For more complex provisions with the need for dialogue about specific customisation, more centralised decision-making may be needed involving negotiation between managers at some level. Space management issues, like rebuilding projects and workplace design, could be typical examples.

But for decision-making related to strategic FM, it is important to create a close collaboration and alignment between the FM organisation and the core business to achieve the necessary business orientation. Such collaboration could take the form of a coalition managed by a forum of representatives from FM and the different parts of the company. In the case of conflicts and disagreements, the company board of directors could act as a steering committee. Other ways of organising such collaboration could be found. My main argument is that in the case of strategic FM a business orientation and a close relationship to the core business is necessary because decision-making needs to be on behalf of the corporation as a whole, taking into consideration its general interests.

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Event based simulations: enabling improved lifecycle and risk management of facilities

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Abstract

Dynamic economic appraisal in Real Estate normally regards changes in the environment of a system, but not in the behaviour i.e. the flexibility of a property or the behaviour of facilities management (FM) in the case of an event is not considered or plays a minor role.

In the research and development project «discreteFD» at the Swiss Federal Institute of Technology Zurich (ETH Zurich) methods and tools were developed in cooperation with the Swiss industry partners SUVA and redKG, which map system behaviour of facilities and facilities management across the life-cycle of a property. As a consequence risk management and the optimisation of real estate development concepts advance to a new level.

The project team translated alternative model mappings of the relevant components and behavioural patterns of the property during the life-cycle into Architecture-Spikes (test implementations) in order to immediately examine the effectiveness of the new concepts and life-cycle models for practice and to provide the opportunity to find the optimal software architecture for the problem defined. Subsequently the models were translated into software and verification and validation were carried out to examine the plausibility of the abstraction of a real system.

Empirical tests of the models and the software tools proved that the complex dynamic system facilities management can be evaluated more precisely via these tools and thus enormous optimisation potential for real estate development (RED) and facilities management can be achieved.

Keywords Discrete event simulations, lifecycle management, risk management

Introduction

Due to the increasing pace in which the general economic settings of cooperations change as well as individual life styles inflexible, poorly interpretable and badly managed properties as well as properties with high operating costs do not meet the changing needs of users or tenants any longer. The results of this development are observable in many cities. Properties are vacant, are renovated for alternative use at high costs or are demolished at an early stage of their life-cycle for redevelopment. Consequently neither the targeted return on capital is achieved nor a sustainable use.

Research at the ETH Zürich showed that institutional investors as well as users increasingly develop buildings which are flexible in their use over time. Within in the framework of the research and development project «discreteFD» funded by the Kommission für Technologie und Innovation (KTI) the ETH Zürich develops in cooperation with its partners SUVA[1] und redKG[2] new concepts of real estate development where the layout of the building is developed simultaneously with the respective facilities management concepts. As a result these concepts ensure successful long-term investments. Even though improved risk management and the taping of the market for service-enhanced properties represent the current

research objectives in real estate, so far adequate methods and tools to evaluate and estimate the risks of this new type of facilities as well as for the optimisation of building, use, financing and operation concepts are lacking i.e. to prepare facilities for a dynamic and complex future.

The objective of the project «discreteFD» was to understand current and future business models within real estate development, to find adequate abstractions for the application of simulations in lifecycle-oriented real estate development and to develop simulation tools for risk management and the optimisation of concepts.

Research- And Development Approach

Research at the ETH Zürich regarding Discrete Event Simulations (DES) relates to facilities developments[3] defined as the phase prior to the actual building planning and to projects where building, use, financing and operation is developed in an integrative way. It is based on the thesis that the adaptability of a building, its interpretation potential i.e. its fitness as well as the types of management within the operating phase and the property-related services are critical for sustainable property value and use. In the preliminary studies the concepts of facilities management are to be optimised regarding possible future events on which developer or operator have no bearing. This seems evident concerning owner-occupied properties (CREM) and public real estate (PREM), but also regarding letting and sales of properties to third parties the performance and adaptability of properties and services over time becomes more and more relevant, the more customers regard those aspects as significant and the legislator requires transparency e.g. in the form of a «building pass».

As «discreteFD» pursues business, simulation-related and information technology-related objectives methods and tools from business analysis and business modelling on the basis of software development were applied. Via the narrative forms of story telling from eXtreme Programming[4] the business processes of facilities development, the requirements of the business field and the expectations of the end-user were collected and defined.

