A Generic Support Module to Site Planning with Road Access

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ABSTRACT

The aim of this paper is to present a generic module providing several support functions for site planning. The site will be composed of several building lots in harmony with each other and the surroundings. The site plan should satisfy the goals, conditions, rules and regulations explicitly or implicitly indicated by the design brief. The maximum size and the placement area for the building on each of the lots are part of the plan. Proper road access should be provided for each of the building lots. A variety of ideas and patterns are used to create unified groups of building lots subject to certain restrictions on size, form and other attributes of the composition. Two basically different approaches for the road planning will be compared. One of them is space planning first with some preconceptions on the structure of the road network, followed by the actual road formation. The other one starts with planning the road access first - provided that the site is properly divided into subareas. In the second phase of this approach the building lots are formed on each of the sites created by the road network. In both approaches several iterations might be necessary. A logic programming prototype with Prolog implementation is presented. Connection to earlier support modules and ideas for an integrated support system are outlined.

1 INTRODUCTION

The complexity and multidisciplinary nature of site planning makes it plausible, that with the advent of computer era there are many efforts to provide computer support to site planning. In fact there are many commercial computer systems that deliver services in handling large amounts of geographical data, like MapInfo and ArchInfo. Other systems (ArchiCad, CorelCad, AutoCad) give excellent visualising tools for engineering type of work and rendering in great details is also possible.

On the other hand the type of assistance which gives open possibilities to combine different ways of thinking, encourages the creation and the definition of new concepts, possibly with knowledge- and rule-based systems running in the background - is still in a research phase and done in more or less developed prototypes. The present paper also presents such an approach, based on several years of co-operaration between the authors. Until now many prototypes has been tried out confidently showing a way for more and more interaction between them. Now is time for trying to gradually build up an integrated system with more and more

functionality, but still maintaining a high level of modularity for continuous development. The road-centred approach can be a good starting point, because road networks are influenced by many site planning aspects and having strong effects on many others. The network as a metaphor is also very powerful to suggest more integration and communication.

Such dialog may be conducted fruitfully between many areas of scientific research and of applications. Talking about methodology and different ways of thinking, flexible site planning support development may benefit particularly from several research fields. Artificial intelligence (AI WEB bibliography, Nielsson 1988, Luger 2002, Laurière 1990) contributes with human centred approaches. Operations research (Wolsey 1998, Glover et al. 1992, Dantzig 1963) is particularly strong in model development, feasibility studies and algorithmic model solving. Logic programming (Apt et al. 1999, Cetus Links, Sterling and Shapiro 1994, Gazdar & Mellish 1989) is the basis of very compact, powerful and expressive languages and strong reasoning. Knowledge-based- and rule-based systems, problem solving (Coyne et al 1989, Walker et al. 1990, Lucas and Gaag 1991, Polya 1990) principles and technology might provide the framework of an integrated system, which is modular, open and sufficiently flexible to accommodate new ideas, concepts and new ways of thinking. Furthermore they may work interactively giving sufficient explanation about their knowledge and activity. These are the components we are using in our research (Kovács, Kotsis and Dobosy 2000, 2002, Kovács 1980, 1991, 1992, 1993, Kovács and Galle 1994) . In a previous paper (Kovács & Kotsis 1998) we have outlined a system concept including an incremental development methodology and presented some prototype modules for assisting site planning. Our partner István Kotsis is working with site planning problems of very different scale in an architect firm. Beside his knowledge and experience we used relevant literature (Bacon 1967, Lynch and Hack 1989, Krier & Kohl 1997, Baker 1989, Meggyesi 1985, IJDC home, Lawson 1991, Mitchell 1992). Patterns (Alexander et al. 1977, Gamma et al. 1995, Grand 1998-9, 2002) help in many ways to get a variety of strong and flexible solutions both on a physical level, in systems development and in introducing alternative ways of thinking.

