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RESEARCH ARTICLE

The development of an online supply chain simulation game (SCSG)

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Abstract

The potentialities implied in the web surface version of the supply chain simulation game, presentation of the planned functions. Designing the database serving as basis for the programme, the connection between core data and communication, the process of transactions. Showcasing the preliminary surface plans, the correlation between creating the surfaces and human errors. Various mathematical methods and solutions necessary for the realisation of more advanced functions.

Keywords

supply chain simulation · web-based realisation · optimization methods

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1 The supply chain simulation game

In the spring term of the school year 2009/2010 a supply chain simulation game (SCSG) took place at the Department of Transportation Technology of the Faculty of Transportation Engineering at the Budapest University of Technology and Economics, with the supervision of the teachers of the Department of Transportation Technology and the participation of students of logistics (students of both the BSc and the traditional five-year programme). The game had double objective: one was to allow the students to test their theoretical knowledge in practice with the help of a simulation environment; the other was to gain experience of operation necessary for the future development of the game [1] . This version of SCSG ran through an FTP server and Excel files [2].

The competition work prepared for the Students' Scholarly Circle Conference (SSCC) and the grant obtained from the Innovative Research in Logistics Youth Programme at the Department of Transportation Technology serve as basis for the further development of the supply chain simulation game.

2 The possibilities implied in the development

During the game, it occurred to the participants that the simulation can and must be developed further, so that the developers and the students can gain all the more useful experiences in their professional lives with the new version of the game. The problem tree of the experiences of the developers occurring during the game can be seen in Fig. 1.

After gathering and discussing the ideas of the students participating in the development, the possibilities of realisation began to take shape, whose infinite run contains the following important and useful examples listed below.

The placement of the orders, the transportation of the virtual items, the financial transactions will take place safely, without loss of data or damages in the future programme but at the same time the programme surface shall be easily manageable. The programme needs to be able to handle the partial completions as well.

The programme shall be able to defend the user against the possible human, typing errors and the erronous data entry.

