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Discussion Paper

Towards integrated parallel Markets - A Solution Approach to the Order Allocation Problem

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ABSTRACT

Today's financial electronic markets are a result of the remarkable development in information technology during the last years. With the growth of electronization in financial markets and the establishment of new electronic trading services the design of the market structure moved in the focus of interest. Design decisions determine the market microstructure, influencing trading patterns and investors strategies and therefore market outcome. This paper motivates the necessity of a new flexibility in market design to tackle economic problems like the fragmentation of markets and the resulting split up of liquidity. As a possible solution we propose the concept of cascading Dynamic Market Models (cDMMs), supporting multiple market models. To understand the implications of cDMMs, we analyze the vices and virtues of parallel market models.

1. INTRODUCTION

Over the last years new technology, new trading procedures, new products, new pricing models, and a change of the market participants' behaviour have led to a tremendous development in the field of electronic marketplaces. Especially the electronization in financial markets worldwide has progressed quickly – exchanges of financial products, independent of their size, are adopting new technologies to automate trading. Information technology has become one of the strategic resources in establishing such electronic marketplaces. This electronization process also gave rise to the following two developments:

- Due to the lower set-up costs of electronic markets, the number of electronic markets increased steadily.
- The growing competition led to further diversification and sophistication of electronic markets.

A result of these developments was a high degree in fragmentation and a split up of liquidity in the markets. To counteract a fragmentation of markets and to increase market liquidity market providers are looking for new ways to offer improved trading environments to market participants.

Consequently, the market design decision became more important. Design decisions must accommodate the preferences and demands of the market participants by determining design options such as parameters of the market structure. In fact to meet the needs of the participants is one of the most demanding tasks in market design. Market participants mostly have

- *heterogeneous preferences* and
- *inconsistent preferences* over time

(Neumann et al., 2002). Heterogeneous preferences of market participants refer to the individual demands and needs of market participants or groups of market participants. Inconsistent preferences over time imply a change of the participants demands over time and from transaction to transaction (*transaction-wisely*). Preferring a certain market model in time period *t* does not mean preferring the same market model in time period *t+1* for the same product. To capture these heterogeneous and inconsistent preferences within one market model is a challenging task of market design. As a promising solution concept Neumann et al.(2002) proposed *cascading Dynamic Market Models (cDMMs)* providing multiple market models within the same platform.

In Chapter 2 we discuss the concept of cDMMs and give a more comprehensive definition of this concept. We also outline two problem cases which we identified by analyzing the cDMMs.

To classify the situations in which these two cases appear, we analyze and specify the market phases of an electronic negotiation process in Chapter 3. Chapter 4 reviews related work in the field of electronic markets. Finally in Chapter 5 we conclude the found results and give research directions in the area of market design and electronic markets.

2. CASCADING DYNAMIC MARKET MODELS

As described above, different investor groups pose different demands at the market. It seems to be impossible to combine all these demands into one single market. This leads to many different markets, and thus to a split of liquidity between all markets. This dilemma of liquidity vs. adaptability cannot be resolved in conventional electronic trading systems. Therefore, to fulfill the requirements of the investors and to avoid a splitting of liquidity in the marketplace, a new market concept has to be found. One idea of a new market concept is the integration of the markets within one market model.

Budimir and Gomber (1999) introduce the concept of *Dynamic Market Models (DMM)*. Market participants themselves are given the opportunity to choose market structures' characteristics according to their preferences in a DMM. This idea of dynamic market models fulfils the postulated characteristic of more individual market design, but cannot prevent the split of liquidity between markets. Besides, DMM provide not much more flexibility than traditional market models, because the market participant just chooses *one* set of market parameters and therefore one market he wants to put the order in.

Therefore, Neumann et. al. (2002) extend this concept to *cascading Dynamic Market Models (cDMM)*, considering the integration of single market models within one order book. We suggest a more comprehensive interpretation of this concept of cDMM. The cascading concept supports multiple market models. The designer is able to combine market models within one larger market model in both ways, sequentially and parallel.

