ABSTRACT
In Enterprise Information Systems, users are facing complex user interfaces with a multitude of functionalities. These interfaces still rely on the WIMP-paradigm including forms, tables and dashboards, which are meant to be used with mouse and keyboard. This contribution argues that there is a gap between the increased process complexity and the traditional concepts in visualization and interaction. In this paper, an exemplary scenario addresses these challenges by exploiting tangible interaction on a tabletop system.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – graphical user interfaces, interaction styles, user centered design, input devices and strategies

General Terms
Design, Human Factors

Keywords
Enterprise applications, production planning and scheduling, user interface design, tangible interaction, multi-touch, tabletop system

1. INTRODUCTION
In current enterprise applications, a steadily increasing amount of data with close interdependencies is generated. In contrast to numerous developments in technology and functionality, progress concerning human-computer-interaction in the area of enterprise applications and especially production domains is insufficient. Concerning the increased process complexity, users have to tackle challenging tasks by dealing with these applications. Within the last years, user interface design principles in the field of enterprise applications have not been subjected to research sufficiently. The term user satisfaction is rather limited to the participation of users in the implementation process, Top Management Support, Self-efficacy or perceived usefulness of the system [6].

While multi-touch devices and corresponding interface concepts are widespread in other domains, enterprise applications – especially in the upper levels of automation – are still dealing with interfaces that consist of forms, tables and dashboards and are meant to be controlled with mouse and keyboard (e.g. SAP R/3 UI- History in [9]).

This Innovation Gap in visualization as well as interaction is contradictory to the increased complexity that users are facing in the production domain and which demands for advanced user capabilities in handling this complexity. Hence, users are forced to focus on interaction problems rather than fulfilling their actual tasks. Problems mainly occur in the identification of the correct functionality and its subsequent access or in handling the overall system complexity [11]. This results in tedious and costly trainings and often frustrated users.

On the one hand, this contribution emphasizes the gap between the user interface problems in the field of enterprise applications and the promising potentials offered by innovative multi-touch approaches in entertainment and collaboration. On the other hand, a concrete solution is proposed which empowers users to control their Manufacturing Execution System (MES) and Advanced Planning and Scheduling (APS) workflows in an intuitive way.

This contribution argues a significant gap in the field of enterprise applications between complex business and production processes on the one hand and traditional visualization and interaction techniques on the other hand. By the adaption and application of promising paradigms known from other domains, the authors present a prototypical application that bridges this gap. First motivated by insufficient research concerning the user interface of a broad range of enterprise applications, the presented concept finally focuses on a production planning and scheduling solution. The subsequent chapter on related work reveals that little research is available which addresses the deficiencies mentioned in this contribution. For an adequate comparison between the conventional production planning procedure and the suggested approach, a short introduction to the standard workflow is given. In the following sections, the novel concept is explained in more detail with focus on the tangible objects and their handling. These radial controls allow the user to adjust parameters intuitively throughout the whole application. After having introduced the set of tools, the adapted workflow and its contained screens are presented. Especially the manual scheduling functionalities in an interactive visualization (see Figure 3) promise a significant benefit compared to the standard approach. Finally, the handling of conflict situations during process translations is discussed.
2. RELATED WORK
Multi-touch interfaces or touch screens in general have been initially introduced on the machine control level. However, due to their amenities, they are getting more and more popular in the middle tiers as well. Nevertheless, available solutions are often specialized for distinct purposes and do not exhaust their full potentials or are in an early stadium [8, 10]. Hence, related work specifically dealing with multi-touch or tangible interaction in the field of enterprise applications can be rarely found. In the following, relevant approaches from related fields are discussed.

Tabletop systems are mainly used in business applications at the point of sale or point of information. Games and entertainment is another obvious field in which tabletops are used today. However, more serious application areas like outage scenarios [4] or disaster control management [7] are being investigated by researchers. The spontaneous usage of such multi-touch systems for a group of people with diverse backgrounds is a great potential. The interface can be designed to be easily learned, exploiting the joy of use which stems from the direct interaction with digital content. Moreover, the communication of people at a multi-touch table is supported, allowing the interaction of multiple users with digital content.

The research project Mind Map APS [5] assumed an upcoming fundamental change in the handling of enterprise applications within the next years. Therefore, the three aspects Search Engine based System Access, Interactive Business Process Modeling and Zoomable User Interface Design were taken into account to investigate their potentials. As a primary goal, users should be able to interact with the system more intuitively through map-based, interactive and scalable process visualizations. Although the estimated breakthrough could not be fully achieved, several prototypes were conceived which deal with 3D-visualizations in oil industry, mobile process assistance for healthcare scenarios or semantic search paradigms to ease the user’s system access. Despite the innovative approaches for enterprise applications, multi-touch or tangible interaction has not been part of the considerations so far.