In addition business data of the project partners and their customers were evaluated empirically in order to find influencing factors, which decide success or failure of facilities development (FD). From this a Meta model for FD was deducted representing the basis for test implementations and simulation software. With various test implementations and Architecture-Spikes[5] potential modelling types as well as technical solutions and software architecture were evaluated, yet again based on the methodology of eXtreme Programming. These test implementations perform single features (user stories) in order to answer the simulation questions e.g. the question of the optimal room mix of a hotel (single and double rooms) for an assumed demand.

For the translation of the simulation Meta model, in which the business processes were abstracted into software, transition diagrams and state charts were used; specifications of Unified Modelling Language (UML)[6].

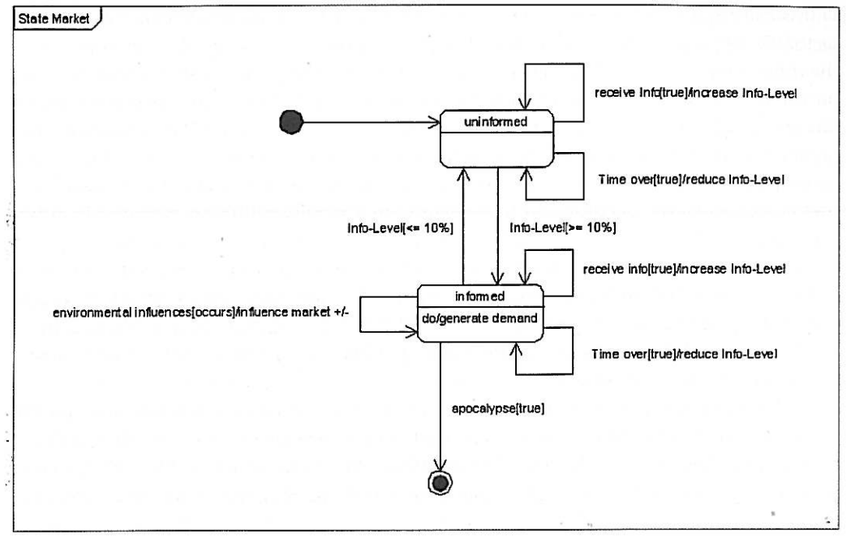

Figure 1: State chart of the marketing of facilities

The validation of the simulation Meta model and tests of the software through practical cases represent the last step of the project and are continuing.

State of the art simulations and risk management in the construction sector and FM

In some areas of civil engineering sporadically dynamic simulations were applied. Chahrour and Franz (Chahrour and Franz, 2004) specifically applied simulations from Logistics and Business Engineering in construction site organisation in order to determine the utilisation of specific equipment and their waiting time. At the 16. International Conference on the Application of Computer Science and Mathematics in Architecture and Civil Engineering in Weimar in 2003 Eichenauer, B. (IBE Simulation Engineering GmbH) and Scherer, K. (Fraunhofer-IMS and inHaus-Zentrum Duisburg) made a presentation on «Modelling and Simulations of Intelligent Building Systems with attributed Petri-Nets[7].» Literature research showed that whilst event simulations are applied in some areas of civil engineering, the application of simulations in real estate development represent a new phenomenon.

For an assessment of the profitability of an investment currently methods of dynamic investment analysis also known as Discounted Cash Flow or Net Present Value method are applied. With the help of spreadsheet analysis as for example Excel the future progression of the net present value as well as of the interest rate is projected. These methods are often referred to as dynamic calculations (Schulte und Allendorf, 2005), (Ropeter, 1998), (Schelkle, 2005) as through the inclusion of the interest payment for equity and dept capital the factor time. Strictly speaking these methods represent merely static simulations as they do not include a simulation clock and in the instance of conditions and event no changes in the system status occur. To our knowledge dynamic event simulations in real estate development and FM are up to now not applied.

As real estate development represents the business with the highest risks involved in the sector, the appropriate handling of risks is of vital importance. In real estate development at the time of investment neither reliable information on the expected costs are available, nor on the prospective return. In addition real estate development is confronted with unpredictable events which are not within the influence radius of the developer. Consequently the higher risk involved, on the one hand generates extremely high returns, but on the other hand the cooperation may get into a financial disorder in the case of a poor development of the project. However, decisions on investments are generally still taken subjectively rather than analytically.

