

# Map of Denmark

*First-Year Project, Bachelor in Software Development,  
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Group 12

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# Chapter 1

## Preface

This report is the result of a project at the bachelor in Software Development on the IT University of Copenhagen spanning from early March 2011 to late May 2011. The project was given as a first semester project in groups of 4 to 5 randomly picked students. 2.5 months of the semester was set aside for this project. The time not spent on the report was spent on planning, coding, thorough testing and bugfixing of the actual program.

## Chapter 2

# Background

### 2.1 Problem area

Over the last decade people have switched from traditional roadmaps to using the web-maps. This is a change without any significant negative side-effects. The online services remove all the problems with determining the quickest route between two points and you spend no time flipping the pages of the map to find what you need. With the smartphones on the market today, the online maps are even more useful, since you no longer need to prepare your trip before you leave.

The online maps have now been used for many years and haven't been slow at adopting new features to improve their usability. Many has implemented satellite-maps, that allow us to see the entire planet from above, and lately the feature called Google Street View has upped the stakes, when allowing us to look in any direction from a given point of a road. The two maps that we use the most are Google Maps and the Danish map called Krak. These maps both have the mentioned features but slight differences in the way the user navigates and searches for routes.

Because of the widespread knowledge of the online maps, the users have grown accustomed to certain features and ways of using the map. It is very important that we, with a new map program, use this knowledge to our advantage and don't try to reinvent the wheel. By using some of the commonly used controls in our map, a user will be able to quickly adapt to our program and use it efficiently.

## 2.2 Requirements for the map

Our teachers had a few requirements for features in the project. The requirements were presented to us during development, in 3 steps. This made it easier for us to focus on getting the basic features of the program to work, but it made it harder for us to plan ahead as well.

Here is a list of the features we had to implement:

- We had to make a visual representation of all the roads from the dataset.
- We had to draw different kinds of roads in different colors.
- We had to adjust our drawing of the roads, to the window size of our user interface.
- We had to make mouse zooming possible. The user should be able to drag and select an area with the mouse, creating a square or rectangle, and zoom in on the selected area.
- We had to implement a method to find a route from one point on the map to another, and we had to allow the user to find that route by clicking at each of the points.

We had to consider these requirements while deciding how the program should be designed. Of course, some of the requirements were so self explanatory that we would have made them regardless of them being required.

## 2.3 Our requirements

In the process of designing the program, we made some requirements, that we wanted to make sure was met, before making more advanced features. Since it was required to make the user able to zoom-in on the map, we found it logical to allow him or her to:

- Zoom out
- Pan around on the map

With these basic features covered, we decided which advanced featured we wanted to implement. In order to give the user a chance to find more specific places, we decided to show the user the name of the road closest to the cursor. This means that the user can get orientated without clicking or pressing any buttons.

The most interesting feature of our Map of Denmark is perhaps the option of selecting whether you want to travel by car or by bicycle. Many Danish people use bicycles to travel and as such this feature is a very relevant and nice one to have in the software. It is a feature not usually seen on international maps - this is most likely due to the size of these maps.

We also decided to let the user create routes with an unlimited amount of waypoints. This makes our map well suited for planning bicycling trips or longer car rides where you want to reach more than one destination. Because this feature can be quite demanding when a lot of waypoints are selected, we had to make sure that the algorithm for finding routes was fast enough to ensure that the map is pleasant to use.

We wanted to make sure that the shape of Denmark is recognizable when the user is zoomed far enough out to show the entire country. There is a balance between showing a big amount of roads and the delay when navigating. We wanted to make the user able to navigate the map with an acceptable delay.

The fact that we chose specific requirements for our program gave us two big advantages. It both made the planning process easier, and it did the design phase a lot easier, when we knew what the program should be able to do. In the process of creating the program, we had to change and create new requirements for ourselves, when we felt some feature was necessary for the end-user to have. In the last part of the coding process, we decided on our final requirements and worked towards completing them.

