Pattern Matching for Decision Support

by

Ir. A.J. Boelen M.Sc.

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Delft University of Technology

Faculty of Architecture and Urban Planning
P.O. box 5043
2600 GA Delft
tel: +31 15 278 4064
fax: +31 15 278 3694
e-mail: A.J.Boelen@bk.tudelft.nl

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ABSTRACT

In this paper is discussed how we can use pattern matching techniques in combination with object orientation to support decision makers in arranging offices and industrial and commercial facilities in existing urban areas. The method used is based on the findings of a Ph.D. project almost finished when writing this. The tool under development is specifically useful for rehabilitation of deteriorated industrial or commercial areas.

I consider such an area already occupied and surrounded with all kinds of urban objects and connected to all kinds of infrastructure. I can describe this area in available objects and facilities. Furthermore we can describe the areas capacity left within the infrastructure, the capacity in for example work force or clients and the available band width in noise or pollution. By describing the area in terms of availability of capacity to absorb or produce flows of people, goods, energy and information we sketch the room available for certain types of industrial or commercial facilities.

I developed a technique to describe industrial and commercial facilities in such a way that we enable the match between these and the characteristics of an area available. Pattern matching techniques enable the system to generate best matches between available areas, locations and facilities. This model can be adapted in several object oriented geographical information systems and be integrated with other information systems that for example calculate the pollution of certain kinds of facilities. The rules to match with are partly based on objective, measurable data like available capacity on the electricity network and needed electrical power for certain facilities. Other matching rules are based on political norms on for example acceptable pollution levels and suggested pollution of facilities.

The paper presents the problem area of industrial area rehabilitation, describes the architecture of the modeling technique and presents the first findings of implementation studies.

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Pattern Matching for Decision Support

THE PROJECT ENVIRONMENT

A group of participants of the LWI project considered the need for a planning tool for urban facilities and commercial and industrial activities. Four proposals for decision tools were the inspiration for this project.

1) The road infrastructure department of Arcadis B.V. proposed to develop a tool to enhance the insight on infrastructure occupation in relation to the attached operations.

2) The spatial planning department of Arcadis B.V. proposed to develop a tool to show the friction between the planned environment and the autonomous development of an area.

3) The TNO-NITG proposed a decision support tool for the relation between potential developments of an area and the soil and underground characteristics.

4) The faculty of Architecture and Urban Design from the Delft University of Technology proposed a tool to explore the potentials of an existing urban environment to changing functional developments.

The LWI MainPorts project group has as its mission the development of tools for decision support. These tools should support the sustainable planning and management of intensive used urban, harbor and industrial areas. One of the main problems in this kind of areas is the increasing lack of room for new industry activities. The over-intensive use of space and increasing congestion of infrastructure clarifies the need for more efficiency in using infrastructure, environment and build up structures. A better concordance between new plans and existing infrastructure is necessary. Hereto decision makers need tools to explore wishes, probabilities and potentials of the environment. One of the main items is the efficiency of activities in relation to yet existing infrastructure and industrial activities. I am developing an instrument to facilitate this exploration by simulation of the processes facilitated by different alternatives. My aim is: **Develop a tool to optimize the use of space in existing industrial areas.**

The primary end-users of the proposed tool are port authorities, governmental organizations that work on industrial planning and infrastructure planning and large companies with their own environmental planning department.

I consider the next reasons to use the proposed tool:

- A factual situation of inefficient use of space. (for example, vacancies, extensivation, environmental damage, external bottlenecks, image problems, mismatch of sizes of parcels with demands for parcels)
- Expectation or prognosis of inefficient use of space.
- Hypothetical policy questions to explore alternatives.

I consider the next aspects to influence the use of space and infrastructure in an area:

- Vacancy of parcels,
- Change of activity within a parcel,
- Changes in the production techniques used,
- Intensifying or extensifying of the use of space needed to perform activities,
- Changes in the external infrastructure like increasing congestion, new connections etc.,
- Changes in laws and norms, like with environmental issues and technique.

Governments need to monitor industrial areas for these changes. Simulation might support the development of ‘trigger’ values for the parameters involved. This implicates the development of norms for developing inefficiency of land-use. With these norms decision makers have the tools to discover degradation and the point where they have to take action. Decision makers have to consider whether the inefficiency is structural or conjuncture related. They also have to consider whether the inefficiency developed gradually or sprung up instantly. I assume that inefficiency is bound to a certain level of scale.