In this paper we present the idea of a road network centred support module to site planning, including its potential roles, main functionality, connections to other support modules and a prototype implementation with examples. The paper is structured the following way. Section 2 gives the basis for the discussion by an account on the interdependent nature of site planing with many sources of conditions, constraints, relations and criteria. Each of these sources can be a starting point to get new ideas or new ways of approaching the design task. They might also be considered as dialog partners to the present design process having a different focus at the moment. Two figures from a real site planning process illustrates some of these points. After some thoughts on the role of preliminary analysis, given in Section 3, the central part of the paper Section 4 discusses the two complementary approaches to site planning, i. e. the area-centred and the road network-centred methodology, the emphasis here is being on the latter. Many direct and indirect effects of the structure,

location and formation of road network are discussed in Section 5, with a summary of the main functions of a support module. Then Section 5 shortly overviews a logic programming / Prolog implementation of such a module. Several figures are illustrating some simple functions with further thoughts on potential continuation and importance. The final figure is an illustration of integrating the area- and road-based approaches to get a site partitioning with road access and house lot groups.

2 WHAT IS SITE PLANNING CONCERNED WITH?

The purpose of this section is to provide a view of the many interdependent aspects of site planning influencing both the process of design and the resulting site plan. This view should serve as a basis to imagine and gradually develop computer support modules and later a more integrated support system. We try to find the main sources for conditions and criteria of a good site plan, as they would naturally arise for the first time in the design process. Thereafter these subjects may reappear in any order requiring a gradually deepening understanding of each one of them.

The first round may be to look up what is on the site at the moment. Topography of the site includes the terrain that is unsuitable for roads or would make the construction very expensive. Lakes, ponds, brooks, rivers might give other concerns both of technical difficulties and of preserving natural beauty. A geographical survey may reveal hidden difficulties or limitations of the site. Other environmental questions include avoiding pollution (earth, water, air and noise), keeping & emphasising present values, e.g. green areas. After the potentials of nature on the site we may take a review of what kind of man made objects are found in the planning area and how they were / are / estimated to be used in the future.

The second group of sources of conditions & criteria may include the purpose of construction / reconstruction of the site including the main driving forces and interests behind the project. A short version of this - emphasising particularly the main customers' view - is the design brief. But there may be several other aspects of interests of the involved parties: present and future inhabitants, owners, investors and officials representing public policy and other groups of people. Economic interests are also many folded and include prices, costs, investment values and indirect consequences. The quality of the developed place and the quantity of the built houses and other facilities of different kind may be difficult and certainly insufficient to convert into pure economic terms. They have a substantial contribution to formulating basic criteria to judge the complete site plan and compare alternatives.

Town- & regional planning rules, regulations and recommendations represent the collected professional knowledge & experience, as well as international, national and local traditions and norms. This is a meeting place for architecture, regional- and town planning, low and politics. The past is forming the present. But the present site plan and its realisation are also going to change the future. Particularly on this and the neighbouring sites, but it may have an even larger effect by creating new patterns of objects and thoughts.

Land partitioning with functionality in mind and creation of a traffic network are two complementary activities non of which may dominate the other. Starting with either of them has certain advantages and disadvantages.

