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INTEGRATION OF SIMULATION, CAD SYSTEMS AND DATABASE IN THE DESIGN OF PRODUCTION SYSTEMS

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ABSTRACT

Nowadays there is great pressure on production systems design to be developed rapidly and efficiently. For these purposes several software tools have been used – mainly for project analysis, design and validation. Nevertheless, these tools have been used with low integration levels, including absence of data coherence, and lack of layout optimization.
This work deals with production systems design, and more specifically, with the integration of commonly used software tools into unified system architecture.
The paper identifies a variety of tools, describing their functions and principles of integration. It also addresses the way this integration enables automatic generation of simulation models and different patterns of production layouts. A short application example, based on a cement production factory, is presented. This example permits a complete comprehension of both integration of data and automatic generation of programs. Advantages and disadvantages of the suggested approach are discussed.

INTRODUCTION

The *production systems design* is a process of managing technical and organizational alternative solutions in order to configure system elements with respect to optimal usage of all resources (i.e. material, energy, space, equipment – including material handling facilities, and workers) in *internal logistics* processes. These alternative solutions deal with spatial layout and with dynamic time changes (Muther, 1970,Zelenka 1995;). The aim is to design a network of resources, where each node of the network must be located in the best possible position regardless the presence of multiple objectives (Taylor, 2008).

Generally it is possible to divide the software tools used in *production systems design*, into four groups:

- **Databases** for data analysis, data storage, data mining (e.g. Product/Quantity (PQ) analysis - *for selecting production approaches*, cluster analysis – for *designing of manufacturing cells*, etc.). Most common database systems are MS Access, MS Excel, SAP, etc.;
- **CAD systems** for graphic designs, verification of spatial layout alternatives (generic tools, e.g. AUTOCAD, SOLID WORKS, MICROSTATION or specific software tools focused into layout design like FACTORYCAD, MATPLAN or FASTDESIGN) (Markt, 1997);
- **Discrete event simulation systems** for verification of scenarios with time changes (WITNESS, ARENA, SIMUL8, SIMPRO, etc.) (Dias et.al, 2007) (Mecklenburg, 2001; Moorthy, 1999);
- **Visual systems** for 2D, 3D animation or virtual reality for improved understanding and illustration of suggested principles (Power Point, MS Visio, 3DS MAX, BLENDER, MAYA or modules of virtual reality included in simulation tools like VR WITNESS or 3D ARENA PLAYER).

We have identified the following fundamental drawbacks associated with the use of non-integrated or low-integrated software tools:

- Absence of data-flow between programs;
- Existence of several independent data-sources (originating incoherencies);
- Absence of feedbacks (necessary for the registration of changes suggested during the design process);
- Lack of support for the phase of evaluating different solutions and choosing the optimal one.

The absence of automatic data-flow causes time delays in the design process, duplication of work and could also be the source of significant errors.

The idea of integration is not new. There are several software tools used in the area of logistics and production systems design that deal with some kind of integration, at different levels (Moorthy, 1999; Mecklenburg, 2001; Havlík, 2005; Vik, 2009).

There is still not some similar solution in the market for small and middle sized factories with integration approach and with functions focused on these kinds of factories and production problems. This represents a great opportunity to concentrate our effort and focus on

the conceptualization and creation of a simple to use integrated system, capitalizing in commonly used industry tool, identifying clearly and incorporating the minimum set of functionalities yet enough to cover the majority of significant problems in systems design.
In this context, the following most frequent barriers and challenges of the design process area are addressed (Taylor, 2008):

- Dimensioning of storage space and buffer capacity;
- Identification of optimal layout resources positioning;
- Analysis of material flows;
- Finding bottlenecks on production system;
- Designing of material handling systems (AGV, milk-run, conveyor, manual handling, etc.);
- Designing of aisles for material flows;
- Optimal resources utilizations;
- Considering of real constraints (current facilities, walls, pillars, ergonomics, etc.) – and solving re-layout problems;
- Designing of transport units (containers).

DESCRIPTION OF THE INTEGRATION APPROACH

Both approaches are based on "Systematic Layout Planning" developed by Muther (1973), but there are evident differences with respect to tools integration (Vik, 2008).

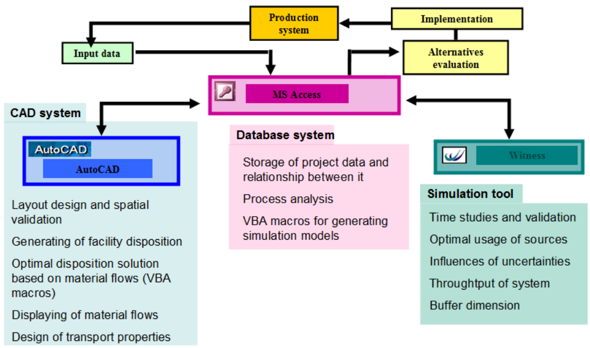

Figure 1 Most Common Functionalities of Each Integrated Tool

Three programs were chosen and integrated:

- **MS Access 2003** as relational database system
- **Witness Simulation tool** v. PwE 2.0 for discrete simulation (see Figure 2)
- **AutoCAD v. 2011** (CAD system for drawing of layouts - Figure 3).

For the integration and control of programs, Visual Basic for Application (VBA) was chosen as the programming language.