For example in a large harbor area a local inefficiency can arise because of the removal of one industrial site. On the other hand the degradation of a whole branch of industry can cause inefficiency for the whole industrial area.

THE PROBLEM IS A MISMATCH

I want to develop a tool to solve the mismatch between the use of space in industrial areas and the available infrastructure and other conditions within those areas.

Sub optimal use of space occurs in almost all complex industrial areas. Such areas age slowly. While aging, the match between the activities in the area changes as well as the match between these activities and environmental conditions. Furthermore dynamic external processes like law development and technical and social developments have their influence on this match.

The increasing need for space for new industries and the use of infrastructure caused by the need to connect these areas, demand efficiency in the use of space. I focus on existing industrial areas with a sub regional level of scale (radius = 1 [km]). The smallest elements under consideration are objects with a radius of 30 [m]. I do not intend the tool to support detailed studies of these areas. I assume the relevant time scale to model with, is in periods of 10 years. I assume 8 hour shifts as the smallest time units to be considered. I do not focus on the gathering of data. I consider the necessary data available.

USING OBJECT'S BEHAVIOR MODELING AND PROFILES

My challenge thus is the development of a tool that (a) is comprehensible and (b) sustainable in a dynamic environment. I want the tool to be comprehensible because the intended users are assumed model illiterates. I assume I can reach a high level of sustainability by avoiding the use of meaning or values anywhere in the kernel of the tool. Combining the concepts elaborated by Goodman [**Goodman, 1991**] and De Jong [**Jong, 1992**] show how this might be reached. The tool will contain models of industrial areas. Hofstede [**Hofstede, 1992**] and Lauwerier [**Lauwerier, 1992**]consider modeling as an abstracting and generalizing technique needed to enlarge the understanding of structures and processes. I add to this [**Boelen, 1998a**] that modeling facilitates prediction of impacts of changes in the environment modeled. I therefor assume that the tool I develop should enable decision makers to explore alternative interventions in industrial areas. This exploration covers the impact on mismatches between land-use and infrastructure. I base this tool on interrelated characteristics of the objects encountered in industrial areas. These characteristics enable the dynamic development of impact models on several aspects in these kinds of areas [**Zeigler, 1990**]. I selected a comprehensive and influencing group of object characteristics related to these aspects for the development of the first prototype. I am still developing this "**Matching tool for modifications of activities in industrial areas**". This tool enables the decision maker to select a new location for industrial activities within a region or area. The tool enables the decision maker to check whether the proposed new activity in a parcel fits to the location's conditions.

To perform this project I made several assumptions. The main assumption is that I consider the objects defined in an industrial environment as ‘black boxes’. These 'black boxes' have predefined input and output streams. These streams are the ‘visible’* results of the objects’ characteristics. The streams defined enable impact analysis on the different aspects as intended. To support all these characteristics I am developing the tool based on the Object’s Behavior Modeling framework [**Boelen, 1998b**]. The next paragraph is devoted to a short description of this technique.

DESCRIBING OBJECT’S BEHAVIORAL MODELING

Coyne indicates that we can describe the environment in terms of objects [**Coyne, 1989**]. With the set of objects that emerges we can build models for the physical environment (compare this with building scale models). To enable these models to simulate the behavior of the real environment we have to add relationships to this combination of objects. In multiple-dynamic systems like the environment we can not model all relations between all objects on beforehand. In the Object’s Behavior Modeling technique only the behavior of the individual objects is modeled. The relationships between the modeled objects is not build in but only facilitated by the framework. The O’sBM framework supports the dynamic determination of relationships between objects. In this framework there is no need to define the inter-relationship between objects or between objects and their layer in advance. There is no need to know exactly what other objects can influence objects modeled. In the O’sBM framework I regard processes to be the result of -- not described or even unknown -- internal processes within objects. Processes manifest themselves by the resulting outgoing streams of objects [**Batty, 1986**; **Coyne, 1989**]. In this framework I base modeling behavior on the relationships between input, internal processes and output of objects. Parameters control the strength of the relationship between objects. Examples of these parameters are: distance and number of senders and receivers within range. Another important factor is the amount of output send and input received. The system solves conflicting relations using statistical and random set parameter values.

