

# **LOCATION BASED SERVICES AS CHALLENGING CASES FOR PROJECT-DRIVEN EDUCATION**

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## **ABSTRACT**

The Delft University of Technology (the Netherlands) opts to educate the students with a proper mix of knowledge, perception and skills in science, research and design. Project-driven education is very suitable to obtain these goals. The developments in Location Based Services, as an apparent link between positioning, geo-information services and cartography, are ideal cases that can be investigated and programmed during a short, but intensive course on GIS design & implementation. This paper presents the results of a five-year educational experience on this topic with ArcView 3.2, which has proven to be a very appropriate environment for prototyping LBS-applications.

## **1. INTRODUCTION**

The perception of the results of education can be partly determined by looking at the quality of the graduated geodesists and the way in which they meet a certain professional or research profile based on their own preference. Another possibility is to have a closer look at the present curriculum. For this reason the involved lecturer and students of the MSc course GIS design & implementation decided to evaluate whether the requirements to provide information are fulfilled. This subject is very suitable for such an evaluation, because one of the aims is to establish a good cooperation with practice. Moreover the results are often so successful, that they would justify writing an article about it even without this extensive introduction. Special is also the chosen form: by means of a GIS development course in accordance with the Rapid Application Development (RAD) approach the emphasis lies not only on the final result, but also on carrying out an assignment according a thematic approach.

This paper is based on the results of a five-year experience and the reports of the students, which took this course in the past years. An attempt has been made to include parts of these reports as much as possible in an integral way. Although this may cause some inconsistency in style, it justifies the work of the students. After an overall description of the objectives of the course, the developed applications in the field of Location Based Services (LBS) will be dealt with. Within LBS a number of core elements of the geodetic education converge. Positioning, routing, map-making and –integration are researchable elements within LBS. The use of low-cost GPS-code receivers and GSM-Base

Service Area techniques, dynamic network analyses and the limited possibilities of small displays have to be taken into account.

The past years a number of prototypes have been built in which always a certain part of these elements has been elaborated. It involves the applications *Track 'n' Go*, *Skoeter* and *MoNa*, which has been developed over the past years. *Track 'n' Go* is a Personal Digital Assistant (PDA) guiding system for walking and cycling routes. *Skoeter* is a so-called 'pizza application', which guides the user – based on a integrated GPS/cellular telephone – to the wanted Point of Interest. *MoNa* is a Mobile Network Analyser, a simulator that makes it possible to get an impression of the quality of GSM (cellular phone) positioning. To make the whole story more 'realistic' a co-operation with ANWB, CMG and KPN-Mobile has been established during the past years. ANWB and KPN-Mobile delivered the cases, whereas CMG brought in knowledge and experience in the field of system development and project management. Because not only the final results counts, but also the way that led to it, the used RAD-method will be discussed as well.

The GIS package ArcView 3.2a with the extensions Network and Tracking Analyst and the development environment Avenue have been used for prototyping. Although ESRI itself has taken a turn with ArcGIS, this environment has proven to be very suitable for short and iterative development projects, especially for an object-oriented approach. Finally earlier developed applications will be reviewed.

## **2. EDUCATIONAL OBJECTIVES**

In order to mobilize the geodesist as an integrator within the geo-information process in a proper way, it is important to get an insight in the geo-ICT field of action. Together with a course in geo-information analyses a more technical content oriented course, like GIS design & implementation is needed to reach the following objectives:

- Having knowledge of and developing skills in various methodologies and devices for designing, building and implementing GIS,
- Being able to work as a team and to determine and establish the functional specifications of a GIS in a programme of requirements in consensus with the end-user or client. Based on this to make a design and to build and implement it in accordance with an agreed methodology and planning,
- Object-oriented programming and developing in a specific GIS development environment and making this applicable in a practice oriented situation.