In general market models can be considered from two different points of view:

- *market designer's view* and
- *order's view.*

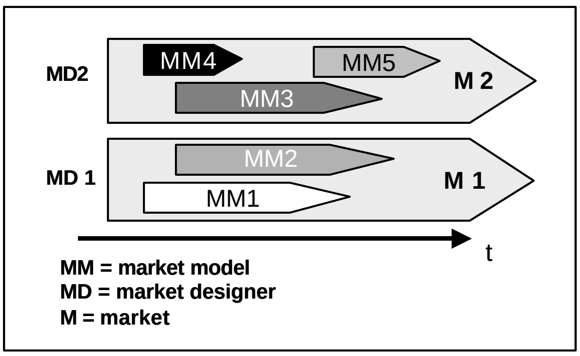

Figure 1: Cascading Dynamic Market Model - market designer's perspective.

Figure 1 illustrates the market designer's view. The market designers MD1 and MD2 each configure a market model , i.e. the trading rules. Note that two or more market models can run simultaneously within one market. Figure 1 depicts the case where two market models M1 and M2 are designed. Market designer MD1 combines the two market models MM1, e.g. a hit & chat market, and MM2, e.g. a double auction, determining the new market M1. Market designer MD2 combines the three market models MM3, MM4 and MM5 to the new market M2. The two aspects of cDMM, sequence and parallelism of multiple markets, are fulfilled in both markets M1 and M2. In market M1 market model MM2 exists parallel (with a short time delay) to market model MM1. In market M2 market models MM4 and MM5 exist sequentially, whereas market model MM3 exists parallel to both MM4 and MM5.

From the order's point of view cDMM allow the market participant not only to choose more than one market to put the order in simultaneously, but also to define preferences for the sequence of markets the order has to pass through. This is depicted in Figure 2. As shown in the market view, there exist six markets M1 to M6. The orders A and B, illustrated in the order view, choose a sequence of markets to be traded in. The order A has the preference of first being traded in market 1, then if not executed in this market, then moving on simultaneously into the parallel markets M2 and M3 and lastly being traded in market M6. A second example is given for the order B. Order B first goes into market M4. If not executed order B exists simultaneously in M1 and M2 and afterwards, if not executed, enters market M5.

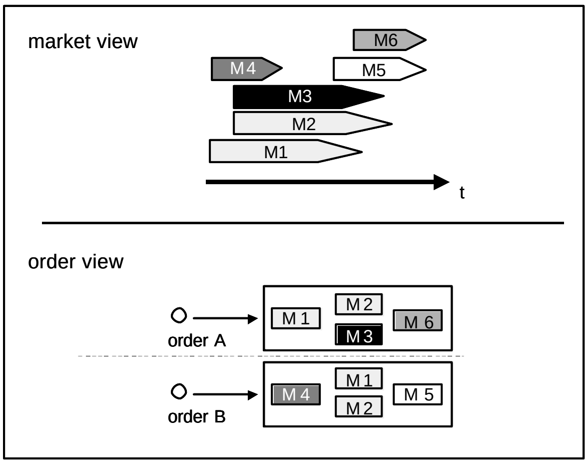

Figure 2: Cascading Dynamic Market Model - order's perspective.

The concept of cDMM poses economical and technical questions of allocation on the *parallel existence* of orders. As *parallel existence* we consider a simultaneous existence of one order in two or more different markets. We identified an asymmetric and a symmetric order allocation problem:

- The *asymmetric case* emerges, if one order A exists in two markets at the same time (parallel existence) and is matched with order B in one market and with order C in the other market. Just one market can get the priority to be executed order A.
- In the *symmetric case* order A and order B exist parallel in both markets and are also matched against each other in each of the two markets M1 and M2. Order A prefers the price in M1, whereas order B favors M2. This leads to a deadlock problem, which means both markets are waiting for a result in the respective other market.

The mentioned cases only appear in specific situations. To classify these situations we introduce market phases and differentiate two specific states of market phases, the *stringent* and the *non-stringent state*. These states are defined in the following chapter.