For this O’sBM technique I make a strong emphasis on the understanding of levels of scale [**Alexander, 1977**; **Boelen, 1996**; **Zimmermann, 1996**] and conditions [**Rao, 1993**; **Zeigler, 1990**]. Levels of scale make the process limit itself to a certain minimum and maximum size of the objects and area involved. Conditions concern the presumptions about materials, elements, compositions, structures, activities, meaning and values for objects used in modeling [**Boelen, 1996**]. I use the concept of scale to keep a model of the environment manageable. At all levels of scale we can define a scope and a grain. The scope is the outer limit of the environment considered. The grain is the radius of the smallest area or component to be

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* Visibility does not concern visible by the human eye but perceptible by other objects in the modeled environment.

considered part of the modeling environment. The ratio between scope and grain differs per domain. The system hides the behavior of components with a reach smaller than the grain inside other components.

DESCRIBING ENVIRONMENTAL OBJECT'S CHARACTERISTICS

I consider (materialized) geometry to be the basic property of all environmental objects.

> *Consider the description of a storehouse naming the functions it gathers. One presupposes some kind of geometric environment describing a storehouse this way. One considers this geometric environment as the physical limits of the concept storehouse. One considers the functions to take place **inside** the physical limits of the storehouse.*

Within the O'sBM framework I consider an **element** to be a materialized environmental entity. I consider a **component** to be a composition of elements. Within the framework I consider **structure** to be the image of the relationships between components. The O'sBM framework represents structures as the streams between components. The framework represents **behavior** as the interrelated action of these components enabled by the streams.

The O'sBM framework enables the modeling of physical components as well as mental components. These components can be put anywhere on the (x, y, z, t) coordinates. The framework supports the connection of streams to the components. The framework distinguishes two kinds of streams. Line dynamic streams (LD-streams) contain more or less countable particles. These streams move linearly from source to destination. Examples of LD-streams are: people, goods, information, energy etceteras. Area static streams (AS-streams) move from a source in every direction. These streams do not focus on a destination. Examples of AS-streams are: noise, warmth, light etceteras.

DESCRIBING ENVIRONMENTAL COMPONENT'S BEHAVIOR

Components can only have any **meaning** in a model if they have some kind of behavior. For the outside world the only relevant behavior is the behavior that results in the expel and/or intake of certain streams (Figure 1). We therefor only need to describe the expel and intake of the relevant components at the levels of scale involved. I measure the relevance of behavior by its 'visibility'[*] from the outside world.

[*] Visibility does not concern visible by the human eye but perceptible by other components in the environment.

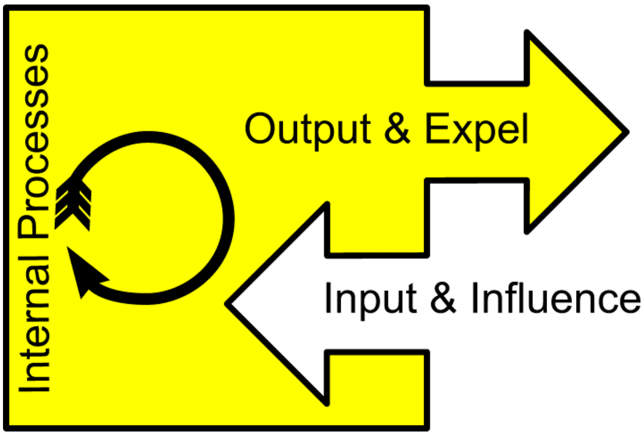

Figure 1 I regard all components as black boxes. The streams set all relations with other components dynamically. The component only communicates to the outside world with a generated output stream. The component reacts upon the world around accepting input streams from the outside world. The streams can be of any kind. The kind depends of the level of scale we project the component in.

The O'sBM framework distinguishes four types of streams for a component. The first type of stream contains the input needed for the internal processes of that component. The second type of stream contains the input the component is sensitive for. Intended output and waste a component generates are the other two types of streams. A component needs internal processes to change its input streams into output streams (see Figure 2). The type of streams is only relevant per component. The input stream for one component might well have been the waste stream of another component. Streams turn into a neutral state when a component expels them. They potentially become the input or influence stream of another component or become bundled or manipulated by other streams in the environment.