All this has to be achieved in a period of seven weeks with a total study-effort of 120 hours. This puts of course a great pressure on the group of students, the supervisor and the client. One of the possibilities to handle this pressure is to create enthusiasm. For this reason a new and actual topic is selected every year involving preferably a new end-user or client. Due to the chosen development methodology this client plays a very active and important role. It

is agreed upon that the work will be carried out without financial compensation, but also without a defined final result at beforehand. It is just not possible to make this demand.

During the development phase the students have to face a number of system development methods. The methods involved are among others the System Development Methodology (SDM) and the Iterative/Interactive Application Development. All these forms aim at realizing an original thought into an understandable idea (implementation). It has to be avoided that the project slows down and frustrates, because components in data transfer and in objectives do not match. By an (non-) intentional chosen slightly chaotic mentoring of this course the appearance of these problems is deliberately strived after in order to confront the students with them. After all communication is a two-way process and not everybody is a good listener. By choosing a method with very interactive communication techniques, like brainstorming, programming sessions and prototyping, this becomes often painfully clear to the students involved.

This approach could result in a lot of mixed feelings afterwards. This can be learned from the following assessment made by the students:

*Designing, building and implementing of a route guiding system has been fun and it has been extremely pleasant to make use of our GIS-knowledge. The project has been split up in order to allow students working in smaller groups. Of course these parts have to be joined at the end. This asks for a good project management. This could not be realized, because all the students were busy with building and learning. In fact a project leader is necessary to steer the project in the right direction. However, the small scale of the project made it possible work without project leader after all.*

This was – however - not intended. 'Project leader' and 'project supervisor' is not the same. In practice it means that lecturers have to exercise restraint. It goes without saying that the built applications are evaluated, cleared and if necessary built out by the supervisors at the end of the project, before delivery. And although the final goal is not the end product, it is pleasant to see that most of the time the project resulted in a grown-up prototype application.

### **3. THE CASES**

#### *3.1 Track 'n' Go: Walk your PDA for a change (2000)*

Track 'n' Go is an informative Internet application for the selection of walking and cycling routes and a navigation system, which can be divided into a user application for a Personal Digital Assistant (PDA) and a server application, that provides the user with itineraries. These three parts are built as a prototype in ArcView trying to simulate and present the communication and data flow between these three parts as best as possible. In general the system works as follows: the user selects at home via the Internet application of at the spot via the PDA on the server a route he likes to cycle or walk (Figure 1).

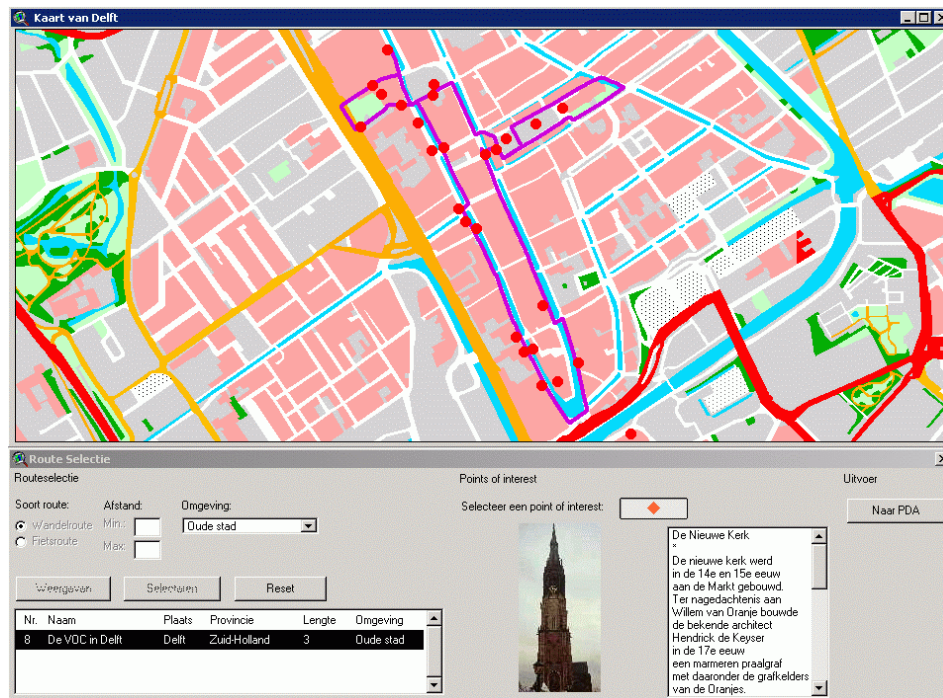


Figure 1: Selection of the desired route.