## 2.4 Data set

We have been provided with a dataset of roads and intersections in Denmark from Krak. Additionally we were given some code for loading the data from the text files.

### 2.4.1 UTM-coordinates

When using the UTM standard the earth is divided into 60 rectangles that each has the origo at the south-west corner. Most of Denmark is within the UTM-32 rectangle so all the coordinate data is given as UTM32-coordinates. These coordinates need some conversion when used in Java since the origo is placed differently. This will be explained further in the section about ?? on page ??.



### 2.4.2 Graph

When the data has been loaded it is stored as a **Graph** object containing **KrakNodes** and **KrakEdges**. The **KrakEdges** are the road segments and contains the name of the road, an estimated drive time, a direction of traffic and references to the two **KrakNodes** that are at either end of the road. The **KrakNode** itself contains only the coordinates for the point. The **Graph** contains a number of useful methods for searching the data like getting all edges that is connected to a **KrakNode**. We will be using these methods extensively throughout the project both for drawing the map and for finding the route between two points.

## 2.5 MVC structure

In order to achieve a decent code structure and separation of responsibilities, we utilize the Model-View-Controller (MVC) architecture. By doing this, we split the code into smaller sections, which can be easier to handle and easier to cooperate on the code.

This is because we split the code into three parts: graphical user interface (“view”), data handling (“model”) and the connection between the two (“controller”). Read more in section 5 UML-diagrams on page 25.

### 2.5.1 What is it? How does it work?

In order to achieve a decent code structure, it is important to split the responsibilities of the program into different pieces, which work together to make the program work as intended.

One way to do this, is to have the graphical user interface in a class of its own, and the rest of the program in another class. The downside to this approach, is that it can get ambiguously where to put specific pieces of code (button listeners and such).

We chose to utilize the Model-View-Controller (MVC) architecture, which is another way of structuring a program (a better one). With MVC we divide our code in three main parts, in order to achieve a decent separation of data, logic and the graphical interface.

Like the picture above shows, every graphical window has its own class. These classes are called “views”. Where we beforehand had one class to handle both communication with the data and the graphical windows, we now split this into two: “models” and “controllers”.

The models handle all communication with the data sources, and every model handle one data source. If we were to use relational databases, we would have a



Figure 2.1: Overview of MVC

model for each table in the database. In our case we only have one data source (Krak's dataset), and therefore only have one model, to communicate with this.

**Controllers** Now we only need a way to connect the graphical interface with the data. This is where controllers enter the picture. In MVC you have one controller per view. This controller provides the view with all the necessary data from the models. The controllers also have listeners on the view, that listens to events on the view (like when the user presses a button, clicks his/her mouse and such). Then the controller can provide new data to the view or save new data from the view to the data source (through the models).

An example of this could be that the user updates some info and presses the "Save"-button. Then the controller listens to this event, passes the new data to the models and it gets saved. In our case we have listeners to (among other things) mouseclicks, so we can place pins when the user clicks the map.

## Chapter 3

# User Interface analysis

In this chapter we describe our decisions and present our analysis and arguments regarding possible features that we find might have been interesting to have implemented in our Map Of Denmark program.

### 3.1 User interface as a whole

When we designed the first version of the graphical user interface in the first part of the project, we decided to make a window inside of the graphical user interface where the actual map should be displayed. We chose to have this window placed on the right side of our graphical user interface and interaction with the user mainly placed on the left.

We believe that this is a simple way of representing a user interface for a map. A lot of software use a menu bar with dropdown menus for selecting different functions. When we designed our outline for the graphical user interface, we did not design it with a huge amount of functions in mind.

The features that we have implemented in this version can easily fit in our simple user interface, but if features like searching for roads or other features are included, then space and overview may become an issue on the left side.

If new features are included, we feel it would be beneficial to let the main window change when different feature types are selected.

Below is a screenshot of our user interface. How to use it will be explained in the *Manual* on page 32.



Figure 3.1: Screenshot of GUI

## 3.2 Interesting features

This section presents some of the interesting features we have implemented.