The framework distinguishes production and change processes as possible internal processes. Production processes for one -- type of -- component might be the change processes for other components. Again processes are neutral entities until related to a certain -- type of -- component.

Describing Industry, Infrastructure and Area Profiles

I want to match the profiles of different categories of companies and areas. I thereto have to consider what characteristics are relevant to incorporate in the profiles. One can think of the needed or available sizes, the needed or available connections to infrastructure, etceteras. I use common categorizations of industries as a first step to develop profiles. I selected the characteristics, considering the interventions I expect to occur most frequently. From data gathered from Chamber of Commerce[*] and other registering organizations I determined 'profiles' for objects, infrastructure and areas.

* KvK (chamber of commerce) codification of company types

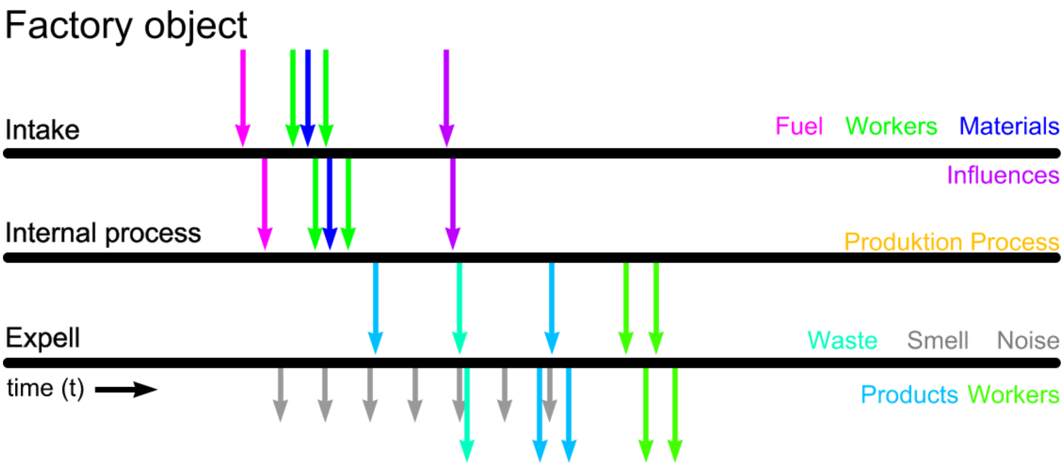

Figure 2 An example of an internal process. I represent a process as streams coming in and streams going out at different moments in time.

I am developing profiles for companies, areas and infrastructure. I am using existing methods and divisions as base material when I describe the company and area profiles. The company profiles contain the settlement requirements and wishes of economic activities. I consider this the demand side of the profiles. I use the division in company types, target groups[*], pollution profiles[†], mobility profiles[‡] and building type[§]. I use and, if necessary, refine these divisions to enable the mapping of the profiles on environmental objects.

Area profiles contain the characteristics of locations. I base their division on pollution profiles[**], market profiles (based on reachability, organization and surroundings) and mobility profiles (based on connections to infrastructure). Many of the area characteristics originate from the relationship the area has with infrastructure objects.

The infrastructure profiles describe the available infrastructure's characteristics. I incorporate a description of the type of infrastructure and the used and available capacity on that element. I want the tool to support decisions to come to a more efficient use of the existing infrastructure. With the development of these profiles I am taking care of the matching part. This exercise leaves us with a set of potential companies and available areas with characteristics that can serve the matching process.

