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User Behaviour Modelling

Applied in the context of space utilisation

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Abstract: The aim of the proposed project is to develop methods for the simulation of space utilisation. Up to now no methods for building performance evaluation are available which involve the occupants of the building. Instead, assumptions are made about people's movement through space and their responses to the environment. These assumptions are input for important design decisions (e.g. capacity of elevators, width of corridors, escape routing) sophisticated calculations (e.g. cooling and lighting calculations) and simulations (e.g. airflow simulation, evacuation simulation). Reliable data on human movement are very scarce and can be valuable input to research in other research areas. New computer technologies allow for dynamic simulations that will provide insight into the building to be built. The research project builds upon existing methods that need to be tailored and/or extended to apply them to the building domain and to support real-time simulation.

1. INTRODUCTION

During the last century building performance analysis has become a well-established tradition, especially with regards to the domains of structural engineering and building physics, e.g. cooling and lighting calculations. In these calculations, assumptions are made about the utilisation of space and the activities users perform at a certain time, although there is little knowledge about real behaviour of users of a building. Analysing a design for a new building is not only relevant for the above-mentioned engineering domains; it is also important for designers, like architects. For them, analysing the real behaviour of users (the human individuals) is far from standard. It is still difficult to predict how design decisions will influence the human behaviour.

We think a system is needed that can simulate representative, real human behaviour and space utilisation in complex buildings. With this system it is possible to analyse the performance of a building design and it can also substantially improve the relevance and performance of the engineering methods and/or models.

In this research project, we will develop a system that can test and evaluate a building design in relation to human behaviour. The aim of the project is to develop a model for the proposed system that builds upon two existing methods, namely colored Petri nets for business process modelling and activity based modelling for predictions of transportation.

The paper is organised as follows. First, we discuss some related research. Next, in the research approach we will describe both models and we will compare the two methods on their potential for usage in user behaviour modelling. We will finish with a discussion how these two methods can be integrated into a comprehensive simulation system.

2. RELATED RESEARCH

The proposed research project is related to topics in the research area of pedestrian and evacuation dynamics. Models developed in this research area can be divided in three categories, namely cellular automata models, agent-based models and social force models.

Cellular automata models are used to model dynamic processes that are discrete in space and time. In a cellular automata model, space is represented as a uniform lattice of cells with local states, subject to a uniform set of rules, which drives the behavior of the system (Dijkstra, Timmermans, et al., 2000). Cellular automata models have been applied to model road traffic. This is done in order to model a variety of effects known in real traffic scenarios. Cellular automata models seem also suitable for pedestrian and evacuation dynamics. An example is the Bypass project at the University of Duisburg-Essen (Meyer-König, Klüpfel, et al., 2001) for simulating evacuation behaviour on cruise ships.

Agent-based systems are currently developed for simulating virtual human behaviour in a variety of disciplines. The PEDFLOW model, developed at the School of Computing of the Napier University Edinburgh is an example of an agent-based evolutionary system that allows modelling of pedestrian behaviour (Kerridge, Hine, et al., 2001). Another example is the

Streets project, which provides a more comprehensive model of pedestrian simulation (Schelhorn, O'Sullivan, et al., 1999). The developed model simulates the movement of a pedestrian population around the urban district as influenced by its spatial configuration, predetermined activity schedules, and the distribution of land uses. Pedestrians are represented as agents. This project as well as other agent-based developments are part of the research efforts of CASA (Centre of Advanced Spatial Analysis) at UCL, London.

The third category uses social force fields to model human behaviour. These social (or behavioural) forces determine the amount of behavioural change (e.g. changes in acceleration or in direction) as reaction to external forces, e.g. forces exerted by the environment. The forces have a stimulating or repelling effect on the motivation of humans to perform certain activities. This approach is taken in the SMM (Seamless Multimodal Mobility) programme of TRAIL (The Netherlands Research School for TRAnsport, Infrastructure and Logistics) for example for simulating traveller behaviour in railway stations (Daamen, Bovy, et al., 2001).

In our research project we suggest a different approach for pedestrian dynamics. This approach will be discussed in the next section.