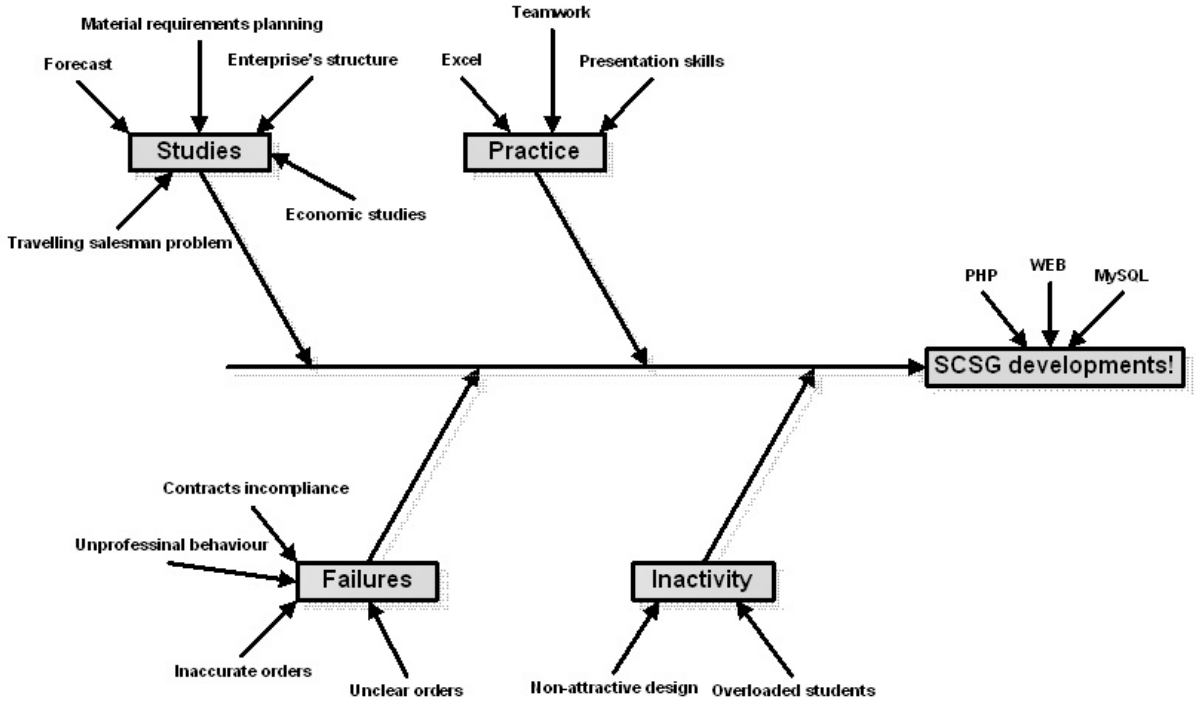

Fig. 1. Summary of experiences in a problem tree

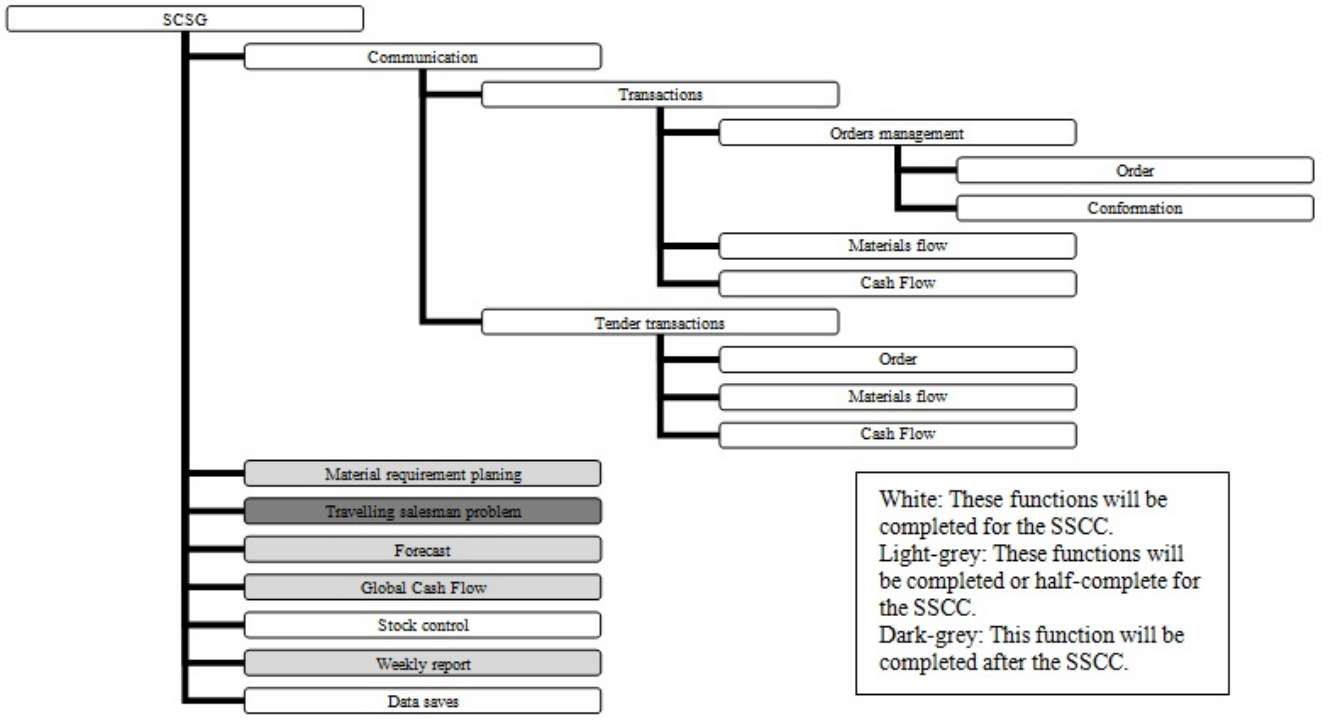

Fig. 2. Structure of SCSG, with details of communication

Transactions are to be started only if correct data are provided. These include for instance the data of the customer and the carrier, and the date of completion that need to be filled in mandatorily and correctly, so that the transaction could take place.