Upon arrival in the field the GPS receiver determines the current position of the user and this position is sent on via the PDA to the central server. On the basis of the route and the current position the server computes a map of the actual situation, a route direction and looks if there exists an object of interest in the neighbourhood. The server sends the map and other information back to the PDA, on which the user can see his position, his travelled road, his route direction and possible objects of interest. The user can make a choice between a simplified map and a detailed map around his present position. The route direction is given as (spoken) text as well as a pictogram. In case of objects of interest background information can be written or a picture or video can be looked at. Furthermore the system can guide the user from and to a route in case of a wrong turn has been taken or to give the user the possibility to start from a station or a parking place. Although the prototype misses still some functionality and does not work completely stabile, it does prove that a hand-held navigation system is technically possible. However, no attention has been paid to the communication between the PDA and the central Track 'n' Go server.

### 3.2 *Skoeter – Croquettes per SMS! (2001)*

The project *Skoeter* is comparable with *Track 'n' Go*. However, in this case more attention has been paid to the actual use of an available GPS/GSM telephone: the *Benefon Esc!*. Currently Garmin offers the *Navtalk*. (Figure 2).



Figure 2: GPS and GSM in one device: Garmin Navtalk / Benefon Esc!

The Benefon Esc! is able to send a SMS including the location of the user. Imagine you are at the market place in Delft and you feel like 'Foe Yong Hai'. If you do not know that there is a Chinese restaurant around the corner, you can send a SMS to a service provider like the ANWB (Royal Dutch Touring Club). After a few seconds you will receive a SMS with the address of and the route to the restaurant.

With the sent SMS as input, the server has the possibility to generate the output. In the server part various computations are made which results in finding the nearest POI. The SMS has to fulfil a number of requirements. Each category and specification has its own identification code. E.g. ETD is the identification code for 'Eating and Drinking' and CHI for the specification 'Chinese Restaurant'. In case the client has no preference, it is not necessary to mention the specification. For this also an identification code exists. Also the maximum distance one likes to cover (measured via the road) and the means of transportation have their own identification code. All identification codes can be found in a short and easy to handle manual that comes with the Skoeter Service.

The prototype of Skoeter has been developed within the development environment of GIS ArcView. By making use of a dynamic design strategy enabling intensive contact with the client/end user it becomes possible to achieve a real result within a short period of time. Via this way of project-driven education the students had the possibility to get in touch with the practical applications of the discipline and with the methodology and skills that are necessary to solve the encountered problems. However, the disadvantage of project-driven education is that in order to make it well-founded in a didactic way, everybody has to carry out all operations and tasks. As a result of this the efficiency of the project decreases: either the quality increases or the project will take more time. This might be disappointing for the client. Nevertheless this project has been experienced as useful. Moreover a good and real result has been achieved.

### 3.3 MoNa – Mobile Network Analyser (2001)

The development of GSM (cellular phones) has created new possibilities for positioning. Of vital importance for this kind of positioning are the mobile telephones of the users of GSM and the infrastructure of GSM that has been built up by various network providers. The current GSM network is irregularly spread over the country. Each of the bases has its own 'service area' i.e. BSA (Base Service Area), in which all mobile telephones located in this BSA cell are linked to this GSM mast (see figure 3).