### 3.2.1 Zoom

We have a few options for zooming in and out on the map. As described in section 2.2 Requirements for the map on page 6, it was required that we made it possible to zoom by dragging a box around the part of the map the user wants to look closer at.

In addition to the option of using the mouse to zoom, we have implemented a zoom-in and out function on the GUI and a hotkey for zooming out to the original zoom level. We made the original zoom function a hotkey only because we did not want to have too many buttons on the left side. We considered making it a menu bar item, but we did not manage to get it into this version.

We felt we really needed a zoom out function, so users do not need to close the program and start it again, when the user wants to view the map further zoomed out. A combination of the zoom in and out functions helps the user a lot when navigating the map.

We have limited how far a user can zoom in and out. If the user tries to zoom out further than the original zoom level, the view will default to the original

zoom level. If the user attempts to zoom in too far compared to the models view, the zoom function will do nothing.

### 3.2.2 Navigation

We have made it possible for the user to navigate the map by using the arrow buttons on the graphical user interface. When one of the buttons are pressed, the “view” will move in the direction specified by the button. While it was not specified as a requirement for the project, we felt it was a necessity to implement at least basic navigation functionality.

Like we did with the two zoom functionalities, we have limited how far a user can move around the map. If the user moves too far outside the map, the move function will not do anything.

### 3.2.3 Hotkeys

We have implemented hotkeys for all the buttons on the graphical user interface plus an additional for zooming back to the original zoom level. When we discussed the benefits of hotkeys, we felt it was important for experienced users of the software should have a less cumbersome time navigating the map.

At first we just had hotkeys for the clearing of markers (mentioned in section 3.2.4) and zooming out to the original zoom level, but we later added the hotkeys for the rest of the functionalities. If more features are added in a future version, it would be important for us that a hotkey were provided, if at all possible.

### 3.2.4 Route planning and markers

Part of the requirements for the project was to provide the user with a way to get the fastest or shortest route from one point to another. We accomplish this by putting a “marker” at the spot where the user clicks with the mouse. The marker shows which number in the sequence of markers it is. This will change if a marker is removed. Originally we had “pins” instead of markers, but we changed it, as we felt the pins we had were a bit large.

We have made it possible to place more than the two markers the project requirements asks for. If the user places more than two markers, the software will find the shortest route between 1 -> 2 and 2 -> 3 and so on. This was cheap for us to implement, and we felt it added a nice touch to our program.

We have implemented two methods of removing pins from the map. We have assigned a hotkey to the graphical user interface button “Clear Markers”, which removes all the markers from the map. The other way of removing pins is by

### ***3.3. FEATURES NOT IMPLEMENTED 3. USER INTERFACE ANALYSIS***

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clicking on them. This functionality is both intuitive and confusing at the same time. It is intuitive to click the marker you have just placed if you want to remove it, but it is not obvious in our interface. We believe that it is enough to have the “clear all markers” functionality for those who do not find it intuitive to click markers to remove them, and for the users that do find it intuitive, we offer them an easy way to undo a missclick.

#### **3.2.5 Bike/car**

Another interesting feature in our Map of Denmark project is the option to switch between bike and car routes. The user interface will start with car selected when the program starts.

Whenever a route is calculated, it will display the length and the estimated travel time on the left part of the user interface. When the bike option is selected, it recalculates the route for a bike, without visiting highways and other roads that bikes cannot or are not allowed to drive on. If the user switches back to the car mode, it recalculates the route again, but not visiting small paths and other roads where a car is not allowed to drive. The estimated travel time is also recalculated. The user does not need to have planned a route before he/she changes the type of transportation.

We have implemented this to help our software target a wider group of people. The bike/car options were a bit costly to implement, but we categorized it as a very beneficial feature and we did not feel we could leave it out.

### **3.3 Features not implemented**

This section presents some of the features we chose not to implement. These features are not in the final program, because we did not feel there were compelling arguments for implementing them.

Features that we wanted to implement, but did not make it into the final version, will be discussed in chapter 8 Product conclusion on page 36.