Up to today only two publications on risk management in real estate development (Wiedenmann (2005) and Schelkle (2005)) are known. Real estate development as an academic discipline was first described in Bone-Winkel (1994) at the European Business School. Isenhöfer expanded this approach in 1999 in his publication on strategic management of real estate development companies.

Risk management in the real estate industry in general, but also which risks are typically involved in real estate development, were dealt with by several authors (et al. Brauer, 2003; Diederichs, 2006; Hellerforth, 2001; Vogler, 1998; Wüstefeld, 2000; Schulte, 2005; Maier, 2004; Ropeter, 1998). The options to manage those risks, though, were not examined or covered.

Research results

Analysis and Evaluation of Alternative Modelling Types and Simulation Tools

The first milestone of the project «discreteFD» was to examine whether the event based simulation is better suitable than other methods e.g. continuous simulations for mapping reality i.e. the lifecycles of facilities from a facilities development perspective. For that reason existent real estate development and properties in operation were analysed and test implementations of the mappings of the lifecycles of respective properties were developed and evaluated utilising various modelling methods and tools.

For the various test implementations different simulation methods and tools were used:

- Monte Carlo Method (MC)
- System Dynamics
- Petri-Nets
- Discrete Event Simulations (especially eM-Plant)
- Simulation package SimPy and the programming langugage Python as Excel-AddIn

The Monte Carlo simulation represents one of the most used simulation method and got its name from the world-famous casino. The method is particularly appropriate for the analysis of static problems including known probabilities. The Monte Carlo simulation represents a static simulation and does not cover dynamic situational or status changes.

System Dynamics represents a systems theory, based on the paradigm of information feedback as the behaviour-determining structural component. System Dynamics roots in the findings of cybernetics and applies continuous simulations in order to examine behaviour of non-linear models over time. This theory does not map results.

Petri Nets represent a modelling type which is very neutral in terms of application. It is able to model and analyse dynamic system behaviour. An event based simulation may be applied with a time-related Petri Net model. Various simulation tools are based on Petri Net theory e.g. PACE, Umberto, etc. For practical use higher-level Petri Nets are required for which no constituent notion exists. Higher-level Petri Nets are complex to develop and analyse.

The simulation software eM-Plant represents an integrated simulation system. The advantage of eM-Plant is the complex support of simulation projects. The user concentrates on mapping the relevant system components and not on programming. The efficiency of modelling with eM-Plant is generally higher as with other simulation languages, but the high costs for purchase and operation of the software represent a disadvantage. In addition there is a risk that the results are misinterpreted by inexperienced users. The simulation software partially includes its own programming language which must be acquired for efficient and professional use.

Expert interviews showed that facilities development is always based on assumptions of events for which probabilities concerning their certainty to happen are assumed. The empirical analysis of lifecycles demonstrated that the events or conditions which are considered to be certain to happen generate system behaviour which contributes significantly to success or failure of a project: customer behaviour, behaviour of FM, etc. The modification of properties tends to be volatile. The exact process between events is of minor interest i.e. discrete event based simulations, which jump over time from event to event and simulate discrete modification of the system status in relation to the event, are highly suitable to map the lifecycle of facilities appropriately.

In the project «discreteFD» not only the question which tools are the most appropriate for the simulation was raised, but also the question how the simulation tool developed is to be applied. The project partners e.g. the future users of the tool decided against a component simulator which would have enabled them to develop individual models, but decided in favour of a proprietary development of a parameter-based model where parameters are changeable.

Integration of System Behaviour in Economic Appraisal

As a result of the findings outlined distribution probabilities and system behaviour of simulations of lifecycle-related real estate development were included in the development of «discreteFD». Discrete event simulations (DES) were developed to provide a tool for new forms of real estate development and risk management for the industry project partners. The simulations implemented primarily generic features which are applicable within a wide range of projects.

The performance of facilities over the lifecycle i.e. the profitability for investors, operators and users, but also the eco-efficiency depend on a multitude of factors. The project «discreteFD» modelled and simulated those factors in variable and flexible form including the factor time, which were defined as relevant on the basis of data analysis and expert interviews and which have not been mapped before.

The life or durability of properties and building components, which has an important impact on the performance of facilities in connection with time, is not included in the simulation. «discreteFD» simulates on the level of building concepts.