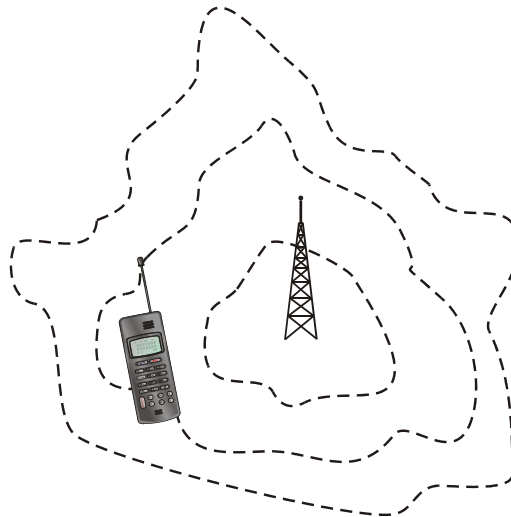


Figure 3: Cellular phone location determination by Base Service Areas

The shape of this BSA cell depends on the position of the antennas on the mast. Besides the presence of buildings and topography is of importance (see figure 4).

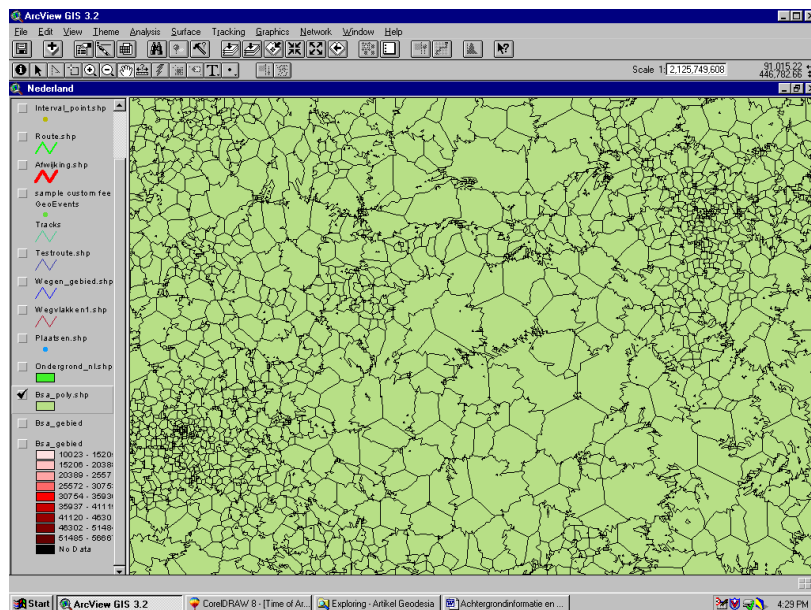


Figure 4: Example coverage of Base Service Areas

The providers of mobile telephone services make use of files recording the BSA cells that are among other things used for improvement of the mobile

network. The file consists of a number of data from each BSA cell, of which especially the BSA code and the coordinates of the GSM mast of this BSA cell are important for the present shape of positioning by means of GSM. If the user turns on his mobile telephone he is automatically linked to the GSM mast of the BSA cell where he is located. Other GSM masts of surrounding areas are not used. In case the position moves to another BSA cell, a link with a new GSM mast is automatically established.

As stated before the GSM positioning in its current shape is restricted to pointing out the coordinates of the GSM mast to which the GSM is linked. The size of the corresponding BSA serves as a quality indicator. Of course this quality leaves a lot to be desired. However, the possible position of the user can be limited to positions on the road network. The final quality of GSM positioning depends on a great number of factors, i.e. the complexity of the road network and the specific position of the antennas, which appears from the configuration of the BSA cells. After all positioning makes active use of the road network. The complexity of this system influences the number of possible positions. To detect on which scale level of roads (highways, motorways, secondary roads, etc.) positioning is possible, various road networks can be chosen. The influence of adding or removing an antenna can be tested by choosing the corresponding BSA cells file.

All roads with a BSA code that are included in the BSA registration are selected. The road selection will be defined as a new road network. On the basis of the first and last BSA cell in the file the start and end point of the driven route is determined with the help of 'Network Analyst'. The better the points are known, the more precise the route calculation will be. Next the shortest route will be calculated on the new road network. It is possible that the first attempt to make a route will not be successful, because the network is not complete. This could be the case when the sample frequency does not trace enough BSA cells and thus the road network is not covered entirely (see figure 5).