In the field of factory planning and production optimization, the Fraunhofer Institute for Manufacturing Engineering and Automation proposed a concept utilizing a tabletop system in a multi-user scenario [1]. It aims to assist operators, architects and logistic experts in their interdisciplinary factory planning workflow. Three-dimensional visualizations of the prospective factory can be manipulated using standard gestures like scaling, rotating or translating. However, the application is focused on factory planning and layout optimization.

Kammer et al. investigated novel tools and paradigms that are beyond established manipulation gestures for multi-touch surfaces [3]. In their contribution, five levels of manipulation in multi-touch interactions are introduced, which reach from simple manipulation gestures constrained by grids up to rich semantic gestures. In addition, the aspect of multi-user collaboration is taken into account. With the help of several case studies, the authors point out the benefits of multi-touch and tangible interaction for presentation and entertainment purposes. Nevertheless, investigations related to the potentials of the introduced concepts in the scope of enterprise applications are missing.

3. USAGE SCENARIO
Nowadays, production planning is customarily based on Excel-sheets supported by planning and simulation tools that are limited to textual or diagram output [2]. Some tools visualize the planned tasks as a Gantt-Chart, but direct interaction is not supported. In the following, a user’s routine production planning workflow is described, which basically consists of two steps: planning of upcoming processes with the help of optimization algorithms and the handling of deviations and interruptions during runtime.

In a first step, process orders have to be planned considering available machines, their features, set-up times, buffers or material and time restrictions. For this purpose, the user enters the textual parameters into a form via mouse and keyboard. Afterwards, powerful optimization algorithms aid the user in accomplishing his task and finally recommend the most suitable schedule for the problem in a textual or visual way (e.g. Gantt-chart). The algorithm’s parameters (especially optimization goals) are either related to a distinct machine, a tool group or even the whole factory.

In a second step – during the operational phase – users are occasionally forced to react on events that might lead to deviations from the production schedule (e.g. priority changes, maintenance or breakdown). Once such an event occurs or impends to occur, processes have to be rescheduled manually by the user. Such interferences cover time shifts or machine shifts and require the recalculation of the now obsolete schedule. The user therefore has to switch back to the input screen, perform the necessary changes and initiate the planning and scheduling algorithm again.

In addition to the conventional workflow described above, the presented application uses three steps to cover the necessary views and functionalities: Parameter Input to setup the subsequent optimization algorithm, Iterative Result Presentation to observe the iterative output of the algorithm step by step and the final Result Presentation & Manual Scheduling screen.

4. CONCEPT
The suggested user interface is based on a topological floor plan (bird's eye view on the map) that depicts the machines at their topological positions instead of the conventional textual presentation (see Figure 1).

Figure 1. User interface of the application consisting of: (1) floor plan with machines and tool groups, (2) step-specific panel (here: Gantt-Chart), (3) dialog control, (4) progress bar, (5) visualization options, (6) tangible, (7) material flow
The machines have incoming and outgoing connections among each other to visualize the material flows relative to the underlying manufacturing process. Current and upcoming tasks for selected machines are visualized in interactive Gantt-charts. On top of these views and in addition to standard touch gestures, tangible objects are used for selection and adjustment tasks.

4.1 Step 1: Parameter Inputs
In order to create a new production schedule, optimization goals have to be defined. These serve as restrictions and influence the optimization algorithm. For the selection of a machine and the assignment of parameters, a physical object is provided. The user places this tangible onto the selected machine in order to activate a corresponding ring widget (see Figure 2). It consists of two parts: a composite circular ring illustrating the influence of the weighted parameters and the parameters themselves arranged at the outer ring in form of a pie chart. The control allows the user to adjust the parameters from full to no influence continuously. Furthermore, this approach enables the user to model a well-balanced and sophisticated optimization goal for each machine and allows for subsequent optimization algorithms.

In the first version, the user can increase or decrease the influence of the parameter by simply sliding it to the center or in opposite direction (see Figure 2 left). The corresponding segment of the circle increases or decreases relative to its part in the whole parameter composition. The second version uses handles to adjust a parameters influence. The handles control corresponding splitters between two proximate parts of the ring. In contrast to the first variant, an adjustment of a single splitter affects only two parameters simultaneously. Finally, both controls allow the user to adjust the parameters from full to no influence continuously. Figure 2 shows the adjustment of parameters as described before.