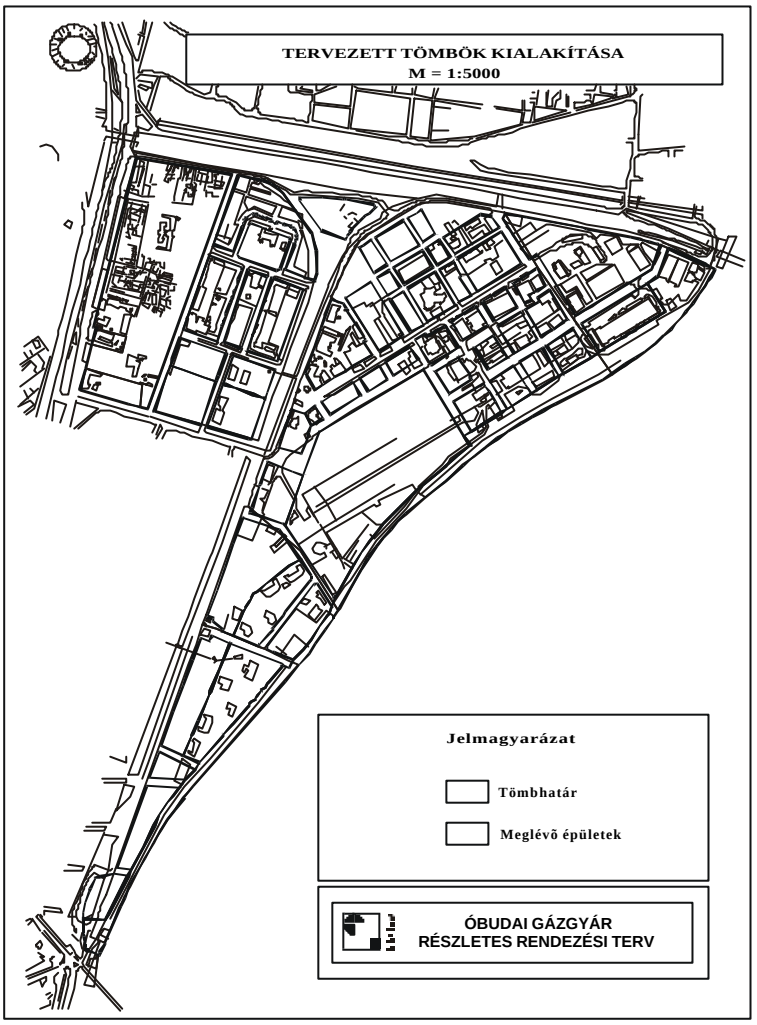

Figure 1: **Planning blocks on a site**

It is most likely, that these complementary aspects are going to be developed in dialog with each other and with many other aspects mentioned above. The road network should satisfy the demand for internal and external traffic, such that it joins well to the city road network; creates a desirable land partitioning on the site; ensures pedestrian and vehicular traffic safety; preserves natural resources and land value. The cost/benefit of road networks is quite complex, includes total road length, earthwork, maximum velocity, traffic intensity, road joining quality and maintenance. The road network should also be judged after aesthetic values both when travelling on it and when looking at it from smaller or larger distances. The land partitions - their sizes,

forms, locations and relative positions within the site - are at least as important as the traffic network. Connected pieces of land should be in harmony with their intended functionality, supporting the creation of appropriate house lot group patterns and other well formed units planned for the area.