3. RESEARCH APPROACH

This research project builds upon existing methods for simulation of space utilisation in buildings. Two approaches are considered for describing an activity model for an organization housed in a building: Colored Petri nets and activity based modelling. In this section we will describe both approaches and compare them.

3.1 The Activity Based Modelling Approach

Everyone performs several activities on a day. Some activities are biological or social determined, such as the standard day-to-day activities: sleeping, eating or working; other activities are optional and more special or irregular, e.g. watching TV or going to the theatre.

In the last decades many so-called activity based models have been developed with the intention of predicting the performance of activities by individuals. These activity models have especially received much attention in the area of transportation. In this section the focus will be on activity based modelling in transportation. The research area of activity based modelling tries to develop models, which can predict travel behaviour by means of predicting which activities are conducted (Ettema, 1996). Based on certain factors (see section 3.1.2.1) these models are able to create an activity schedule. These schedules reveal the predicted travel demand as derived demand from the activities. The activity models can be used to predict the effect of policy measures on the possibilities of individuals to participate in activities and on the resulting travel demand (Arentze and Timmermans, 2000). Examples of these policy changes are changes in the opening hours of shops or changes in infrastructure or land use planning.

3.1.1 Activity Based Modelling in Transportation

Which activities people engage in depends on their desires and responsibilities. People engage in a particular activity to fulfil some wish or need. Almost every activity has a cause or reason. This reason can be social, psychological or something else and is influenced by the context in which a person lives, like the personal and household characteristics, social status, political and economical environment, etc. This need can be very fundamental to the society in which an individual lives, for example people need to earn money to be able to eat in order to stay alive. Or it can depend on more personal beliefs and wishes, e.g. meeting friends, going to a church.

Another matter that unites most of our activities is that activities demand some type of transport. Normally an individual makes a trip for a particular reason; going from an activity to another a certain distance usually has to be covered. Travel can be considered as a derived demand. If a person wants to participate in activities, which are at different locations, he/she has to move between these two locations or in other words: he/she has to make a trip.

If models are to predict the human travel behaviour there has to be an understanding of the human decision making process when scheduling activities. The models should be able to answer questions, like: why people engage in activities (and so why they travel) and how individuals make decisions regarding activities and trips. Researchers have put much effort into trying to capture the human decision making process in activity models.

In the activity based modelling approach two major steps can be differentiated, namely activity scheduling (see section 3.1.2) and activity execution and rescheduling (see section 3.1.3).

3.1.2 Activity Scheduling

Activities can be divided in planned and unplanned activities. Normally people plan most of their activities days, weeks or months in advance. This depends among others on the type of activity and if the presence of other persons is needed. Other activities happen in a somewhat unplanned way. These activities can be a result of unexpected events (e.g. accidental meetings) or are a result of impulsive decisions (e.g. filling in unplanned time with shopping). The difference between planned and unplanned activities is that for planned activities the scheduling process takes place before the execution of the activity, while for unplanned activities the scheduling and execution process more or less coincide.

Activity scheduling is the decision making process in which individuals make decisions about which activity to engage in and how to travel between the activities. This process is cyclic. It starts with an almost empty schedule in which an individual keeps adding activities and subsequently evaluating the schedule until it yields the optimal (at least as the individual is concerned) utility (or satisfaction). When the person is satisfied with the schedule the process is stopped (see table 1 for an example of an activity schedule). Participating in an activity returns a certain utility to an individual. People will usually choose the activity, which returns them the highest utility. The goal of the activity scheduling process is to find the schedule with the highest possible satisfaction (maximizing the utility).

Table 1. An example of an activity schedule.

00:00 - 08:30	Sleeping
08:30 - 08:45	Eating (breakfast)
08:45 - 09:15	Travelling to work
09:15 - 12:00	Working
12:00 -12:30	Eating (lunch)
12:30 -17:30	Working
17:30 - 18:00	Travelling home
18:00 - 19:00	Eating (dinner)
19:00 - 20:30	Cleaning house
20:30 - 20:45	Travelling to cinema
20:45 - 23:00	Watching movie
23:00 - 23:15	Travelling home
23:15 - 00:00	Sleeping

3.1.2.1 Activity Scheduling Factors

There are many factors which influence the decision making process. A major factor is that humans in general cannot investigate every possible solution to the problem of finding an activity schedule for the period in question (for example 24 hour). Investigating every possible solution simply requires too much time and brainpower. When scheduling his activities an individual has to make some decisions, considerations and choices, and when he finally stops the scheduling process, he probably did not end up with the most optimal schedule.