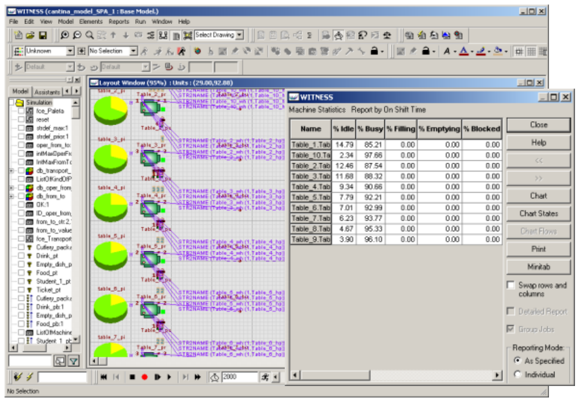

Figure 2 Illustration of Witness Simulation Model

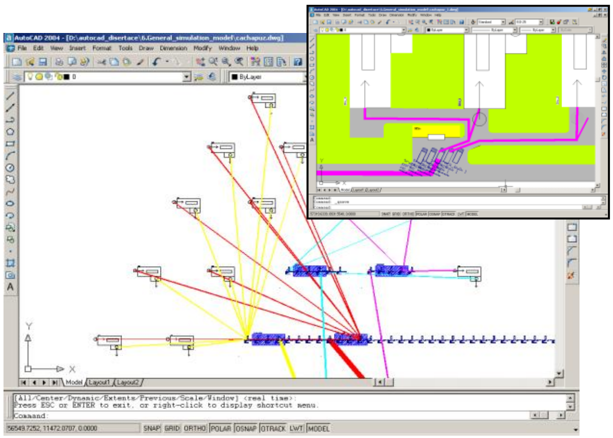

Figure 3 Illustration of Generated Layout with Material Flows

EXAMPLE OF USAGE

This section presents an example of the use of the integration approach for the purpose of a layout design focused on necessary sizes of parking space (capacity).
Figure 4 shows the complete set of tasks performed. Initial data are loaded into the database ❶. Then it is possible to automatically generate a Witness simulation model ❷ and experiment it ❸ a.
Obtained data (in this case mainly information about capacity of each parking place, resources utilization and total system throughput) ❹ are recorded into the database for further analysis ❺. It could be just the value (minimum, average, maximum) or overall time behavior of parking place capacity usage ❸ b. This information helps to determine optimal parking sizes.
Based on these results, CAD blocks are automatically inserted, representing trucks into unconstrained layout (*ideal layout*) and user can delete, replicate or move them accordingly to real limitations❻. After these eventual changes, the system automatically updates correspondent database values. Layout can also be changed according to spatial and other constraints (current production facilities, building limitations, suggested transport routes, etc.). This arranged layout

would be considered as the *real layout* ❼ . That layout information (coordinates of resources) is automatically loaded into the DB (facilities location and real material flows)❽ . Now, new designing iterations could be started with different and more realistic parameters❷. Alternatively, for example for designing better aisles, new iterations could be started at ❻ or ❼ . Then, the final solution is the result of all this effort ❾ .

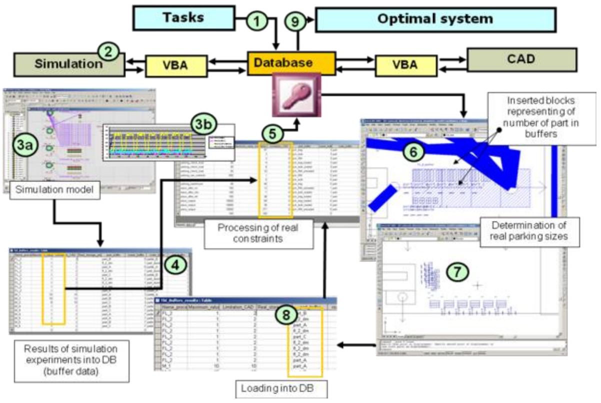

Figure 4 Schema of Steps for Integrated System Design

Figure 3 (right upper image) shows a final layout, focusing on the three silos and parking areas. This drawing has added manual changes over the object positions according to the real plant constraint (e.g. current buildings, roads) and actual capacity of trucks in parking position and also a CAD layout representing parking next to the silos.

CONCLUSIONS

The described solution integrates software tools used in production systems design into a unique system where all tools are connected by a database. The general aim of this work was to improve the process of production systems design, **removing redundant activities** and replacing "manual" work by automatic design phases - for example the automatic generated simulation model takes minutes in place of many hours if performed manually. The work integrates static and **dynamic layout optimization**, increasing business competitiveness while helping the design of flexible and **robust production systems**.

One of the major advantages of this solution is the usage of general engineering **wide-spread software** (MS-Access and AutoCAD) shortening the learning time and money investment.

However, this solution, in fact, deals with **only generic control logic** specification, so more complex systems can't be supported automatically. Due to the automatically generated simulation models, the **simulation computer run time** is higher and produces some useless output because it collects almost all possible statistical data. So, the user must still have some expertise selecting and **interpreting the simulation results**. Due to the absence of a standardized approach in the production systems specifications, the synchronization of data between enterprise databases and our project database is needed.

Future work will then be focused on using this integration approach for solving **other real production problems**, keeping our attention on improving some **functionalities** like using an improved automatic generator of spatial layout design, and also on improving user-friendly interfaces.

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