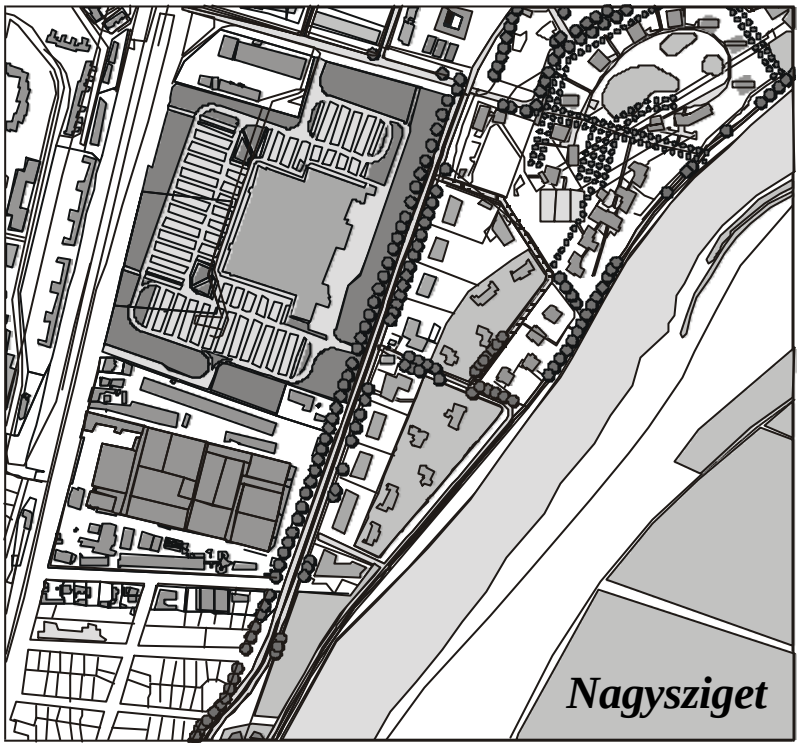

Figure 2: **Adding details, patterns and harmony**

Areas that cannot be built up for housing may be utilized for other purposes. As an illustration, Figures 1-2 show the result of two phases of site planning on a previously industrial area to be converted to a mixed utilisation district with apartment houses, a large software house, parks and sport facilities, etc. Figure 1 indicates the result of planning blocks, which are candidates of lots used for a variety of purposes. The northern border of the planning area is about one kilometre long. The Eastern border of the site is the river Danube, in the northern part of Budapest, Hungary. Figure 2 contains one enlarged detail of the previous figure indicating more details and also substantial changes in the organisation. Note particularly the nicely curved road with office buildings along and a park in the middle, which is seen in the northeast corner of the figure. This is now the new home of a famous company producing software systems for architects.

3 PRELIMINARY ANALYSIS

The purpose of preliminary analysis is to get and organise the available information in the light of the first understanding of the design brief. For example it can be a kind of feasibility study concerning the house lot sizes and forms. Similarly lot group patterns may be formed to get a variety of their typical characteristics. Larger potential planning units may be created from these housing patterns and other objects to be located in the planning area. Some of these larger units may be combined with each other, while certain combinations of the smaller or larger units may be considered as alternatives.

Looking at or analysing the site itself may give a complementary information on which parts of the site may accommodate what kind of planning units. It is not only a question on appropriate size and form, but many other aspects like the quality of the soil, available natural resources or values, geological and topological conditions, views to and from the surrounding areas, functionality and built-up of neighbouring sites may contribute to such a good match.

The third kind of preparation may be looking up the potential areas or channels through which the main roads may be conducted. An initial reasoning and some calculations may support or reject certain hypotheses about forming the road network. These results may be compared and combined with the previous two analyses on housing lot formations and site partitions.

The three kind of preliminary analyses or perhaps also others are meant to be assistance and not a limitation to form good site plan alternatives. Therefore creating and trying new ideas with some early sketches may come even before any analysis. Creative design ideas and analysis or planning of some detailed structures may also be done alternatingly.

4 ROAD ACCESS BASED SITE PLANNING

An advanced version of the site planning support system should not differentiate between area-based- and road access based design support. It should be the designer, who decides what kind of analysis, preparation or partial design to make next. Distinguishing the area- and road views serves the purpose of establishing two kinds of functionality in a simple form and then making a gradual development both conceptually and in the application software system. Finally the two views will be integrated.

Area based site planing with added road network can be shortly characterised the following way. It is given a planning area, either exactly or allowing for certain extensions and variations of other attributes. A preliminary analysis provided us with the limits of the sizes and other constraints to be imposed on the housing lots to be created. The main part of this approach produces variants with different number, size, shape and group formation of the housing lots. Finally road access is ensured for each of the housing lots on the basis of some preconception tacitly built into the lot

formations. For example lot groups can be moved or lots can be reduced a bit to form the road network. The advantage of this approach is the free and favourable area utilisation and it is quite restricted in road formation.

Road access based planning, the complemented approach, starts with designing the backbones of the road network - possible a single main road, such that the subareas created by the road network are appropriate for housing lot group formations. Secondary roads are determined by either of the two approaches. But there are many other conditions, constraints and criteria that should be considered when forming the main roads on the planning area. They constitute the basis of developing the Road Access Design Support Module [RAD_sm], the main subject of the present paper.

RAD_sm is invented to support site planning activities directly connected to vehicular- and pedestrian traffic. But as roads and streets have a large effect on many other aspects of site planing - close co-operation with other site planning & design activities and corresponding support modules are expected to be gradually developing. There should be a particular emphasis on the fact, that roads are not only connecting places, but also separating parts of the land and creating structure and patterns. In Section 2 we have overviewed some of the most relevant sources of conditions, constraints and criteria influencing design processes design decisions that may be supported by RAD_sm. In the present section we summarise the expectations and some of the early results from the support module.