It is important for the producing companies how long it takes to produce the ordered products and that the orders could be executed in time, by the agreed deadline. On the basis of the given production parameters the programme calculates the time needed for production and shares it with the student. The manufacturing takes place in the programme, in the communicated timeslot. Fair competition is protected by this, should the players take unmanageable pledges.

According to the FTP game's rules, a company is allowed to start or complete only one type of transaction only once a day

towards another company. With regard to this, the programme needs to be able to recognize if a given type of transaction has been started during the day, if so, then it should not permit a new one.

The traders need to use their own vehicle fleet to deliver the orders; they need to organize them into route and to optimize them according to their own demands, which happens at their own discretion. The process of optimization might play an important role to keep the deadlines agreed with the retailers. Students can rely on their knowledge based on previously accomplished subjects, what is more, that is the only way of completing the task.

The submission of weekly reports can be checked in more than one way. It can simply be their existence or if they were submitted in time, or in a more complicated way their contents can also be checked, meaning whether the submitted data match the reality of the simulation. In the latter case, the programme not only needs to store the data of a given transaction or product but it needs to summarize and process them. This increases the level of intricacy of the programme but it is also a possibility of feedback for the companies. It has cropped up that the administrators can be given the possibility to punish the possible late submissions and errors, a means of which can be a fine to be paid.

If the programme, as listed above, keeps track of the companies' operations continuously, the players can be aided by information about the quantity of their prevailing utilizable capital. This would give them a quick feedback regarding the correctness or incorrectness of their decisions.

The programme would imply the possibility of providing the students, in numerical data or in the form of a diagram, with various trend lines and curves in order to help them with forecasting their demands. The forecasts could also be 'purchased', increasing the competition.

Another possibility and aid would be, with relation to forecasts, a stockpiling strategic module, which could help or even automate determining the appropriate stocks and safety inventory. This could also be purchased, as a sort of services.

For the students it would be important to save and download the data arising from the game and to use them in their own self-created resource planning. It would also be important to make their own forecasts and analyses, to keep track of their stocks and finances, if they cannot do so in the programme. The outcome of the query needs to be a well-structured set of data in a widely applicable file format.

The game can include automated penalties, so that the players are encouraged to compete with honour. Such cases would be late or incorrect executions, unpaid entries or the above mentioned late and incorrect submissions of the weekly reports. Setting these penalties would be the task of the administrators at the beginning of the game, thus enabling them to encourage and control the students.

It is worthwhile to authorize the administrators with setting options as wide as possible, in order to adjust the programme to the prevailing educational objectives. The two types of settings are the various aids and penalties.

The administrators' tools to influence the simulation are not only the setting of aids and penalties, but also their possible ability to affect the ongoing transactions. Pirate attack on a shipment, unexpected situation of danger during deliveries or a strike at the manufacturers make the illusion all the more lifelike and bring it closer to reality with the unexpected and unpredictable problems.

The main objective of the web-based version of the programme is to overcome the above listed problems originating from human errors by the structure of the programme itself. In completing the professional assignments the task is not the complete resolution of the individual problems, but to provide the students with such partial solutions that could increase the quality of the solution of the entire problem, and thus helping them gain invaluable experiences.