3. TOW STATES OF MARKET PHASES

The parallel existence of one order in several markets depends on market restrictions. Some markets premise an exclusive existence of orders. This exclusive existence depends on the phase of interaction the market is situated in and the rules of the market.

For the classification of market phases we refer to the *Media Reference Model* of Schmid (2000), which identifies four phases of interaction:

(i) *Knowledge*,

(ii) *Intention*,

(iii) *Agreement*, and

(iv) *Settlement*.

Market participants gather information about products, markets and other market participants in the knowledge phase. Demand and supply of an order is specified in the intention phase. The *Montreal Taxonomy* (Ströbel and Weinhardt, 2002) extents this model by subdividing two phases, the intention phase (ii) and the agreement phase (iii).

In the intention phase the following subphases are identified:

a) *order specification*, when participants determine their constraints towards the transaction object,

b) *order submission*, when the order is transmitted to the recipient, and

c) *order analysis* by the recipient to check for compliance with certain conditions and rules.

The terms and conditions of a transaction are specified during the agreement phase. In this phase the Montreal Taxonomy differentiates

a) *order matching* to identify and score pairs of orders as potential candidates for a transaction,

b) *order allocation* to determine the final pairs of orders for transaction execution out of the set of potential pa irs, and

c) *order acceptance* when market participants accept or reject the detected order allocation.

The agreed-upon contract is executed in the settlement phase, including payment or post-sales support.

The described phases are useful for the analysis of dependencies in the case of parallel existence of orders in different markets. One order is only allowed to exist parallel in two different markets if the market rules permit the withdrawal of orders. This permission depends on the phases' state of the markets. We differentiate between *stringent state* and *non-stringent state*. In a non-stringent phase the market rules permit to withdraw orders whereas in stringent phases withdrawal is not possible.

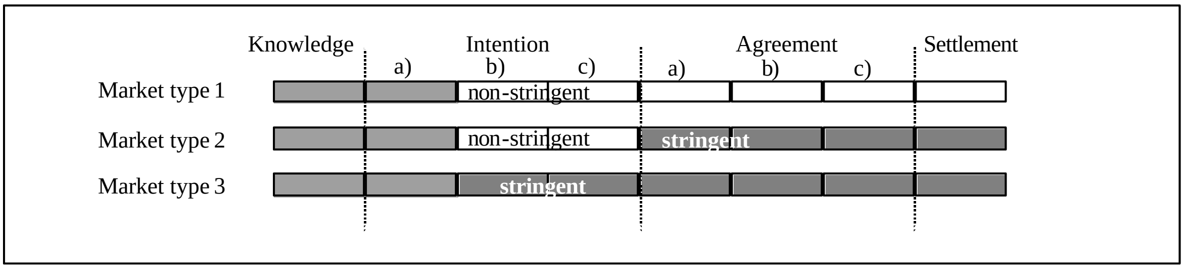

Figure 3: Basic types of markets with stringent and non-stringent phases.

The knowledge phase (phase (i)) and the order specification phase (phase (ii-a)) are always non-stringent, because during these phases the order is not submitted to a market. Therefore these phases are not relevant for this differentiation. The phases to be considered last from the order submission phase (ii-b) up to the settlement phase (iv). A market can consist of both non-stringent and stringent phases, but phase transition is just allowed to change from non-stringent to stringent. This implies three basic types of markets as described in Figure 3.

A market consisting exclusively of non-stringent phases characterizes type 1, whereas type 2 describes a market starting with non-stringent phases and switching to stringent phases. The switch from non-stringent to stringent phases can be initiated by temporal or causal events at any time depending on the market rules. Type 3 indicates a market consisting of stringent phases only. Markets of type 3 never accept parallel orders. Therefore parallel existence of orders is just possible during non-stringent phases. We want to point out, that orders in parallel markets can exist in different phases as long as these phases are non-stringent (e.g. order A exists parallel in market M1 and market M2, whereas market M1 resides in non-stringent Phase ii and market M2 in non-stringent phase iii). This characteristic emerges due to the fact, that in a specific market not all phases exist or phases might coincide.