We might say, that site planning is driven by the conditions & criteria outlined in Section 2 and based on a preliminary analysis showing hard- and soft facts as well as potentials of the site. But this is a strong simplification, because both the expectations and the site analysis are usually going on in parallel with the site planning process. In certain stages it may be very useful to think and sketch several alternatives without having too much influence by the 'hard' facts and conditions, some of which may not be that hard after all. Good alternatives violating some of the basic facts or assumptions may have very positive effect on the design process - even if they are really infeasible in their first stated form. Therefore we mention a few wild ideas to create alternatives to the road network. The designer may add her own ideas any time - she is the one who is controlling the system anyway - and may get inspiration from one of the 'wild' alternatives fulfilling some of the expectations substantially better than others. In a later stage, revisions, compromises or combinations of good partial designs may lead to generally better site plans.

Let's start with finding basic alternative backbones of the road network. First we may note lines or sets of appropriate boundary points that may be used as traffic entrance / exit to the planning area. Some of those points may be connected by simple polylines in different ways - creating a set of sufficiently varied alternatives. Proper land partitioning and connecting certain internal points or areas may give sufficient guidance. Some essential features of the planning area may also be helpful. When selecting our main alternatives to work further with, other criteria may also be used like variability / flexibility, representatives of some good ideas/principles relevant on this site, natural forms and patterns, good potentials for connecting necessary side

roads, etc. Patterns may be used to ensure flexibility and expressive power; in creating road networks, housing lot groups, comfortable environments; when establishing new concepts or relationships to organise our thoughts, the physical objects and the goals to achieve. (Alexander et al 1977)

Ideally, each of the constraints, conditions or criteria that is substantial and closely related to the road network, should have some - direct or indirect - ways of influencing the road formation. This may happen either by suggesting a new starting network alternative or by modifying, combining the existing ideas and their concrete realisations. For this reason we mention a few main support functions which are planned or implemented for the RAD_sm:

- connecting two or more points by polylines, in alternative ways
- determining a polyline through / avoiding certain points or areas
- partition a given area into subareas of desired size and form / pattern
- converting a polyline into a polybezier line
- modifying a road (polybezier line) according to actual traffic safety requirements
- planning / changing a road to reduce construction costs
- connections to other modules (site partitioning, environment, economy, etc.)

These support functions should work so, that their combination with other support modules should be relatively easy, flexible and open for further development.

5 ROAD ACCCESS DESIGN SUPPORT MODULE

The purpose and some of the functionality of RAD_sm has been outlined in the foregoing section. Now we would like to talk about the implementation of this module and show a few examples to get a first impression. RAD_sm is built up according to logic programming principles and implemented fully in Prolog (using LPA WIN-Prolog), including the interface window and the graphics. Future versions will communicate with various databases and modules written in other computer languages. The graphic window in the present implementation of the module is only used for visualising the sketches, which are the alternative solutions produced by this module. But through some of our other modules we can have interactive graphics as well, for example sketches by mouse and corresponding semantic information may be received. As a first example, let us consider a site with two boundary points A,B as entrance / exit to the site. Furthermore let C,D be two given internal points of the site. The task is to create a variety of quite different and good looking paths through the points A-C-D-B. Figure 3 shows three of the solutions.