Advancement from the FTP version was planned by all means in a web-based version. Because of the workload and the necessary time, the primary objective is that the communication module of this new version would be finished by the SSCC in November, which could serve as substitute for the exchange of data working through FTP, based on exchange of files. In addition, the programme is to be added some other functions as well, as it is marked by the different colours in Fig. 2. Communication is of high importance because its reliable operation is essential for completing the other tasks. Communication will include multiple user surfaces, keeping the work of the teams and the supervisors and operators of the game well separated.

3 Designing the database

The next step in creating our programme was to design and create the database. The developers paid extra amount of attention that the database would be flexibly adjustable for coping with the problems occurring during the creation of the programme. The database stores separately the teams (meaning both ends of the supply chain), the individual materials (their respective 'types' are also known) and their prices per each team, the orders and the various entries belonging to the orders and the current and daily opening stockpile. The current stockpile can be of relevance for the management of the company (also for students controlling themselves by comparing the stockpile with the one in their own enterprise resource planning), while the daily stockpile is the outcome of a query run automatically, which gives us information on the teams' stockpiles and could provide relevant data for further researches. The boards can be divided into 2 main groups: core data and data needed for communication. The relation between these can be seen in Fig. 3.

The communicational operation is shown by a simplified flow chart, as can be seen in Fig. 4 below.

In the pattern of the basic structure, certain boards need to be doubled for the tender but in that case also uploading the data

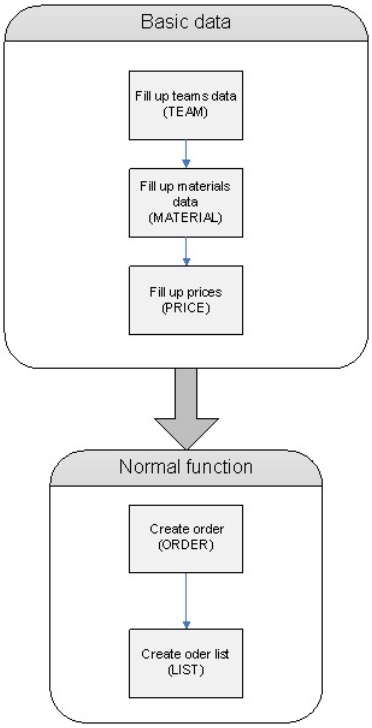

Fig. 3. The relation between core data and data needed for communication

and maintaining the relations are to be executed as is demonstrated above. For the database's relationship diagram see Fig. 5.

Fundamental aims of our development:

- Stable, user-friendly structure of the programme, easy handling of the transactions,
- Compliance with the rules of executing transactions (one (partial) transaction of one type per day)
- Export of data.

The programme is currently under development, the model of the database that serves as basis for the whole system is completed, at the moment we write the test version of the programme. After this is finished, the next step will be the circumstantial testing with regard to all details, on the basis of which correcting the errors will take place in the end.

4 Showcasing the preliminary surface plans

The simple surface plans being showcased now are merely aiding tools, so that they could help us in constructing the database and writing the test version. The visual representation of the user surfaces and the tools and functions belonging to them is intended to serve the easier recognition of the system's correlations.

The players' and the operators' surfaces: the designed number of surfaces and their functions are not subject to change, since this part of the game is well defined by the rules; a login surface can be watched in Fig. 6.

On the surface of the traders' we would like to present two examples: placing the orders towards the manufacturers, and listing the open orders.