#### **3.3.1 Choice of roads to be displayed**

We chose not to implement the option of selecting which roads to be displayed. In a sense our program already does this by showing more detail the further zoomed in the map is. It could become very confusing if the user had the option of selecting roads, because the graphical user interface could become very cluttered, if all the roads were listed.

### 3.3. FEATURES NOT IMPLEMENTED 3. USER INTERFACE ANALYSIS

We felt that our gradually increasing level of detail is enough, and if the user were to enable all types of roads at once, the map could get quite slow and cumbersome to use.

If we were to implement something like this, it would be to give the user the choice which types of roads should be included in the route planning - ferries, highways, bridges etc. This could be too big a choice for the user to handle though. The user might doubt if he or she has chosen to best options for finding a route.

#### **3.3.2 Smooth scrolling**

We made an attempt to let the keyboard arrows scroll smoothly over the map, but we could not get it to work fast enough, and the user would experience lockups and an unresponsive interface. A solution to this would be to save map as images that you can scroll across - this would be faster, but would require more disk space. Because we store the data the way we do, which forces us to draw every line individually every time the user moves the viewport, we cannot do this fast enough.

In the end, we decided the benefits of the smooth scrolling were not large enough for us to spend a lot of time implementing this feature. The cost of changing that much way we draw the roads, was simply too high compared to the benefits.

#### **3.3.3 Dynamic route finding**

In the final project description, a dynamic route finding feature was suggested. If we had implemented the suggested dynamic route finding feature, a user would be able to mark a spot and then whenever he moused over a node on the map, it would show the route instantly.

We considered implementing this as we thought it was a nice feature to have, but it conflicted with the algorithm we use for calculating the route. More about the algorithms can be read in section 4.3 Dijkstra vs A\* on page 18.

## Chapter 4

# Implementation

Our implementation uses the MVC structure to create a practical class design. We have prioritized to make our design as simple and intuitive as possible. We used object oriented principles to assure that our design has both low connection between classes (loose coupling), and a high degree of cohesion.

By following these principles we have achieved implementation with minimal code duplication and with good possibility for extension.

Some of the basic thoughts on our design is explained in figure 4.1, and 4.2.

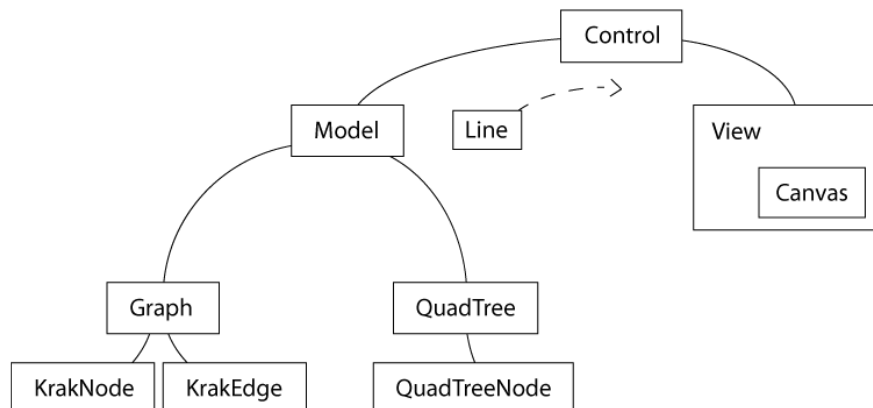


Figure 4.1: The basic design of our implementation. The controller gets a collection of lines, that the view will draw.

This rest of this chapter describes how we have implemented some of the more interesting features of the software. We aim to describe it to enough detail that



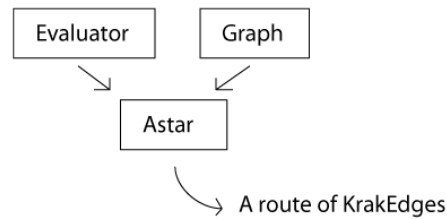


Figure 4.2: The pathfinding part of our implementation. The static  $A^*$  function takes an *Evaluator* and a *Graph* and returns a path.

this chapter can serve as a guideline for implementing the functionalities we describe.