Conceptual Model for Discrete Event Simulations of Facilities Development

The questions which are to be answered by the simulation tools were defined by the project partners as follows:

- Optimisation of the building layout e.g.: What is the best room mix for a hotel or how many conference rooms are necessary in a building?

- Management optimisation in development e.g.: What is the best point in time to inform the market, what are the letting terms?
- Optimisation of rooms and accommodation management of school buildings e.g.: What room mix in connection with which accommodation management is required for the most efficient use of the building during teaching hours?

On the basis of the questions defined a lifecycle of facilities was modelled from the perspective of facilities management and continuously evaluated by the project partners. Thus the system structure was developed and mapped in a conceptual model including the system processes, the individual components as well as their interrelations and impacts

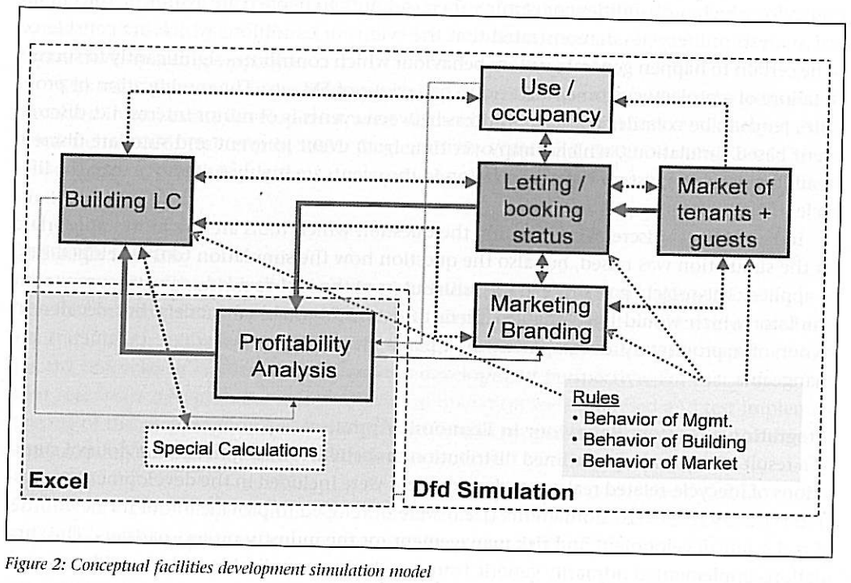

Figure 2: Conceptual facilities development simulation model

The conceptual model is divided into modules and classes respectively, which communicate via information (blue) and cash flows (green). The facilities in this model are presented in four categories and are able to adopt various statuses within those categories which maps reality closely:

- Building LC: the status of a building over the lifecycle of a property (from planning to use)
- Letting/booking status
- Marketing of the facilities
- Use/occupancy level: balance of the actual activities happening in the building

The cash desk (i.e. the profitability analysis) is required in order to value real estate development. Here the relevant key figures such as net present value are evaluated. Through the inclusion of existing valuation models in Excel, the users of the simulation are able to change the calculation modes in Excel.

Changes in the status of one entity class may cause status changes in others. Occupancy may inform lifecycle that the occupancy level has reached a defined threshold and consequently the property is to be used alternatively. In the case of an insufficient occupancy level e.g. the type of use of a building can be changed. If there is no more demand for hotel rooms, part of the building can be converted to offices or apartments. In the case of a high occupancy rate, an extension of the building or an alternative use of other parts of the building can be considered.

The modular structure supports the flexibility of the model. The fact that the lifecycle of a building needed to be implemented only once facilitated the transformation into a flexible model.

Implementation and Testing

In order to answer the questions outlined flexible models were developed from component simulators (eM-Plant) and open source modules (SimPy/Python), which then were validated and tested through existing projects from the hotel, retirement and nursing home and schooling sector. For illustration purposes the empirical findings are demonstrate in the following on the example of school buildings.

The questions determined which were to be answered by the simulation concerning this sector are related to optimal room number, room quality and strategic accommodation management. Firstly rooms were distinguished into rooms for general use and rooms for use for specific subjects such as Biology, Arts, etc. The room demand was assumed as identified i.e. a specific number of teaching hours for a specific number of classes must be catered for with accommodation. The accommodation principles varied as follows.