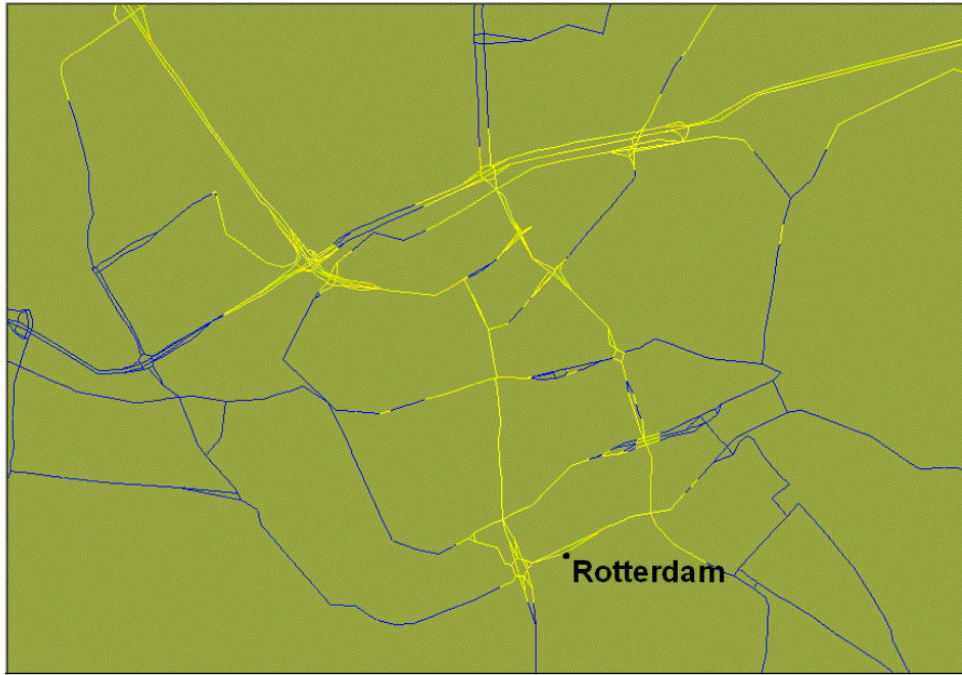


Figure 5: The BSA registration selects an incomplete road network.

If this happens a warning appears and the user gets the possibility to extend all selected roads with adjacent road parts. This selection is added to the original selection. As soon as the new network has been defined, once again a shortest route will be calculated. Due to the extension the change becomes much bigger that roads are unjust added. As a result of this it becomes possible that a shortest route will be calculated which does not correspond with the actual driven road. Figure 6 shows where it went wrong. In a simulation file the car has actually driven through the south, but via the extension it becomes possible to calculate a shorter route.



Figure 6: The driven route and the calculated route differ.



A possible solution to solve this problem is to add a condition for calculating the route. This condition should be that the route should pass all original BSA cells chronologically. This prevents that parts of the input are neglected.

### *3.4 Bike by Satellite: biking with GPS (2002)*

For years and years the ANWB (Royal Dutch Touring Club) sees to it that recreational cyclists are guided along all beautiful spots in the Netherlands. For this purposes signs and road markers are placed in the field and booklets with a description are published. The disadvantage is that it is very expensive to develop and not easy to keep up-to-date. Besides cyclists often prefer to find their own way instead of following a predefined route. For this purpose a group of students developed the system Bike by Satellite. On the basis of this a cyclist can compose his own route. The coordinates of the points in the route are loaded in a GPS receiver and the cyclist can set off for his trip.

The objective was to make a design for a bike navigation system. With the help of a GPS receiver the cyclist is navigated along various objects of interest. If desired the user can arrange or change the route interactively. During the project there has been a close cooperation with clients, i.e. the ANWB (Department of Marketing, Communication and Innovation) and the Recreation Board Drenthe. After the various design phases the intended users and managers of the system were asked to give feedback in order to respond better and faster to their wishes during the design.