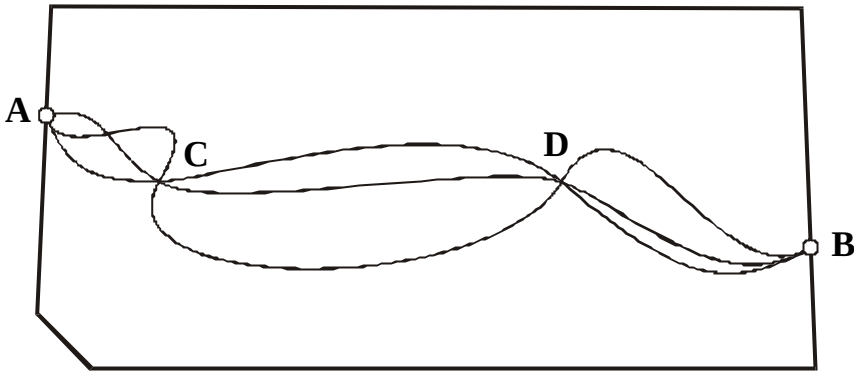

Figure 3: **Several paths through the inner points C,D**

A first rough version of a path or road may be represented as a polyline, which is replaced by a refinement of a corresponding bezier curve going through the same nodes, but being nicely curved. Most graphics programs use bezier curves to create graphics by mouse or pen. The handles of the bezier curves are visually available, but their numerical representation is not available for reasoning and combining it with knowledge based systems, using non-visual objects, attributes and relations. We have chosen logic programming which makes the representation of semantic information, knowledge and reasoning possible. But we had to extend the modest graphics system available in our Prolog. As part of this program a kind of relational representation of geometry had to be built up. Returning to bezier curves, we have used two new representations in which radii of curvatures and tangents of the curves at the defining points are directly available. The result is quite satisfactory, because now we can easily represent and reason with road safety rules when creating new road satisfying many other conditions and criteria. Figure 4 shows the same three solutions together with their bezier handles, which are now useful in both manual and in reasoned automatic changes.

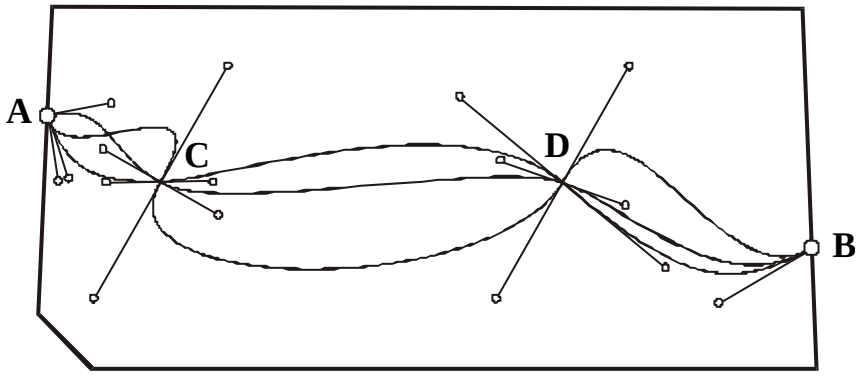

Figure 4: **Bezier handles for connections to rule- & knowledge bases**

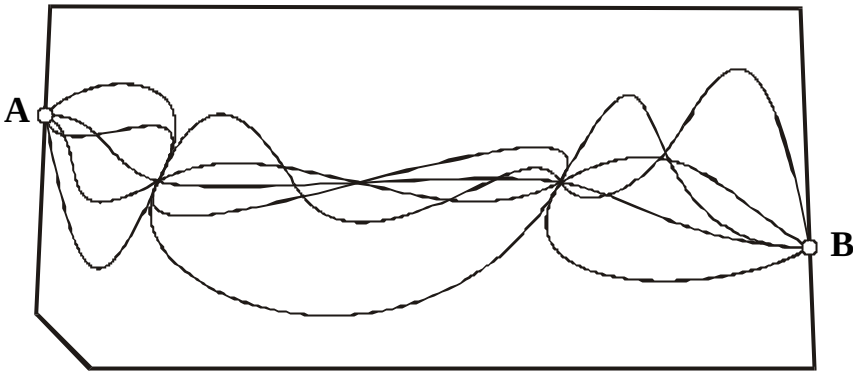

Figure 5: **Further alternative paths and patterns**

In Figure 5 five additional solutions of our simple task is shown. The point here is not only to show how many and how different the good-looking solutions are. If we look at the Figures 3 and 5, then we may see two emerging patterns that might emphasise different aspects of the site planning. How does en entire network of roads or footpaths look like from a larger distance? What impression does it create within you? Can it be a symbol of the place or the group of people living here, including their activities? So the originally linear question of a single road is now extended to be several dimensional.

As a second example, let's take a number of 'obstacles' (existing buildings or other objects) on the same site. Can we find a well-formed road between the two points A,B avoiding all the obstacles? Figure 6 shows a solution, which is smooth, short and doesn't have sharp curves. This one and other alternatives may be created through several steps, using polylines and gradual refinement of polybezier lines.