Both the asymmetric and symmetric deadlock situation described in Chapter 2 can only appear during non-stringent phases. To solve the allocation problem during non-stringent parallel phases it is necessary to specify solution strategies, e.g. preferences for a particular market. Consequently, the deadlock situation disappears, because each order has a preference on one market (e.g. the preference on the market with the best price) and withdraws from all other markets. For example, in the symmetric case order A is matched with order B in both market M1 and M2. Order A prefers M1 for execution and order B favors M2. Therefore, order A withdraws from market M2 and order B withdraws from market M1 and the order allocation problem is solved. The same is true for the asymmetric case.

The transition from non-stringent to stringent phase states leads to an other order allocation problem. We differentiate between synchronous and asynchronous phase transition, which is discussed in the following in more detail. For example one order exists parallel in market M1, M2 and M3 and market M1's state switches from a non-stringent phase to a stringent phase and markets M2 and M3 retain non-stringent state. The order has to withdraw from markets M2 and M3 and solely persists in market M1. This case of *asynchronous phase* transition is illustrated in Figure 4.

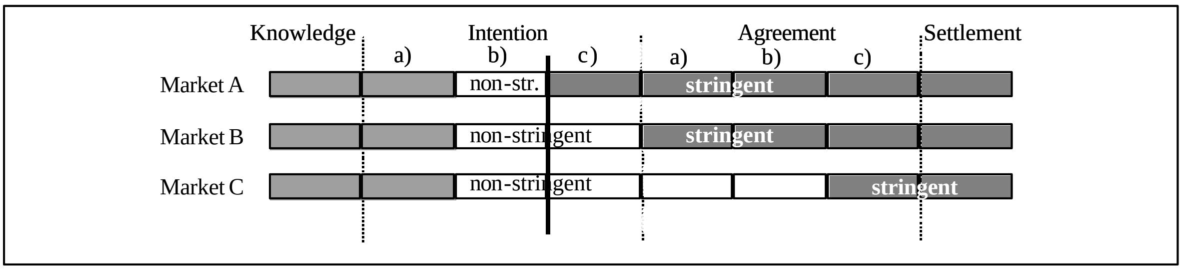

Figure 4: Asynchronous phase transition.

A *synchronous phase* transition leads to a deadlock situation. Two or more markets change states from non-stringent to stringent at the same time and there exists at least one order parallel in two of these markets. To avoid order allocation problems it is necessary to define priority rules, which of the markets keeps the order. Different solutions can be considered, e.g. assigning preferences for specific markets to the order or using the time stamp of the transition assuming that exact synchronous transitions can not exist in the system. The case of synchronous phase transition is shown in Figure 5.

In this chapter, we outlined the need for a stringent and a non-stringent state of the market interaction phases in the development of cDMM.

The deadlock situation described in Chapter 2 can appear during parallel non-stringent phases. In this case the deadlock problem is solved because withdraw of orders form all concerned markets is allowed. Each order resists in one market according to its preferences (for example best price preference).

In the case of parallel stringent phases orders are not allowed to exist in parallel markets and

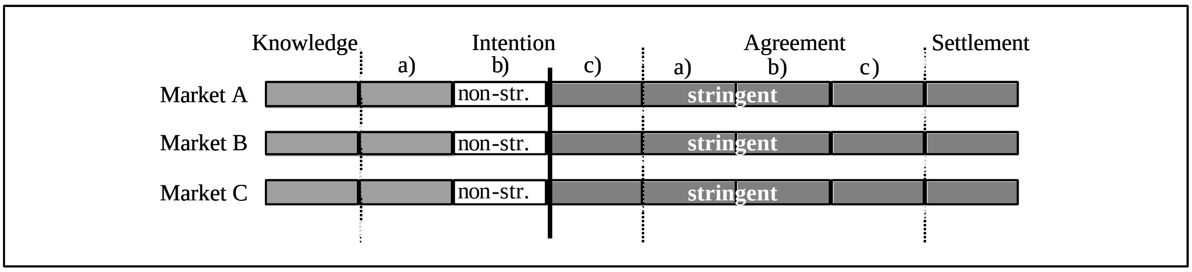

Figure 4: Synchronous phase transition.

therefore the deadlock situation cannot occur.