The individual's lifestyle and other long-term decisions also have an impact on the activity schedule. An individual makes certain decisions about their lifestyle, e.g. what his role in society and household is and what his career plans are. An individual also makes decisions about other long-term decisions like the place where they live and work. These decisions will influence the activity and travel behaviour of people for a long period, because they cause certain activities to happen with a somewhat fixed frequency, like going to work or taking care of children. This kind of activities can be stored in a so-called long-term agenda. Other factors are more incidental and are only valid for a particular period, like traffic jams and strikes.

The tendency (or propensity) to engage in an activity is another important factor. This propensity can be both stimulating and constraining. People are more inclined to engage in activities, which they like or which can improve their career. Other personal and social characteristics, like health status or social status can limit the activities, which they can pursue.

Except the propensity also opportunity plays a roll in scheduling activities. The opportunity to engage in activities can be constrained by several factors, for example:

- Temporal constraints: e.g. no overlaps in activities or gaps between activities are allowed
- Spatial constraints: some activities can only take place on specific locations
- Combinations of both constraints, temporal-spatial constraints: the time to travel between several locations depends on distance and transport mode.

3.1.2.2 Activity Attributes

When adding an activity to a schedule, decisions have to be made about where, when, with whom, etc. to perform the activity. The result of the activity scheduling process is an activity schedule, which describes for every activity the following attributes:

- The type of activity.
- The location of the activity.
- The start time, end time and duration of the activity.
- The transportation mode.
- In some activity models: the accompanying persons.

The activity schedule details the sequence of activities and the routes to follow between destinations. It reveals the travel demand for the planned period. Scheduling activities can be broken down in certain stages; these stages are discussed in the next section.

3.1.2.3 Stages in the Activity Scheduling Process

Planning an activity schedule usually starts with the activities, which have a somewhat fixed frequency for a specific period, e.g. a day, like sleeping, having diner, and working. These are activities, which are performed routinely and which are usually defined in the long-term agenda.

The activities, which have to be performed during the period for which the schedule is being created, will be listed in an activity program. This activity program is based on an activity agenda, which contains the activities, which the individual needs or wants to perform during the period.

Next in the scheduling process, activities that have been formulated in an activity program are planned in detail. This stage usually starts when the period in question is getting more nearby. The activity program is transformed in an activity schedule. Decisions are taken about the attributes of the activities, e.g. where, with whom to perform the activities etc. Furthermore activities are planned which are specific for the period in question, e.g. going to the theatre or visiting friends. It may occur that already planned activities need to be changed in order to be able to add a new activity.

In the last step of the scheduling process of activities, the activity schedule will be executed. Due to unexpected or unforeseen events certain activities or trips may have to be modified or eliminated, or new activities have to be planned. The activity execution phase is discussed in the next section.

3.1.3 Activity Execution and Rescheduling

When the activities are scheduled, they are ready to be executed. When a person is ready to execute an activity she/he has the choice to follow the activity schedule or to adjust one or more activities. The same factors that influence the scheduling process also have an effect on the rescheduling of activities. Adjusting (or rescheduling) a schedule can be done in three ways:

- Adding an activity: the insertion of an unplanned activity.
- Deletion of a planned activity.
- Modification of an activity: the adjustment of one or more characteristics of an activity: like the location or duration.

The rescheduling process is a continuous process. A schedule that is adjusted stays tentative until it is completely executed. The schedule can at anytime in the execution process again be modified. Rescheduling is a cyclic process: after revising one or more attributes of an activity of a schedule, these activities are evaluated and if the schedule is not considered satisfactory (the schedule does not yield the optimal utility) the schedule is again adjusted. This process stops when the schedule cannot be improved anymore within the constraints (the schedule is at its highest utility).

When the activity execution and rescheduling is finished for a specific period, an activity pattern is created. By analysing the differences between the predicated and observed activity pattern a better insight is gained in the human decision making process, with regards to the planning of activities and trips. The results from the analysis can also be used to calibrate activity models. How this can be done is explained in the next section, which gives an example of an activity-based model.