The project Bike by Satellite exists of the design, building and implementation of a prototype for a route navigation system for cycling. The moors in the south-eastern part of Drenthe were chosen as test area for the design (see Figure 7). The final system should be applicable for a larger area of this region, including a part of Germany.

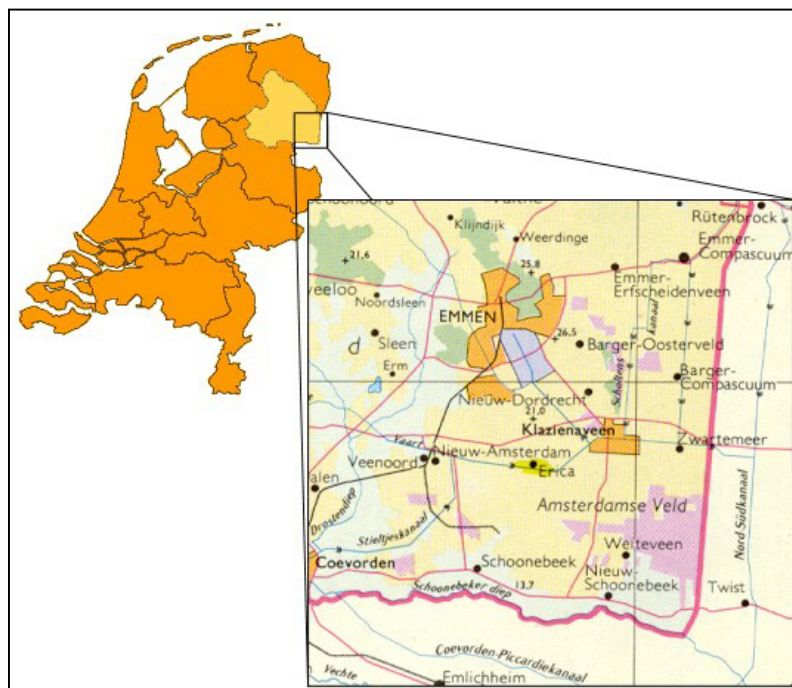


Figure 7: The test area for which Bike by Satellite has been developed.

An important reason for designing such a system is to attract more tourists to this area. At the Tourist Offices and the ANWB booklets with various existing cycle routes can be obtained. In general this are predefined routes, signposted or to be driven on the basis of a map and road markers in the field. In the booklets the route is shown on a map, which makes it possible that the user always can find his way, even if he went in the wrong direction or if road markers have disappeared.

However, the routes are laid down on paper and out-of-date route descriptions may cause problems. Road markers may have disappeared and roads in the field change continuously or are limited available (e.g. as a result of the construction of new infrastructure or road works). Of course it is possible to make and sell up-dates regularly, but making up-dates on paper as well as in the field is very expensive.

A solution to attract tourist to this area and to avoid the costs of updates at the same time, is the development of a system on the basis of which the user can select cycle routes by his own. With this he can select existing routes, tailor them to his requirements, link various routes or even design a new route. Depending on his interest the cyclist has the possibility to choose from different designs. The system calculates a number of points on the route (waypoints) that can be loaded in a GPS receiver. Besides the user can print a description of the objects of interest along the route informing him about the things he will see.

The advantage of such a GIS is that also the management of the system is included. This makes it possible to record (temporary) adjustments of the road network. In this way road works can be taken into account. Also an option to record or modify new objects of interest (on the spot) belongs to the possibilities of the system.

#### **4. ESRI OBJECT ORIENTED GIS DEVELOPMENT ENVIRONMENTS**

This paragraph is meant for giving insight in the use of Object Oriented (OO) GIS development environments within educational environments. Two OO GIS development environments from ESRI that are used during the practical as well as a new environment of the same supplier will be discussed.