Critical in respect to the deadlock problem is the phase transition from the non-stringent to the stringent phase state. The two identified transition situations, (1) asynchronous and (2) synchronous phase transitions, have to be distinguished. In the asynchronous case the change from non-stringent phase to stringent phase in one market leads to the persistent of all orders in that market. The orders withdraw from the markets with non-stringent phases. For the synchronous phase transition situation in which more than two markets change synchronously their phase states from non-stringent to stringent the deadlock situation cannot be solved.

By introducing the phase states the deadlock situation could be solved for the cases described above and restricted to one unsolvable situation, the synchronous state transition. This is a minor problem for the technical realization, due to the fact that exact synchronous state switch does not occur within one platform. This analysis is basis for the understanding of cDMM.

In the following chapter we give an overview of electronic trading system in related research areas.

4. RELATED WORK

As described in the previous chapters the concept of cDMM provides a special market design and structure of market models. The problems and questions we have identified are due to the parallelism of multiple markets and the synchronous existence of one order in multiple markets. In the following some selected work, dealing with multiple markets and market design, is presented.

Wurman et al. (2000b) developed a taxonomy to describe similarities and differences of auction mechanisms. They present a parametrization of the auction space, identifying rules. One parameter describes whether withdrawal of bids in an auction is allowed or not. In our model this parameter can be used to describe the state of the phases. A non-stringent phase allows withdraw of orders whereas a stringent phase denies a withdraw. Wurman et al. implemented their described framework within the following presented system.

Electronic trading systems like the *AuctionBot* (Wurman et al., 2000a), a general platform for price based negotiation, can manage a large number of simultaneous auctions. The platform supports the parallel existence of a wide variety of auctions. From the order's point of view each order is allowed to exist in exactly one auction. Due to this the mentioned asymmetric/symmetric case and the problems of stringent and non-stringent interaction phases are irrelevant. The auctions in the AuctionBot are independent; the interface and the core auction procedures are separated.

MARI (Tewari and Maes, 2000) and GEM (Reich and Ben-Shaul, 1998) have a different research focus, supporting multi-attributive orders (MARI) and an individual design of the market model (GEM). The aspects of the problematic arising from the simultaneous existence of one single order in multiple markets do not appear both in MARI and in GEM at all.

5. CONCLUSIONS

In this paper we illustrate the idea of cDMM and we give the following descriptive definition for it:

A market model is called *cascading dynamic* if it meets at least one of these characteristics:

- An investor can define a market sequence for each individual order. In this sequence market models can be passed through successively or an order can be available for trading in several markets at the same time (parallel existence).
- A market designer can define a market model, which can consist of other market models in a parallel and/or sequential succession.

Furthermore, we illustrate difficulties appearing during the parallel existence of orders in two or more markets. The first difficulty is the asymmetric and symmetric deadlock situations when an order A is matched in two markets M1 and M2 at the same time. The second difficulty is the order allocation problem during the asynchronous and synchronous phase transitions. We show that these problems depend on the particular market phases and on the market rules. For this purpose we differentiate between stringent and non-stringent phases and we define that in a non-stringent phase the market rules permit to withdraw orders whereas in stringent phases withdrawal is not possible. Consequently, both the symmetric and asymmetric deadlock is solved. For the asynchronous phase transition problem we propose a solution. From a theoretic point of view the synchronous phase transition problem remains unsolved. In practice this case seems to be solvable as simultaneity does not exist within one electronic system.

In our future we focus on economical and technical questions of market engineering. Primarily, we want to examine the effects of cDMM on the quality of markets: quality of price, market fragmentation, consolidation of order flow, split of liquidity, information and decision support systems for investors. The basis for further examination is a generic electronic trading platform, which fulfils the requirements of a cDMM. This platform is currently designed and implemented

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