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* SBI codes are a common categorization for economic activities

† VNG developed pollution profiles for industrial activities

‡ V&W has developed codes for mobility profile of locations

§ RGD has developed a codification of building types

** The ministry of VROM (Build up and natural Environment)has developed profiles for industrial areas based on the level and combi

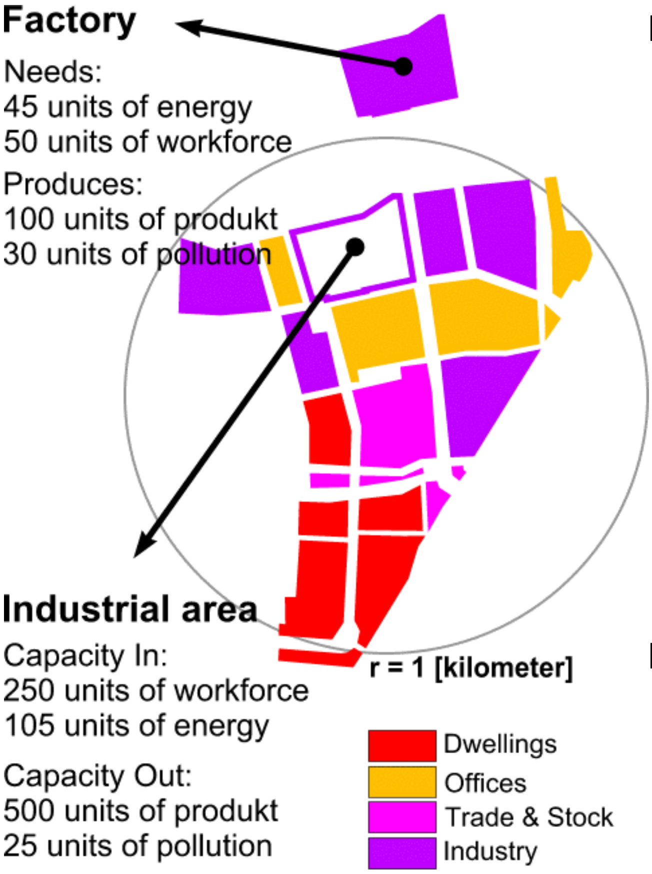

Figure 3 The tool is based on the exploration of matches between industrial object profiles and area and infrastructure profiles. The example shows a mismatch on pollution. more pollution will be produced by the factory object than the industrial area can digest. The other aspects signify a not optimized use of the capacities when this factory would be build here. 200 units of workforce, 60 units of energy and 400 potential units of product remain unused.

Describing different types of interventions

I consider six categories of interventions in industrial areas. Considering these I have to consider the changes that might occur with each intervention.

- Reuse
- Reconnection
- Rehabilitation
- Rearrangement
- Restructuring
- Repositioning.

Describing several types of impacts

For the first phase of this project I consider four sub-domains. These are natural environment, build environment, physical infrastructure and workforce economics. I develop the profiles such that I can eventually perform impact analysis on these domains. To enable this impact analysis I need to map streams on the different domains to the environmental objects in types and numbers.

Examples of these streams per domain are :

- for the natural environment : sound, gasses
- for the physical environment : material, people, energy, sound, gasses,
- for the external infrastructure : material, people, energy, gasses, information,
- for the economic workforce : people, information.

DEVELOPMENT OF AN INDUSTRY-ENVIRONMENT MATCHING TOOL

In this project I distinguish four work paths. The first work path is the development of the IT framework based on the O'sBM framework [**Boelen, 1998b**]. The second is the development of the so called 'profiles'. The third work path is the development of a basic set of potential interventions. With these, a decision maker can enter the system and immediately give most of the parameters their default values. I will not describe these interventions extensively. The fourth work path is the development of object's behavior by domain experts. This behavior is focussed on the enabling of impact analysis on several aspects considered important. Doing this we can acquire the knowledge of these domain experts [**Ford, 1993**] and use it in our impact analysis. This way of behavior modeling permits the development of advanced simulations and what if scenario's. This way of modeling also permits the reuse of objects, streams and processes in different combinations [**Gamma, 1995**].

I base the kernel of the tool on the comparison of area and object profiles. The tool performs this comparison considering the streams modeled (see Figure 3). I combined this with an impact assessment for the change proposed. We can only observe streams and impacts if we assume some process to run. The O'sBM framework enables us to simulate the processes needed. The tool makes the first match between the current area profile and company profile. The tool supports the search for a company to match an area, or the other way around. The match is made on the four dimensions (including time) the tool works with. The dynamics of the streams emitted and requested for by objects is an important matching criterion. The matched situation is the basis for further model runs. These runs will generate a set of possible impacts for a period the user can select. These are periods of 1 year, 3 years, 10 years, 30 years and 100 years.