##### *4.1 Object orientation in ArcView*

The first GIS development environment to be dealt with is ArcView. For some years several versions of this product are used at the Department of Geodesy. Hence considerable experience has been built up. Programming within ArcView is based on Avenue. Avenue is an object-oriented language, which makes it possible for the programmer to make use of a large collection of objects from ArcView. However within Avenue it is impossible to define new classes, to derive new classes from existing classes or to customize existing classes. Although Avenue is called an object-oriented language, the programmer has not the possibility to implement all theoretical OO programming operations within ArcView. E.g. the programmer cannot add functions to classes, which are necessary in order to carry out a certain

assignment with the object. For this reason scripts have to be written that perform certain actions. As a result of this a number of advantages of OO programming cannot be reached. In particular the advantage of joining data and the corresponding operations on these data in an object resulting in enlargement of the practicability and operability is lacking. It is however possible to make use of inheritance within the classes of ArcView. But the programmer cannot make derivatives from these classes in order to extend the model with classes that comply with specific wishes.

How can this all be brought in practice? As stated before implementing the theory of object oriented programming within Avenue is limited to the use of pre-defined classes. The programmer has the liberty to make new instances on the basis of which the built-in operations can be performed. This has however the advantage that the data and the authorized operations are together. It is clear which operations with an object can be performed. As long as no new completed operations have to be used to carry out the assignment this also gives a well-organized code.

Of course one may not expect that everybody can produce the needed code without errors. For this reason it is important that the development environment in case of finding an error notifies the user in a good way what went wrong and where the error has occurred in the code. If an error occurs an error message is given in ArcView and the cursor points out to the place where the error occurred in the Avenue source code. In most of the cases this will be the place where the error really occurred giving the programmer the possibility to correct the error easily.

On the basis of Avenue it is in principle possible to automate all manually activities, which are performed within ArcView. Besides the user interface can be adapted to one own preference. The programmer can add new buttons to the standard toolbar situated at the top of the ArcView window. Via message boxes users can make choices or information can be shown. Finally a Dialog Designer is available for making more extensive dialog boxes in which various controls can be presented, showing the choices that belong together, in a well organized to the users. It is however not possible to work totally without the ArcView main window.

It is definitely possible to customize the user interface of ArcView on the basis of Avenue to present to persons not so familiar with the functioning of ArcView a tailor-made interface, which facilitates working with the application. During the practical the adjustment of the user interface has been limited to adding some buttons to the toolbar and the (sometimes very extensive) use of message boxes to provide the user with information or to allow the user to make a choice. For very user-friendly and robust applications, like the wanted cycle route planner, the possibilities for customizing the user interface within ArcView seem to be too limited. In this case it might be better to use the GUI with another development environment and to have it working together with the GIS functionality in which ArcView is specialized. ArcView has several possibilities for this, but this falls outside the scope of this section.

## 4.2 Object orientation in ArcPad

In 2002 use is made of ArcPad and the corresponding ArcPad Application Builder to add new functionality. ArcPad is a GIS that is especially designed to make GIS functionality available on small handheld computers, also called PDAs. ArcPad works on a desktop computer, which is particularly convenient for developing and testing new ArcPad applications.

For the programming of applications for ArcPad with the ArcPad Application Builder use is made of the language Vbscript. Through the ArcPad Application Builder (see figure 8) a form can be made for the presentation to and the interaction with the user. Besides the toolbars of ArcPad can be customized and extended with own buttons. Due to this new functionality becomes easily accessible for the user.