4.2 Step 2: Iterative Result Presentation
The second screen is informative and conveys an impression of the optimization progress to the user. It illustrates the partial calculation results with the help of a line chart in the lower part of the screen (step-specific panel). Each time the iterative algorithm generates a result, another node is added to the curve according to the timeline (x-axis) and the overall optimization goal (y-axis). Hence, the user can observe the approximation towards the ideal result and skip the calculation if the current value is acceptable or abort if the progress is not satisfying.

4.3 Step 3: Handling Deviations
Once the schedule is in use and an irregular event occurs that needs to be treated by the user manually, two machines for process shifting are selected. Therefore, two tangibles are used which act as indicators for source and destination. A first tangible is placed onto the affected machine whereupon the corresponding Gantt-Chart appears. In addition to their machine selection functionality, the tangibles are also used to select the visible time slot of each Gantt-Chart. By simply rotating the tangible, the user selects the desired time period. Afterwards, the second tangible is placed onto an alternative machine, whose Gantt-Chart also appears and acts as destination for process movements. Hence, process movements regarding time and between machines can be easily achieved by simply dragging a process’ visual representative (see Figure 3).

Equipped with a floor plan for machinery overview, Gantt-Charts for allocation details and tangibles for intuitive interaction, users have the tools at hand to react on interruptions efficiently. A major challenge in the conception of such an interaction design is the visualization of consequences. If the user drags a process object from one machine to another, he needs all the relevant information about this action’s side effects immediately. The user’s increased awareness of the impacts is a crucial prerequisite for subsequent and expedient planning decisions. To prevent the user from constructing inconsistent states, the application supports the user by indicating conflicts. The system distinguishes between the conflict situations Machine qualification, Process already started and Translation before now. The proposed conflict visualizations for each situation and a short conflict description are listed below:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine qualification</td>
<td>If a process cannot be treated by a machine because of missing functionalities, the user is not allowed to assign the process to that machine. Once the user tries to assign the process (yellow), the machine’s Gantt-Chart turns red.</td>
</tr>
<tr>
<td>Process already started</td>
<td>Processes whose beginnings are in the past cannot be moved. Once the user tries to drag that process, it does not move and a red icon appears.</td>
</tr>
<tr>
<td>Translation before now</td>
<td>To keep planning and execution synchronous, changes in the past are not possible at all. If the user tries to move processes, the area representing the past turns red. The earliest possible point for process placement is the right edge of that area.</td>
</tr>
</tbody>
</table>
5. SUMMARY
This paper indicates the potentials of innovative user interaction and appropriate visualizations in the field of production planning. Both branches – production planning algorithms as well as entertainment and communication technologies – have reached a certain maturity level, but the conjunction is still at its beginning. If a fundamental paradigm shift in the usage of enterprise applications is approaching is hard to predict. Nevertheless, the assumed benefits of the introduced concept cover:
- Visual iterative result presentation with the possibility to abort or skip ahead of time
- Interactive visualizations allowing manual scheduling in Gantt-Charts
- Tangible Interaction for simultaneous selection of objects and adjustment of parameters
- Topological object placement instead of tables with textual attributes
- Strong visual correlation between topological and temporal information

6. FUTURE WORK
The application presented in this contribution is still in a prototypical status. Hence, comprehensive user studies have to investigate the real potentials in comparison to conventional approaches that are using standard interaction and visualizations techniques. According to these study results in the mentioned branch of production planning, related application areas should be investigated that are dealing with similar entities and workflows. Promising scenarios might be found in the upper levels of automation (e.g. ERP-systems) or in healthcare scenarios. The latter is characterized by similar applications and processes but has special requirements due to a lower planning reliability.

The introduced Gantt-Chart seems to be a promising combination of a traditional view and touch-enabled user interaction. In further scenarios it might be useful to scale processes in time, assign additional processes to a machine or insert new machines into an existing material flow. Therefore, the user could use simple gestures as illustrated in Figure 4.

7. ACKNOWLEDGMENTS
Christian Lambeck thanks the European Union and the Free State of Saxony, Germany for funding this work as part of his doctoral studies. Dietrich Kammer, Pascal Weyprecht and Rainer Groh received funding by the Federal Ministry of Education and Research (Project VALABI, VIP 18).

8. REFERENCES