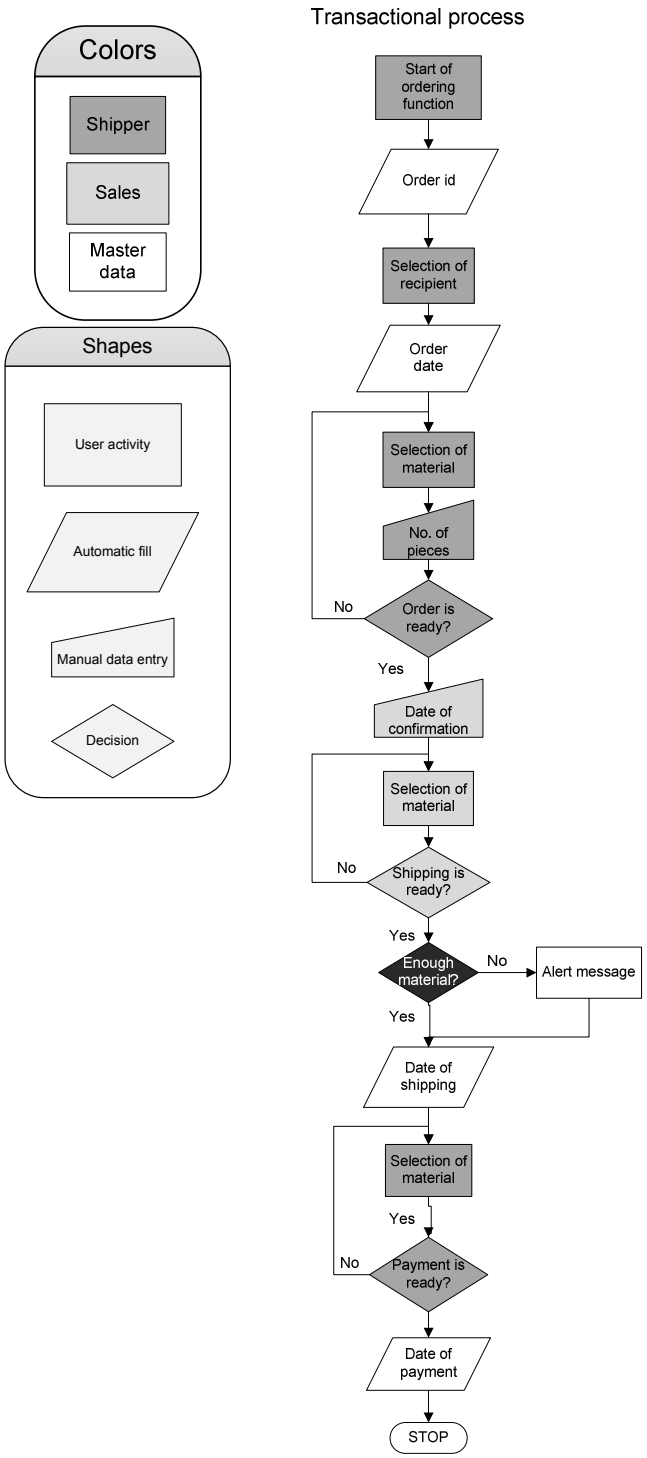

Fig. 4. Processes of transactions

As can be seen in Fig. 7, in the case of orders towards the manufacturers, the user needs to select the parameters from a list, only the quantity needs to be manually typed, the price per piece and the total amount are calculated automatically by the system. Selecting the parameters from a list is necessary because it disables typing mistakes and if parameters are omitted, orders cannot be placed. This logic is being preferred with other surfaces of the programme.