- Class room and subject specific class room principle i.e. Physics, Chemistry, Art, Music, Information Technology and Sport is taught in special rooms assigned for these purposes. Classes are exclusively assigned to a specific class room for general teaching.
- Class room principles apart from the subjects Chemistry and Sports i.e. only Chemistry and Sports are taught in specially equipped class rooms, all other subjects are taught in an exclusively assigned class room.
- Teachers' room principle i.e. teachers are assigned to specific room either via desk sharing or hoteling. Student/pupils change rooms when teachers vary within the schedule.
- Specific class room and course room principle: corresponds to option 1. Class room principle is substituted by course room principle.
- Course room principle for all subjects apart from Chemistry and Sports i.e. for all subjects apart from Chemistry and Sports teaching hours and classes can be assigned freely to rooms

At Bildungszentrum SeeCampus Niederlausitz an event based simulation was conducted for the forms 7. to 13. The results of the simulation show that when the class room and subject specific class room principle is no longer applied which usually represents general practice, 50% of the room capacity could be saved or made available other uses. Considering the fact that school buildings represent the largest segment within the public real estate portfolio, the economic and ecological potential of event based simulations in facilities management becomes evident.

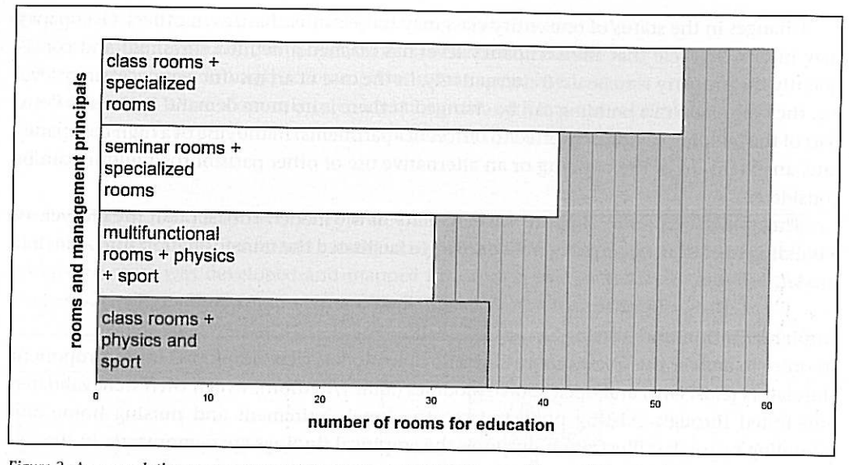

Figure 3: Accomondation management principles and accomondation need/demand illustrated by the example of a German school (Forms 7–13)

The continuous development of a software simulating lifecycle-oriented facilities management with a significantly increased user-friendliness compared to currently available tools through focussed user guidance while entering relevant data represents the conclusion of the project «discreteFD».

Conclusion

Discrete event based simulation tests of flexible facilities in the retirement, educational and hotel sector showed that with the help of simulations optimised building layouts and management concept can be developed which due to the complexity and the dynamic of the business field could not be develop without these tools. The imputed operating costs per teaching unit at the SeeCampus Niederlausitz[8] could be reduced by 40% through the application of a simulation of the lifecycle costs and benefits as well as the resulting optimisation of the building and operation concept.

As outlined the optimisation of facilities development concepts and the evaluation of risks can improved significantly and designed more realistically with the methods and tools developed within the project «discreteFD». Even though the project «discreteFD» represent a generic approach to facilities development not all problems are solved as real estate developments and the questions raised in connection with development projects vary significantly especially in comparison to production and logistics for example. The expenses for modelling, development and implementation can be founded via the resulting increase in efficiency of facilities development projects. For the application of discrete event based simulations on a broader scale i.e. mass production, it is prerequisite though that real estate developer and investors are prepared to increase their investment during the planning phase in view of future benefits. The ETH Zürich plans to transfer and expand the outlined project more and more to questions of eco-efficiency as well as to provide tools supporting the efficient operation of facilities and the decision–making process during the various operating phases respectively.

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2 s. www.redkg.ch
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4 see: http://www.extremeprogramming.org/
5 see chapter «Research Results» and http://www.extremeprogramming.org/rules/spike.html
6 see: http://www.uml.org
7 see: http://www.ibepace.com/download/Opt_wp_de.pdf
8 see: www.seecampus.info