## 4.1 UTM-conversion

When the graphical user interface part of the map tries to communicate with the model through control, some conversions of the different kind of values are necessary. Both when going from coordinates in the java-coordinate system to UTM32-coordinates and back.

We need to convert the values when we want to use the mousezoom and when we want to place the markers for pathfinding. We get an input on the graphical user interface when we mousezoom and this needs to be converted to UTM-coordinates so that we can create the new boundaries of the zoomed rectangle.

When we place markers for pathfinding, we do the same as when we do mousezoom, but instead we store the point as UTM32-coordinates and whenever we move the map, we convert it back to pixel-coordinates so that we know where to draw.

The java-coordinates have origo in the top left corner with the y-coordinate increasing the further down the y-axis you go. UTM32-coordinates are a bit different. UTM32 has origo in the bottom left corner and the y-coordinate increasing the further up you go on the y-axis.

We have a utility class with methods for converting the points back and forth. One takes a point from the view. The model and the view itself a formula for converting the pixelpoint to the UTM32-point.

Below is an illustration of the conversion from pixel to UTM.

We click on a point, 'a', on the canvas. To calculate the the UTM coordinate corresponding to that point, we use the formulas:

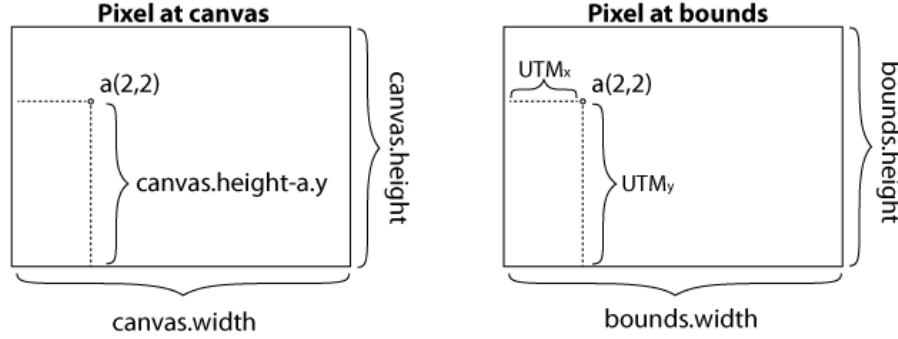


Figure 4.3: Illustration of UTM conversion

$$UTM_x = bounds_x + \frac{a_x}{canvas\_width} \times bounds\_width$$

$$UTM_y = bounds_y + \frac{canvas\_height - a_y}{canvas\_height} \times bounds\_height$$

To convert from UTM to pixels, we use the same formulas but reversed:

$$Pixel_x = \frac{(a_x - bounds_x)}{bounds\_width} \times canvas\_width$$

$$Pixel_y = canvas\_height - \frac{a_y - bounds_y}{bounds\_height} \times canvas\_height$$

## 4.2 Mousezoom

We have implemented the mouse zoom requirement by using `mouseEvents` on our canvas. When the user presses the left mouse button down, it generates a `mousePressed` event. We record the position of the mouse at the time of the `mousePressed` event and wait for the `mouseReleased` event. When the left mouse button is released, it generates a `mouseReleased` event. We use the positions of the mouse at the `mouseReleased` event and the `mousePressed` event to calculate new bounds for the model.

As mentioned in section 4.1 UTM-conversion, we use UTM-conversion to convert pixel values into the UTM values we need.

Often the user will not drag a square that is in perfect ratio with the canvas. If it does not have the same ratio as the canvas, we change the ratio of the dragged

square behind the scenes. We do this by either adding length or width to the dragged square. We always make sure to at least show what was inside the box the user dragged.

If the ratio of the dragged square is smaller than the canvas ratio, we make the dragged box wider. If the ratio of the dragged square is larger, we make the dragged box taller.