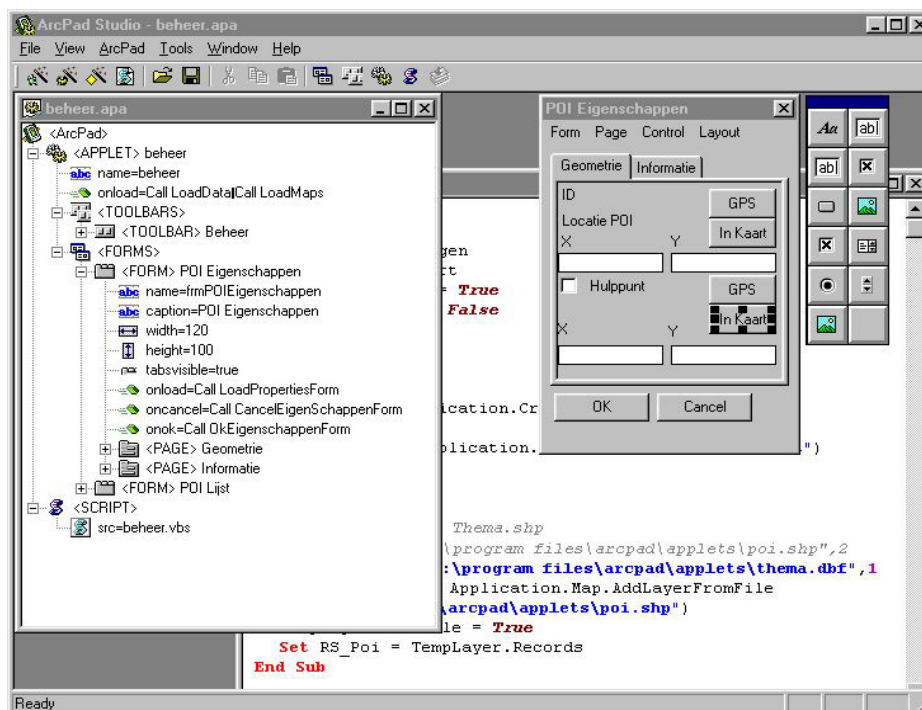


Figure 8: The ArcPad Application Builder.

Concerning the use of objects it becomes clear that for ArcPad almost the same holds as for ArcView. New instances can be made, but it is not possible to define new classes. An example of how inheritance could be applied is the use of the GPS object within ArcPad. Within ArcPad there is an object available that deals with the communication with the connected GPS receivers. In this way it is easy to read in the coordinates of the present position. Within the practical use was made of the Dutch RD-system to describe the coordinates, whereas for GPS usually the WGS'84 coordinate system is used. For this reason a conversion between both systems became necessary. It would have been convenient to make a derivative of the GPS object in which besides the reading out the Latitude and Longitude in WGS'84 also the reading out of RD coordinates could have been realized. Besides this object could also be used in other programmes that need RD coordinates from the GPS receiver. But because this was not possible, it became necessary to write separate functions to handle the conversion.

### *4.3 ArcGIS*

With ArcGIS ESRI targeted at an integrated GIS environment based on open standards like COM and XML. Contrary to ArcView and ArcInfo which were quite different as far as structure and file use were concerned. The ArcGIS family is only available for Windows systems and no longer for the Unix family. The ArcGIS system is meant for all GIS users and offers possibilities ranging from the use of local shape files to the set up of Geo-Databases suitable for many simultaneous users. During the practical no use was made of other products from the ArcGIS line besides ArcPad. Nevertheless it would be interesting to see how ArcGIS could be used for the realization of a system as described during the practical. On the basis of ArcGIS and the corresponding ArcObjects and Visual Basic for Applications a very suitable application could be made. In this case the route planner could make use of well-organized screens showing several choices at the same time. The developer can set down the mode of operation of the system without the limitations coming from GIS software, which was also clearly the case with ArcView. Perhaps that a practical exercise like this could be the key to a better and for sure a more user-friendly result. The forms, like they are used within ArcPad, on which the user gets his information presented in a well-organized way, also give an indication for this. It should be mentioned that the development of a good user interface is not an easy task and that the large choice of possibilities will make more demands upon the developers.

## **5. CONCLUSIONS**

Within the course on GIS Design and Implementation extensive use is made of the GIS package ArcView 3.2a with the extensions Network and Tracking Analyst. Several prototypes of Location Based Services are developed through programming within the object-oriented language Avenue. Although ESRI itself has taken a turn with ArcGIS, this environment has proven to be very suitable for short and iterative development projects.

By making use of a dynamic design strategy like Rapid Application Development that enables intensive contact with the client / end user it becomes possible to achieve auspicious results within a short period of time. Via this way of project-driven education the students had the possibility to get in touch with the practical applications of the discipline and with the methodology and skills that are necessary to solve the encountered problems.

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