3.1.4 An Example of an Activity Based Model

In this example the objective of the activity model is to simulate and predict the effect of policy measures on the activity schedules of individuals. In the example we use a model for the activity scheduling process.

In the model we assume that people will try to maximize the utility of their activity schedules by maximizing the utility of every activity. For every activity we have to make several decisions, like where to perform the activity, with whom etc. This means that for every activity we can consider several alternatives. For an activity an individual will usually choose that alternative, which returns the highest utility for that activity. In theory, in this way the individual will end up with the activity schedule with the highest possible utility for the whole sequence of activities. Normally there would be some form of interaction between the several activities, but in this model we do not take this in account.

The utility of the schedule for adding an activity on stage *s* is defined by the following function, which is modified after (Ettema, 1996):

$$U_s = \sum_k \beta_{sk} X_{sk} + \sum_m \gamma_{sm} Y_{sm} + I_{as}$$

where,

U_s is the utility of the schedule at stage *s*.
β_{sk} is a parameter denoting the effect of the *k*-th attribute at stage *s*.
X_{sk} is the *k*-th schedule attribute of the schedule at stage *s*.
γ_{sm} is a parameter denoting the effect of the *m*-th attribute at stage *s*.
Y_{sm} is the *m*-th characteristic of the schedule up to stage *s*.
I_{as} represents the expected maximum utility of an activity *a* which is to be added to the schedule.

Several schedule attributes (X_{sk}) can be distinguished, like:

- Preferences for a sequence of activities.
- (Total) travel distance.
- Waiting and travel time.
- Time spent on each of the activity types.
- The frequency of an activity.

In case of the schedule history (Y_{sm}) the following attributes can be considered:

- The number of preceding stages up to stage *s* (the metal effort).
- The a priori preference for adding or deleting an activity.

The values of β_{sk} and γ_{sm} have to be estimated before we can use the utility function to simulate activity schedules. A data set is needed for calibrating the utility functions. In our case we need data about observed behaviour; we need data about activity patterns. There are many ways of collecting data about real human activity and travel behaviour. In our case we could opt for asking a sample selection of people to fill in an activity-travel diary for a certain day. If this is done in a (computer-based) system, which can constantly keep track of the characteristics of the schedule and the scheduling process when a respondent is scheduling his activities, we also have the observations needed for determining the X_k and Y_m attributes. In contrast with the estimated parameters β_{sk} and γ_{sm}, the values of X_k and Y_m attributes are based on real observed activity behaviour.

When we have collected all the necessary data, we have to formulate an estimation method to estimate the parameters β_{sk} and γ_{sm}. Formulating a method is a difficult process. There is no simple algebraic function and solution for estimating the parameters. In the literature we can find several examples of estimation methods, like the log-likelihood estimation method (Ettema, 1996) or genetic algorithms (Joh, 2004).

For the sake of keeping this example simple we will assume that we have estimated the parameters β_{sk} and γ_{sm}. Based on the estimated parameters β_{sk} and γ_{sm} and the observed values for the X_k and Y_m attributes of the utility function we are able to simulate the process of activity scheduling. When we compare the simulated activity schedule with the observed activity patterns, we get an idea how the model performs. To verify the validity of the model, we should perform some statistical tests, like determining the goodness-of-fit (Rho^2 test). In this test the simulated activity schedules are compared to the observed activity schedules; this tells us something about the similarity between the simulated and observed activity schedules.

3.2 The Colored Petri Nets approach

Colored Petri Nets (CPNs) are a graphical and mathematical way of describing, analysing, and understanding complex concurrent and/or parallel systems. CPNs are very general and are used in many application areas, like communication protocols, operating systems and hardware designs. Although Petri nets were originally not devised as a business process modelling technique, they can also be used for modelling business process or re-engineering (Aalst, van Hee, 2002) and (Aalst, van Hee, 1996).

3.2.1 Principles and Context of Colored Petri Nets

Colored Petri nets are an extension to the basic Petri nets formulated by Carl Adam Petri in the 1960's. Petri devised Petri nets as a tool for modelling and analysing processes. Since the formulation of Petri nets, several extensions for the original Petri nets have been formulated, like colour, time and hierarchy (see section 3.2.2).