We are able to execute the payments towards the manufactur-

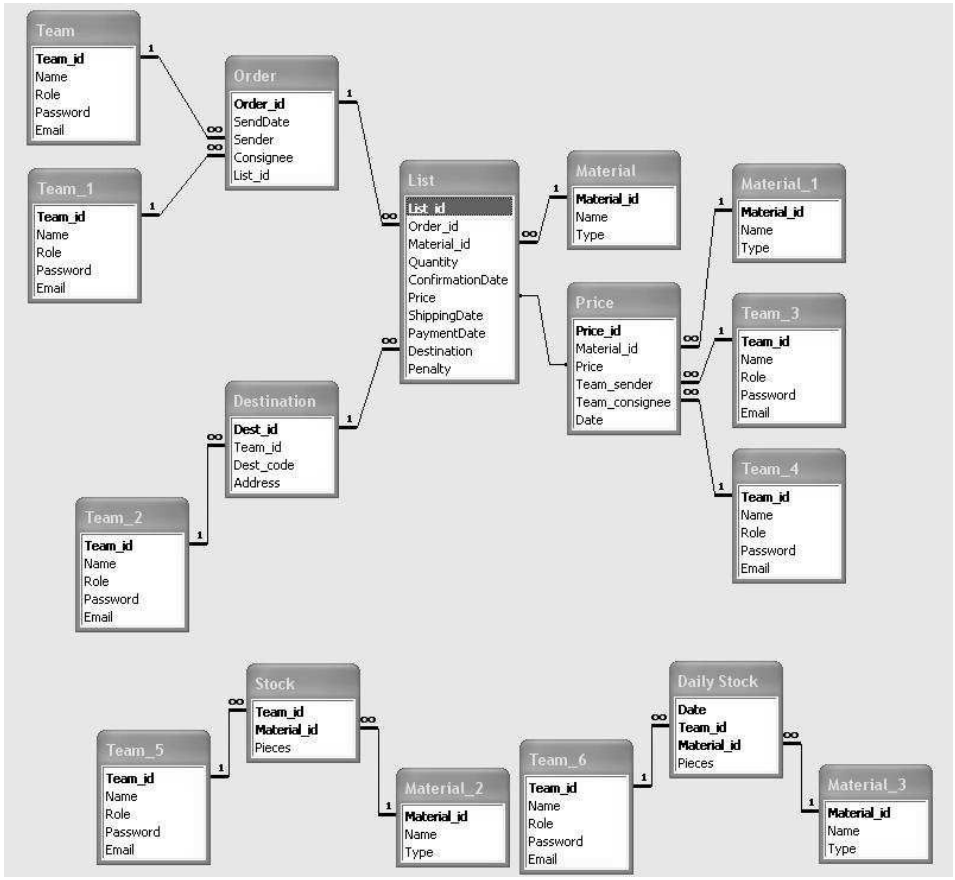

Fig. 5. Relationship of Database diagram

Fig. 6. Login surface

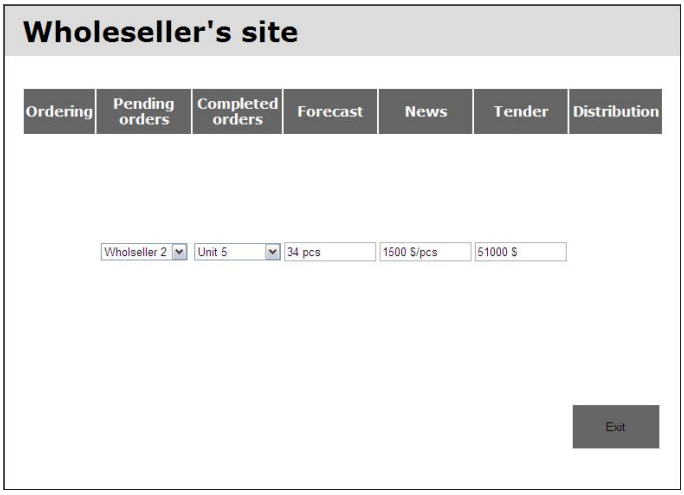

Fig. 7. Trader's surface

ers in the window of open orders. The characteristic features of the orders will be accurately indicated, so that the players will have up-to-date information at hand about the processes of the company.

5 Further directions of development

After the completion of communication, we also aim to realise the modules marked by colours other than light-grey in Fig. 2. Our plans to accomplish the production-plan system, the travelling salesman problem and the forecast are as follows:

The issue of travelling salesman problem can be solved in more than one way. Among these we can find methods providing approximating and exact results.

1 Approximating result can be gained for example by the Dacey-Vogel algorithm, in which the starting point data is a distance matrix. According to the method, we define the edge with the smallest resistance on the rows and columns of the matrix and delete the defined elements. We continue these steps until we get the shortest route.