DEVELOPMENT OF THE O'SBM BASED IT-FRAMEWORK

I base the information technological framework under development on an object oriented environmental modeling framework. I use a modular way of development to enable future expansion and adaptation to new developments. I use Paradigm+ for the system definition and Borland Delphi for the interface and programming modules. The basic geographical facilities are -- for now – also developed in Delphi. I develop the framework independently of the objects and streams used. The O'sBM framework facilitates the description of environmental objects with their incoming and outgoing streams. The framework supports the dynamic binding of environmental objects while performing a simulation.

Primary facilities for the environment modeling framework are:

- facilities to select and visualize the area. (graphical and administrative);
- interactive facilities to define the wanted changes (interventions).
- interactive facilities to explore the consequences of the proposed interventions (impact analysis).

- facilities to explore and visualize the results of the explorations (graphical and administrative);
- implementation and maintenance facilities for objects, streams and internal processes.

DEVELOPMENT OF ACTIVITY, INFRASTRUCTURE AND LOCATION PROFILES

The profiles are descriptions of the incoming and outgoing streams of the objects described (Figure 2). Per object-type I use domain expertise to describe and model these streams and processes. For every environmental object the prototype of the matching model will contain a basic set of streams. The stream descriptions in the table below are the building blocks for higher level streams. In the O'sBM framework I distinguish Area Static streams and Line Dynamic streams. This distinction is a distinction on the kind of behavior a stream performs. In theory all streams can perform both types of behavior. In practice we can consider the subdivision of the streams as noted in the table below. These basic streams can be combined with each other to specialize or represent real world streams relevant for the level of scale at hand.

> *Imagine the stream of students entering a school. When they enter they are a stream of sound producing people with little information. When they leave they produce as much sound but have gained information.*

Streams used in a modeling situation might also be combinations of both types.

> *Imagine a car moving. The car can be considered part of a stream composed of material, people and energy. These form a Line Dynamic stream. On the other hand the car produces sound and gasses. Sound and gasses can be considered Area Static streams. In this case the AS streams are part of the LD stream, thus their source is moving.*

Here follow the basic streams I am modeling in the prototype, followed by the initial parameters I am giving them:

Line Dynamic:

- **Organisms**: type, amount, size, weight, velocity, age.
- **Material**: type, amount, size, weight, tension, phase (solid, fluid, gas), age.

Area Static:

- **Vibrations**: frequency, amplitude, wavelength (for example: sound freq. 20 - 20000 Hz)
- **Information**: shape, contents, type, age.

As you notice these streams have implicit time references build in. This implicates that we can not use streams in static situations. The only way these streams can be distinguished is by observing a period of time. These basic stream definitions are the basic building blocks for behavior of objects. The observability of objects depends on their streams. As noted before objects are further described by their four dimensional shape. This shapes presumes some kind of materialization, organic or material.

DEVELOPMENT OF TYPES OF INTERVENTIONS

I distinguish two axes for the development of interventions. These axes are the level of scale of the change considered and the source of that change. I use two different origins (horizontally) and three levels of scale (vertically). From here I consider six types of potential interventions in an industrial area.

Scale→ **↓ Origin**	**Internal**	**External**
Parcel	'Reuse' (new users)	'Reconnection' (modified connection)
Complex	'Rehabilitation' (modified users)	'Rearrangement' (new type of connections)
Region	'Restructuring' (new types of users)	'Repositioning' (modified environment)

Industrial areas can enter a change process triggered by an intervention in the area itself. On the level of scale of the parcels the intervention will in most cases be the abandonment of that parcel. On the level of scale of a whole region the internal intervention will in many cases be the change of the production process of products and services. I consider this intervention to originate from inside the area when the decision to change lies with the current users of the area. Other trigger events for changes in industrial areas originate from the environment of that area. The change of activities or circumstances will influence different parameters. The most relevant parameters in current days are those concerning environmental characteristics and those concerning traffic and workforce. Short descriptions of these interventions follow hereafter.

An example of these external interventions, on the level of a parcel, is the modification of one of the connections of the parcel; The capacity of the connecting road infrastructure is changed. On the level of an industrial complex the intervention might be the elevation of a new type of connection; A rail connection is added.