Petri nets have a strong mathematical basis; they are completely formalized. The formalism makes sure that the Petri net is modelled in a precise way. This leaves no room for uncertainties and ambiguities. Furthermore the formalism makes it is possible to analyse the behaviour of Petri nets. There are several formal analysis methods and the behaviour can also be analysed by simulation (see section 3.2.3).

Petri nets can be used for modelling distributed and concurrent systems, like telecommunication systems and document storage systems. These systems normally are very complex and difficult to design and test. Due to the graphical and mathematical nature of colored Petri nets, they can be used for modelling and analysing very complex systems. The model created for a system not only serves as a graphical description of the modelled system, it also gives a detailed specification of the system. In this way the model can be used for studying and presenting the system. Furthermore the graphical representation gives the modeller a good understanding of the system while creating the model.

Due to the graphical representation of a Petri net model and the fact that the model is constructed from a limited number of primitives, it is relatively simple to grasp a model, even for people who are not familiar with CPNs.

3.2.2 Basic Concepts and Extensions

This section discusses the basic concepts and extensions of Colored Petri nets. First the basic structures formalized in the classical Petri net will be treated; the second part of this section considers the extensions to classical Petri net. For more extensive information about Petri nets see (Jensen, 1992) and (Kristensen, Christensen, et al., 1998).

3.2.2.1 Classical Petri Nets

A classical Petri net consists of a two node types, namely places and transitions (see figure 1). Directed arcs connect the nodes. Connections between two nodes of the same type are not allowed.

When modelling a system with Petri nets the state variables of the model are represented by places, usually drawn as circles or ellipses. Places are passive and are used to indicate media, buffers etc. A place contains a set of markers, called tokens (indicated as black dots). A token can be used to represent both physical objects (e.g. resources and humans) and information objects (like an insurance claim). The distribution of tokens on the places of the net is called a marking. The initial distribution of token is called the initial marking.

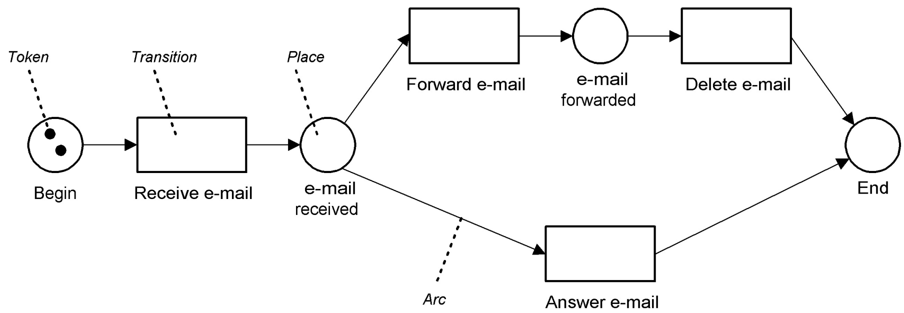

Figure 1. A classical Petri net.

The state-changing operators are the transitions, which are drawn as rectangles. Transitions are the active nodes in a Petri net. They represent actions, like events or operations. The state of a net changes through the occurrence (or firing) of a transition. When a transition fires (e.g. the transition *record* in figure 1) it removes a token from a place connected with incoming arcs (an input place: *claim* in figure 1) and adds the token to a place connected with outgoing arcs (an output place: *under construction*). The result of the firing of one or more transitions is a new marking or in other words a new distribution of tokens over the net. When every input place of a transition contains at least one token, the transition is enabled. A transition may only fire when it is enabled.

3.2.2.2 Extensions

After the formalisation of the Petri nets in the 1960’s it became clear that the theory had some weaknesses or practical shortcomings. Modelling an even relative small system could result in a complex and unreadable Petri net. Several extensions to classical Petri net have been formulated. In this section we will discuss three extensions, namely colour, time and hierarchy.