2 Much more accurate results are provided by the artificial ant colony systems [3]. In the beginning the 'ants' embark randomly in a virtual graph to seek food. Once they find it, they leave traces (pheromones) behind heading back to the anthill on the edges of the graph, logically more along the shorter route. During the next food-seeking they are more likely to choose the path leading to the better food-source with the help of the previously left behind pheromone traces. Finally choosing those edges where the most of the special scent can be found will give the optimal (the shortest, leading to the best food-source) route. Communication via pheromone traces is one of the key elements that allows for, for instance, quick and efficient execution of optimum search during vehicle routing problems [4],[8].

The forecast, meaning the forecast of the demands, can be carried out in multiple ways. The procedures for this have 2 groups, the SOFT and the HARD processes [7].

1 The applicable SOFT processes' mathematical background is relatively simpler, therefore they are less accurate. The applicable processes are as follows (accuracy increases towards the bottom of the list):

(a) Methods of average:
- Moving average
- Weighted moving average

(b) Smoothing methods:
- Primary exponentional smoothing
- Quadratic exponentional smoothing
- HOLT method
- Winter method

(c) Methods of regression:
- Linear regression
- Power functions
- Exponential regression
- Logarithmic regression
- Hypergeometric regression
- S-regression

2 In the HARD processes complicated mathematical and statistical methodologies are applied, which usually have the higher chance to be able to execute a more precise forecast. Such model is the ARIMA (autoregressive integrated moving average) and its development called SARIMA (seasonal autoregressive integrated moving average) [5], [6].

We will prepare for the students a surface which handles the changes of stockpiles automatically. In order to make it possible, an application based on the system of MRP will be developed.

6 Summary

In the process of developing the SCSG we arrived recently to the point when the designing of the programme's structure and its surfaces is underway. The database is completed, but as we already mentioned, it is subject to change depending on the programming's needs. There is still a lot of work to do with writing and testing the programme but we intend to present a steadily working system to the judges at the SSCC. With further developments we approach our long-term goals, namely to produce a programme that enables the players to become familiar with a complex system similar to the enterprise resource planning used in real life, and, at the same time, that it could be used for conducting researches and experiments. Our middle-term aim is that the students and teachers could receive an useful programme in the coming term.

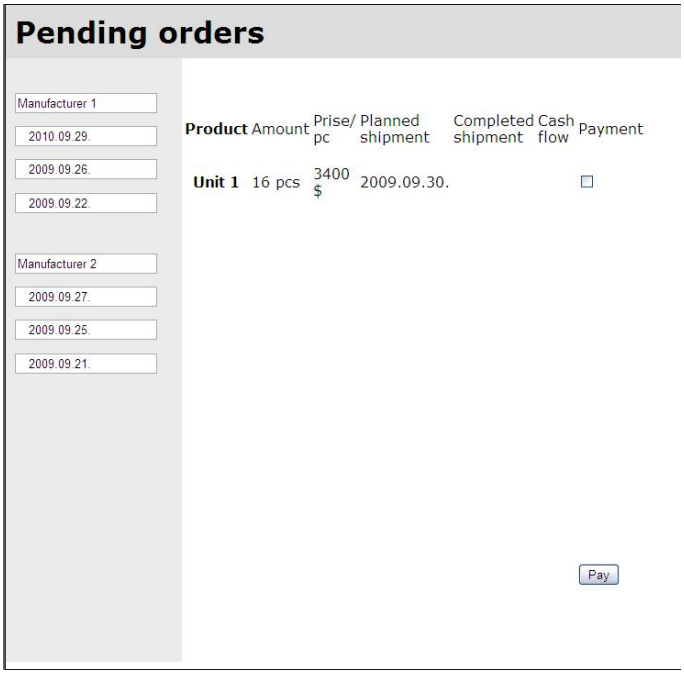

Fig. 8. Further directions of development

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