.1 Reuse of a parcel

Reuse of a parcel is one of the most occurring changes in an industrial area. Reuse occurs when, for example, one of the parcels in an industrial area becomes abandoned or historic reservations on a parcel expire. This forces the responsible government to look for a new user. Sometimes this seems easy. There might, for example, be many potential users on a waiting list. It is however not that easy for the governor to find the **right** new user. Even when there are several potential users known, the governor has to decide which user fits the best to the current and future status of the area. A “first in first out” principle for the waiting list might not be the best option. Circumstances change, thus needed and available connections change.

.2 Rehabilitation of the activities in an area

I consider rehabilitation when within short time several parcels become available for reuse or when the area is enlarged or extended. Questions arise whether the area should maintain its original type of activities or change to other types. In the case of rehabilitation not the individual parcels are accounted for but the area as a whole. The area is considered in relation to its environment. The user now has to search for a new set of users that uses the existing infrastructure most efficiently.

.3 Restructuring of the industrial areas in a region

I consider restructuring to be the reprofiling of the areas identity towards other industrial areas in the region. This intervention will change the conditions needed for the area. The conditions most involved are connections to infrastructure and relations with workforce.

.4 Reconnection of a parcel

I consider reconnection to be the modification of infrastructure elements in the surroundings of a parcel or the changes of activities on connected parcels. Examples of this kind of interventions are digging a harbor and changing the capacity in road, rail, cable or pipe infrastructure. Other interventions belonging to this type are changes in available environmental conditions for natural and non natural gasses, sound, etc. The parcels conditions are changed without the parcel influencing that directly. These changing conditions might influence the efficiency of the current activities on the parcel.

.5 Rearrangement of an industrial area

I consider changes forced by changes in the local circumstances close around an area to be a rearrangement intervention. These are changes like the addition of new infrastructure connected to the industrial area (not on the level of a parcel within that area). This new infrastructure generates a gap between the used capacity and the available capacity at the infrastructure. This intervention might be a trigger to change the combination of activities in an industrial area.

.6 Repositioning of an industrial area in its environment

The last intervention is the repositioning of an industrial area. The repositioning might include the change from industrial area to trade, dwelling or office area. This intervention is mostly triggered by changes on regional or higher level on the field of large infrastructure projects, changes in workforce or changes in needed products and services. These interventions will change the area's conditions radically.

For example the change of laws concerning the allowed emissions of non natural gasses influences the activity that produces these emissions. The emitter might be forced to turn down production with the consequence of a less efficient use of production area.

DEVELOPMENT OF THE SELECTED OBJECTS, STREAMS AND PROCESSES.

In this paragraph I describe how I develop the objects, streams and processes needed to perform the matching and the impact assessment needed. I describe the development per aspect or knowledge domain. The descriptions are just short indicators of the way I am elaborating this development. The descriptions are not meant to be exhaustive. I will discuss the development of the objects, streams and processes related to natural environment, urban environment, infrastructure and to workforce. When the user proposes a change of activities the tool will check whether the new activity fits in the existing objects. The tool will also check whether surrounding infrastructure needs to be changed or whether this becomes void. This assessment will give a first view on the investments needed to implement the new activities.

.7 Objects, streams and processes in the natural environment

For the natural environment the objects, streams and processes I modeled on behalf of this tool concern sound level, air quality and water quality. The system enables the user to evaluate the impacts of a change in the industrial area on these aspects. The system also facilitates the interactive manipulation of the norms for the acceptable environmental capacity for noise and pollution. This enables decision makers to asses the impact of the establishment of new norms. The model generates the integrated impact that emerges from the proposed change. The resulting information indicates the relation between the proposed new activity in the area and the facilities and capacity of the natural area involved.

The streams I model concern the expel and intake of natural gasses like oxygen and carbon dioxide and of water as fluid and as vapor. Other modeled streams are streams the natural objects are sensitive for like sound, non natural gasses and raw material (crop, wood etc.). The objects involved are water basins, flora elements like forest, swamp and grassland and fauna elements like animals and fauna habitats. For these objects internal processes might be defined that generate more accurate responses by these objects to external stimuli. I will not develop these for the prototype.