In the classical Petri nets a token is a very simple data entity. Tokens are really simple black dots; they do not carry any attributes. This make it difficult to distinguish between the several tokens found in the net. A classical Petri net is often very large and difficult to read and handle. The colour extension equips each token with a data value, called the token colour (see figure 2). In this way each token can carry several attributes and it is possible to distinguish between the tokens. Each place has a certain type (or colour set), which determines the kind of data that a place may contain. For a given place all tokens must have a token colour that belongs to a specific type. These colour sets can be relatively simple (like the two attributes stating type and mode in figure 2) or very complex data structures, e.g. a list of many thousands records.

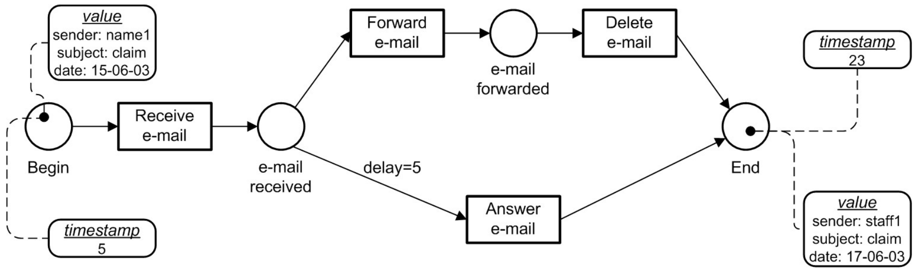

Figure 2. A Petri net extended with colour and time.

Another shortcoming is that classical Petri nets do not possess a time concept; it is impossible to model the timing of processes in a classical Petri net. However modelling the temporal behaviour can be very relevant for modelling real systems. For a modeller it can be essential to be able to analyse the performance of a system. The solution is to extend the classical Petri net with a time factor (see figure 2). This is done by adding a timestamp to a token. This timestamp determines when a token is available to be consumed by a transition. A transition is only enabled when all the tokens that are to be consumed are available. This happens when each of the tokens at the input places has a timestamp equal or prior to the current time of the system. With this timestamp it is possible to model delays and durations in the system.

Systems modelled with timed and coloured Petri nets will be more compact and readable than the same system modelled with classical Petri nets. But even with these types of Petri nets it remains difficult to keep a good overview of the model, because a person can only cope with a limited amount of details. When modelling large systems it would prove the modeller very helpful if he can structure the Petri nets. Introducing a hierarchy construct in Petri nets can solve this problem (see figure 3). The hierarchy extension allows the modeller to construct a large model by using a number of sub Petri nets. These sub Petri nets are called pages. In this way a Petri net consists of a main Petri net and a set of pages which each contains a network of places, transitions and arcs. The modeller can concentrate on the sub Petri net, without losing the big picture. The hierarchy extension makes sure that the Petri nets has and maintains a well-defined structure.

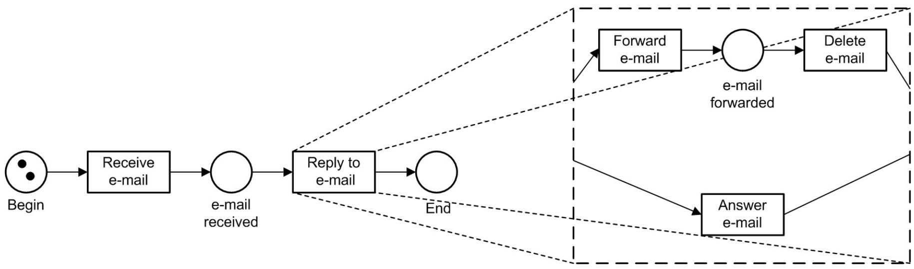

Figure 3. A Petri net extended with hierarchy.

3.2.3 Analysing Petri Nets

When the model has been constructed, this model has to be analysed in order to check that model has the expected behaviour. There are basically two groups of analysis methods available for analysing Petri nets. The first group exist of (interactive) simulation methods. In a simulation the Petri net is executed and the behaviour of the model is observed and recorded. After the simulation the results can be visualised. The second group contains methods, like the performance analysis and occurrence graphs. These methods are used to calculate the performance measures (e.g. the delays, throughput) and to verify the properties of the modelled system, like the occurrence of deadlocks or errors in the system. Detailed information about the above mentioned analysis methods can be found in (Jensen, 1992) and (Kristensen, Christensen, et al., 1998).