### 4.3 Dijkstra vs A\*

When planning the pathfinding feature, we had to decide between two algorithms: Dijkstra and A\*. The latter is based on Dijkstra, but achieves better performance by using heuristics.

The Dijkstra algorithm uses a minimum priority queue to find the shortest path from a given node to every other node by looking at the edges connecting nodes. The program will take a node from the priority queue and add all the other nodes that are connected to the current node to the priority queue. The priority queue stores a value with the node, which is the distance to the current node plus the length of the edge between the two. Since the priority is made to return the node with the smallest value associated with it, the next node in line will always be the one which is closest to the start node. This procedure continues until all nodes have been visited and by logging what edge led to all the nodes, it is possible to trace back the route to the start node.

This algorithm is great if we need to find the distance from one point to many other points, but can be quite slow when using it for finding a path between to nodes, since it just searches in all directions without thinking about in which direction the target node is.

This is where A\* comes in handy. The A\* algorithm is a modification of Dijkstra's algorithm that also looks at the estimated distance from the given node when determining the value for the priority queue. When using the geographical distance as a measure of best route, the value would be the current distance from the start node plus the direct distance to the target (as if there were a road directly to the target). With this subtle change, the algorithm will prioritize nodes that are relatively closer to the target rather than those that are in the other direction. This makes the algorithm much faster since it will not pay much attention to the roads that are not in the direction of the target. We have decided to use the A\* algorithm since we only calculate routes between two distinct nodes and therefore don't need the route from the start node to all others. The time reduction that A\* gives is also a definite plus since no user wants to sit and wait too long for the program to find a route.

The smaller the difference from the direct distance is to the actual fastest possible route, the more we will benefit from the A\* algorithm. This difference will

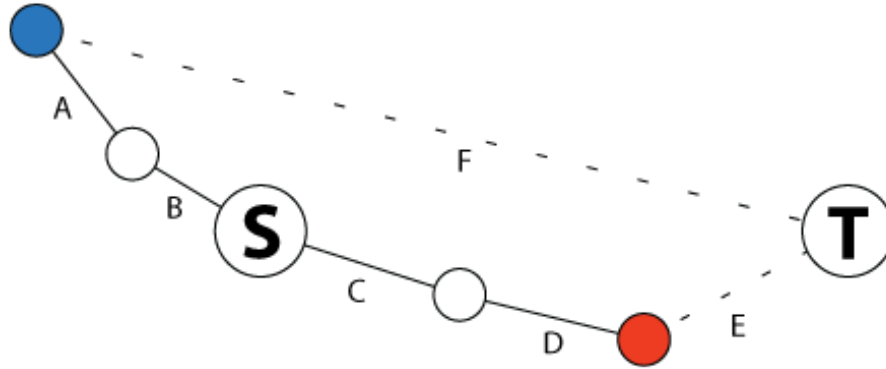


Figure 4.4: A\* vs. Dijkstra example. The dashed lines are the direct distances, used by A\*. The Dijkstra algorithm will check the blue node before the red node, because  $B+A < C+D$ . The A\* algorithm will check the red node before the blue node, because  $C+D+E < B+A+F$ .

often be bigger for the routes calculated for the car. This is because the fastest route would be a straight highway, which often is far from possible. We can therefore conclude that the A\* algorithm typically is more of a benefit when calculating routes for bicycling because they rely on the distance.

## 4.4 Evaluator

In order to make our path finding algorithm flexible enough for different interpretations of the “best route”, we have added an entity called **Evaluator**. This is an object that has the responsibility of evaluating a node relative to the target node.

The **Evaluator** also has the responsibility of calculating the heuristics that the A\* algorithm relies on. By using the **Evaluator** we are able to use the same path finding algorithm for two very different tasks; the biking route and the car route. The major difference between these is that the bike’s heuristics is based on the distance, where as the car’s heuristics is based on the total drive time.

$$dist(p_1, p_2) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

$$time_{drive} = \frac{dist(p_1, p_2)}{1000 \cdot \frac{speed_{max}}{60}}$$

We use these formulas to calculate the heuristics for bike routes, car routes respectively. There are currently three different evaluators in the program as static variables. These are called BIKE, CAR and HAS\_NAME. The HAS\_NAME evaluator is used when getting the name of the road closest to the mouse. There is also a fourth variable called DEFAULT that is a help to any future developers if they are unsure of what to use, this variable is currently just referring to CAR.