.8 Objects, streams and processes in the urban environment

Defining the objects, streams and processes in the urban environment supports the assessment of impacts of a change in the industrial area or its environment on the urban fabric and processes available in the area. Changing activities might involve demolishing build up structures or reusing these. The basic streams I model are streams of people, goods, vibrations (including sound, energy and light streams) and information. Secondary streams are streams of natural and non natural gasses and streams of information concerning risks, meaning and laws. The basic objects I defined are building, paved areas and unpaved areas. For the processes that take place in the urban environment I defined floor area needs, cubic mass needs and needs for streams of people, goods, information and energy.

.9 Infrastructure objects, streams and processes

Defining the objects, streams and processes concerning the infrastructure supports the assessment of impacts of an intervention on the infrastructure. Changing the activities in an area influences the used capacity on infrastructure. If the new function in an area needs more infrastructure than available the infrastructure will be subject to congestion. When a new activity in an area needs less capacity the infrastructure is left with capacity for other activities. Infrastructure in this context can be anything that behaves as a carrier for connecting streams between urban objects. The modal split between the different types of infrastructure might change as a result of an intervention. When an intervention triggers the condition for congestion on an infrastructure element, investments might be a solution to the congestion. The model uses basic calculation numbers for the height of the investment needed. The streams defined with infrastructure directly concern the stream that infrastructure is meant for. Road infrastructure is meant to transport people and goods using cars as carriers. Cabling infrastructure is meant to support the transport of energy (electricity) and information. Objects defined for infrastructure concern elements of that infrastructure. Road segments, crossings, bridges, transformer stations, etc.. Processes that are under development concern for example models for the loss of electrical energy on a power line per distance unit.

.10 Workforce objects, streams and processes

The last set of objects, streams and processes I introduce are those that enable the assessment of the impacts on the workforce. To enable impacts I need to define the internal processes within workforce objects. The workforce objects I defined concern groups of workers belonging to the different types of workers. This workforce is modeled as a subset of the group of people as defined before as a stream. For this tool I consider two types of impacts that can occur for these objects. The first is the impact on the quantity of the workforce. In this case a certain type of workforce has to grow in number.

Only the number of people changes. The type of activity they have to perform does not change. We might for example change a ship dock into a container terminal. The type of work remains the same, getting goods on and off vessels. The number of workers needed however changes. Container terminals tend to use fewer workers than the general cargo vessel handling needs.

The second type of impact I consider is the impact on the quality of the workforce. In this I do not intend good or bad as qualifiers. I intend quality as reference to types of workers without the assumption of any ordering. In this case people have to change their workforce attribute. They become members of another workforce type.

An example for this change is the removal of a factory replacing it with an office building. The workers in the factory performed mainly rough handwork, more or less supported by machines. The workers in the office perform mainly delicate handwork (administrating) and headwork. This asks different groups of people. This change thus has its impact on the needed availability of certain types of people in the surroundings of the intervention.

Both impacts influence the composition of the workforce for the area. The environment as well as the workforce objects themselves might trigger these impacts. In the first case the need for certain types of workers makes the group adapt to this request. In the latter case for example education – this might be an internal process to the workforce objects -- changes the members of a group to another type of workers.

The streams that are related to this group are warmth, oxygen, carbon dioxide, information, money, material and food. Processes are education, digestion and service production.

CONCLUSIONS

With this tool I enable decision makers to explore possibilities rather than restrain their view on the solutions. The tool facilitates easy extension of the aspects involved in deciding. The O'sBM framework offers a very useful set of facilities to enable this kind of dynamic modeling. Matching can be used for exploration as long as we do not try to define all relationships on beforehand. The combination of matching facilities with the O'BM framework offers a promising solution to integral decision making problems.

OUTLOOK, FUTURE RESEARCH

The underlying O'sBM framework is still under development to allow even more flexibility and adaptation to the domains under consideration. The development of this tool is not at all finished. I plan to build a prototype of an "Activity to Environment Matching" tool. This tool will enable the user to select areas to locate different types of activities. The suitability of an area for the activities depends on the match between area and activity profiles.

The intended final products from this project are:

- Systematic notation for company profiles, area profiles and infrastructure profiles
- Comprehensive sets of object, stream and process definitions for natural and urban environments, infrastructure and workforce.

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