3.3 Comparison of activity based modelling and CPN

In this paper we have discussed the methods Colored Petri nets and activity based modelling, which are considered for describing an activity model. Now we will compare both methods on their potential for usage in user behaviour modelling.

3.3.1 Setup of the comparison

Both models will be compared on seven criteria, namely:

- **Application area**: the first criterion establishes the purposes for which the methods are normally used.

- **Formalisation method**: this describes the way in which the methods are structured.
- **Validity**: the models constructed with both methods will be used to predict user behaviour. With the validity-criterion we evaluate the quality of these predictions. Are the models constructed with both methods capable of predicting accurate and factual user behaviour?
- **Sensitivity**: a model constructed with either of these methods will be based on several different interdependent variables. This criterion deals with the sensitivity of these models to changes in the variables.
- **Transferability**: when constructing a model for a particular organization, it is preferable that this model is also usable and suitable for other organizations. The transferability-criterion evaluates to which extent a model is usable in a different context than for which the model originally was designed and constructed.
- **Transparency**: a model can become very complex, large and difficult to understand. The transparency says something about how easy to understand a model is for someone (other than the people who have created the model); is the model a "black box" or not?
- **Level of detail**: finally models will be used to predict very different situations. While some models will be used to predict individual behaviour (micro-simulations), other models will be used to predict aggregate results, like traffic flows (macro-simulations). This criterion treats the potential resolution in among other things time and space of the models constructed with the two methods.

3.3.2 The comparison

In table 2 we show the results the results of the comparison of colored Petri nets and activity based modelling. This comparison is based on our perception and impression of the potential of using these methods for predicting user behaviour in buildings. We think that both methods can be used for describing an activity model for an organization housed in a building. We have evaluated both methods as alternatives for developing a system that can evaluate a building design in relation to human behaviour.

An important remark in this comparison is the discussion of activity based modelling as one whole in the context of one research area. We have described a general overview about this method. In reality activity based models will differ from each other; sometimes there will be serious differences between the models. For certain criteria, e.g. the transparency, the differences between the several activity based models are substantial; one general judgement about activity based modelling would be a little too hasty. For other criteria, like the validity, it is possible to evaluate it as one whole, because this criterion lays in the nature of activity based modelling; it will be applicable for almost every activity model.

Table 2. Comparison of colored Petri nets and activity based modelling.

Criteria	Colored Petri Nets	Activity Based Modelling
Application area	Business Process Modelling	Transportation research
Formalisation method	Deterministic, mathematical.	Non-deterministic, stochastic.
Validity	Good, & many analysis methods available.	Good, & many analysis methods available.
Sensitivity	High, but also depends on size of organization: a change in the components of the organization can have major consequences.	High, normally every change in the variables will have a consequence for the simulated user behaviour.
Transferability	Poor, for every organization a new Petri net has to be built.	Depends on the model, it might be necessary that a model has to be estimated for every application.
Transparency	Good, a Petri net consists of a graphical, easy to understand diagram.	Depends on the model, a model can consists of many mathematical rules, which can be difficult to grasp.
Level of detail	High, Petri nets are normally used to specify detailed process models.	Depends on the model, activity models can be used to predict behaviour at every possible level.

4. CONCLUSIONS

In our research project we will integrate two methods, namely colored Petri nets and activity based modelling. The two methods can be considered alternatives for user behaviour modelling. Each method can be used to create models for predicting human behaviour, but each method has its strong points and its weaknesses. We think that the two methods are complementary. While Colored Petri nets will be used to model organizational workflows, activity based modelling will be applied to model the behaviour of individuals. In case of Petri nets every simulation-run will result in the same workflow. Due to the specification of the organization in the brief and the mathematical formalization of Petri Nets the workflow of a particular organization is fixed. For activity based modelling the outcome of every simulation-run will vary. With activity based modelling uncertainty is introduced to represent human behaviour. This uncertainty will change the fixed workflow process into a dynamic process with emergent organisational behaviour. The combination of these two methods provides a solid basis that ensures process consistency, inclusion of individual re-scheduling behaviour and allows for execution in real time or compressed time intervals. At this moment, it is not clear how to integrate these methods in our research project. It is under investigation and we hope to inform you about that in the near future.

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