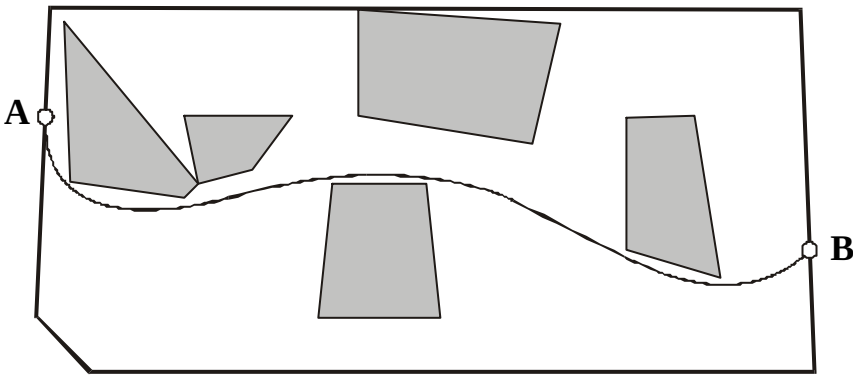

Figure 6: **A smooth, short path avoiding obstacles**

Finally Figure 7 indicates a co-operation between RAD_sm and the Site Partitioning module. It is given a rather irregular site with a steep hill at the Southern border and a

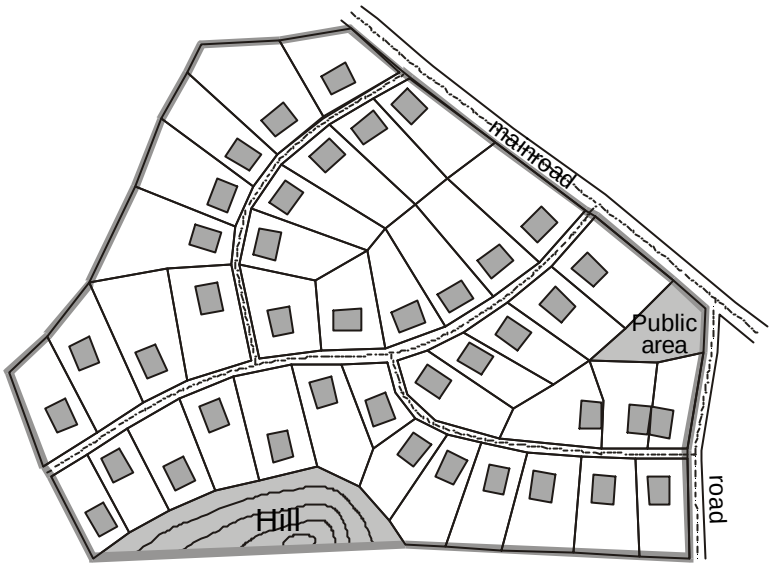

Figure 7: **Combining road access with site partitioning**

small public area in the northeaster corner. There are two asphalt roads denoted on the map and an earth road ending at the middle of the short southwestern side. The planning area may be decomposed by a road network in several ways. The one shown on the figure is quite smooth, connecting to all available roads and partitioning the site into four subareas, each of which can accommodate good house lot patterns. All sites have a direct access to at least one of the roads. Two of the patterns have a relatively large uninterrupted green area, which may be used together or separated only in principle without fences. The Southern housing lot group is going around the hill from which there is probably a nice view over the well organised 'village centre', which is pleasantly curved and gives an interesting view.

6 CONCLUSION

We have presented a support module to site planning that may assist in generating substantially different alternative road networks in co-operation with knowledge bases. Knowledge systems may represent for example knowledge and experience on traffic safety regulations, recommendations and local traditions on forming housing lots and lot patterns. The knowledge bases may also be built as support modules to site planning giving a way to gradually create and open integrated support system with more and more modules and flexibility to incorporate the users new ideas, concepts and way of thinking. We have previously built several support modules which can and will be integrated with the new module on network centred site planning support. The network metaphor and a variety of patterns will help making an open system with high flexibility.

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