply chains

E-supply chains [13] arise by using the Internet and e-commerce mechanisms to classical supply chains modeling all entities, activities, information, processes and resources involved in moving a product or a service from supplier to customer [11]. Modern technologies allow to integrate and automate all processes of supply chain management in all enterprisers involved into the chain. As it was shown, in real-time e-commerce entities very often need to define their demand in a complex way, therefore they have to use complex e-supply chains, which may model all real-time requirements. Market entities have to define commodities parameters, time and localization of delivery and dependencies between complementary goods. In our example of company making short series of untypical custom-made equipment, this entity has to submit offer which, in case of acceptance, ensure timely delivery of all needed materials in proper amount proportions, even if they are provided by different suppliers.

Assume that the company gets order query for an electronic detector in amount at least 100 pieces, and not more than 150, with price 350 for one piece, delivery time 10 days and response time 1 day. To realize such order company needs: 1 printed circuit-board, 2 programable units, 1 detector, 5 resistors and 6 capacitors for each pice of final product; 4 days in advance. Example of $M^3$ offer describing such situation is presented bellow.

```
<m3:Offer id="ex:o23565-78" offeredPrice="300.00">
  <m3:description>Offer for raw materials</m3:description>
  <m3:offerStatus status="m3:offer-open">
      <m3:durationPeriod endTime="2007-07-21T10:15:00"
                         startTime="2007-07-20T10:15:00" />
       </m3:offerStatus>
  <m3:offeredBy ref="ex:SmallCompany"/>
  <m3:volumeRange minValue="100" maxValue="150"/>
  <m3:BundledOffer>
   <m3:offeredCommodity shareFactor="1" ref="ex:circuit-board"/>
   <m3:offeredCommodity shareFactor="2" ref="ex:prog-unit"/>
   <m3:offeredCommodity shareFactor="1" ref="ex:detector"/>
   <m3:offeredCommodity shareFactor="5" ref="ex:resistor5K"/>
   <m3:offeredCommodity shareFactor="6" ref="ex:capacitor15u"/>
  </m3:BundledOffer>
</m3:Offer>
```

Offer is valid through one day (from 2007-07-20 to 2007-07-21), because after that time company has to give a response to the query. Such offer assure that, in case of acceptance, company gets at least 100 and not more than 150 ”packages” of goods containing: 1 printed circuit-board, 2 programable units, 1 detector, 5 resistors and 6 capacitors each, and pay for each ”package” not more than 300. Of course each commodity may become from different supplier, from company point of view only total balance is important. Time and place of delivery, as well as commodities parameters, may be defined by appropriate commodity definition, described in the next section.

The company submits such offer in RTeMarket and, if offer is accepted, the company may give a positive response to the order. The company may try to find necessary materials using one trade platform or many independent trade platforms. $M^3$ mechanisms (two phase commit protocol [4]) allows to ensure complete offer realization even in case of distributed trade environments and many eMarketplaces [9].

In case of fully integrated systems such checking of realizability may be performed automatically. Human need only to translate order query to needed raw materials, define maximum price and deadline for delivery, whereas automatic agent should check their accessibility and order them.

### 4.2 Commodities

$M^3$ allows complex commodities definition. Commodities may have many parameters which determine precisely requirements toward them. In particular they can be easily and unequivocally localized in time and space. In our example, for each needed material, the company has to define parameters, as well as time and place of delivery:

```
<m3:Commodity id="resistor5K" dref="ex:resistor"
  minBalance="0" maxBalance="0">
  <m3:description>
    resistor 5K delivered to Smallcompany on 2007-07-26
  </m3:description>
  <m3:parameter dref="ex:resistance>5000</m3:parameter>
  <m3:availableAt ref="ex:SmallCompanyLocation"/>
 <m3:CalendarScheduledCommodity ref="ex:D070726"/>
</m3:Commodity>
```

Needed commodity has to be type *ex:resistor* and have value of parameter *ex:resistance* equal 5000. Commodity must be available in *ex:SmallCompanyLocation* on period *ex:D070726* (2007-07-26). Definitions of time period – *ex:D070726* and localization – *ex:SmallCompanyLocation* have to be placed in time structure and network element respectively (for details see [8, 10]).

Possibility of complex offer and commodities definition is even more crucial in case of non-storable goods, like electric energy or telecommunication bandwidth.

Commodities on such markets has many various parameters and are strictly connected with infrastructure and time, which has to be precisely mapped in market model. More detailed samples of offers and commodities definition in $M^3$ may be found in [8] and on the project Web page [10].

### 4.3 Limited infrastructure

Infrastructure limiting trade possibilities is typical to some kinds of markets and usually connected to non-storable goods. Although in case of real-time markets limited infrastructure may play essential role also in case of storable goods. Typically role of the infrastructure may be played by limited in time delivery possibilities. For example, limited number of rail cars in specific place and time or limited space on railway track. If there is no delivery time limitation or this period is long enough, these constraints may be neglected (cars may be transported from other places, transport may be divided or shifted in time), but in case of real-time markets these constraints have to be respected and modeled.

In $M^3$, limited infrastructure may be modeled using networks or grouping offers. Networks may reflect diverse constraints, mainly limited delivery possibilities, but also maximum amount of given commodity (telecommunication bandwidth), some dependencies between goods or possibilities of transfer of one good into another, etc. Networks are used to model general constraints concerning a whole market, so called *system constraints*. Virtual networks, which may aggregate physical networks give possibility to model constraints on various levels and constraints concerning various commodities. Grouping offers may be used to model market entities' individual constraints, e.g. limited speed of generation change for a power plant, maximum or minimum power generation in an electrical network node, etc. Detailed examples of infrastructure modeling may be found in [8] and on the project Web page [10].

## 5 Summary

Trends toward standardization and systems integration, caused by tendency to operate in real-time, become more and more important in modern e-commerce. Development of the real-time markets cause new requirements towards e-commerce mechanism and procedures. $M^3$ is a universal and flexible solution, which may significantly facilitate realization of this trends, providing common data and communication models. In contrast to existing standards for information interchange, $M^3$ is not limited to the particular type of market, and my be used on the broad range of various market systems. Existing local information exchange standards concentrate mainly on business and financial data, like invoices, orders, payments, formal information about entities and so on, whereas $M^3$ focus on data concerning directly trade process, market balancing and pricing. Thanks to complex commodities, market entities and time structure; possibility of exact infrastructure mapping; and support for multi-commodity turnover $M^3$ may become very useful tool for real-time markets, where such solutions are lacking.

Important feature of $M^3$ is possibility of application in multilateral distributed environments, what may significantly increase its practical applications area in e-commerce.

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