The Evaluator implementation is a good example of making our code ready for future features, since if we needed to add other means of transportation or simply variations of the ones we have, we would only need to create new Evaluators and not change a single line of code in the A\* algorithm.

## 4.5 Quadtree

In order to improve the drawing of our map, we have implemented a data structure called quadtree. The quadtree divides our map in four squares. In these four squares it divides our roads again into smaller squares, and we keep doing this, until we reach an amount of roads that is manageable. When we want to retrieve data from the map, we can give the quadtree a rectangle, and it will return all the roads within our smaller squares that intersect that rectangle. This technique optimizes the drawing of the roads, because we limit the amount of roads we draw.

However, when viewing the entire map of Denmark, this implementation does not help us. Therefore, it is necessary to only draw the bigger roads when zoomed out. We have discussed two different techniques to do this.

The simplest solution would be to iterate over the roads returned and then remove the road we do not want to draw. However, it would be more efficient to sort the roads before we put them in the quadtree, and then have them sorted in the quadtree. With this method we will not to iterate and remove the roads all the time.

We have discussed two different ways to sort the roads in the quadtree.

The first technique relied on dividing the types of roads into different quadtrees. With this implementation, we only implement the quadtrees containing the roadtypes we want to draw, into our drawing. See figure 4.6.

The second technique relied on putting the bigger roads at the top of the quadtree when building it. Then we could specify at which depth we wanted to search the quadtree. We called this 'the depthcontrolled quadtree', see figure 4.7.

The two methods both have advantages and disadvantages.

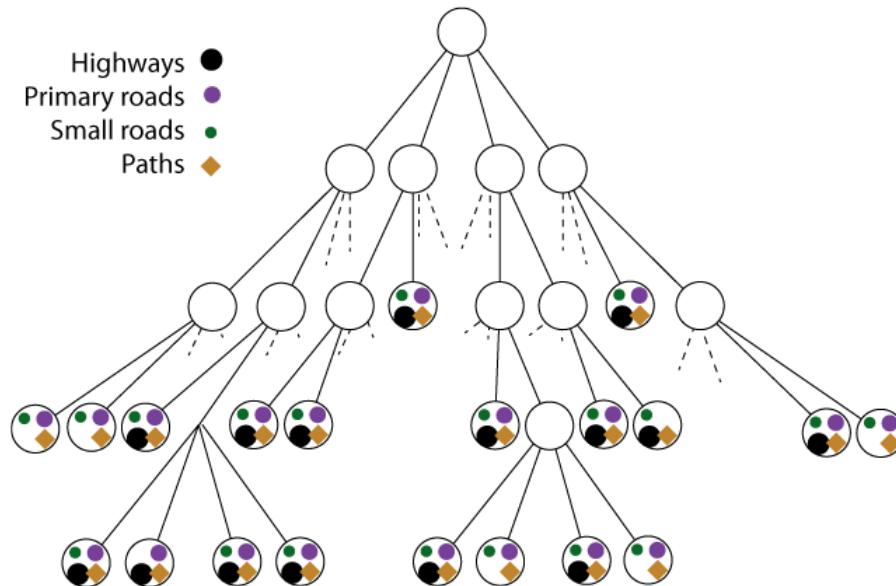


Figure 4.5: *Unsorted Quadtree.* A quadtree where the roads are not sorted. The dashed lines are parts of the quadtree that we do not show for practical reasons.

The depth controlled quadtree would return more roads than the multiquadtree, because the big roads would lie in big rectangles, and therefore be drawn more often.

The depth controlled quadtree requires less RAM than the multiquadtree, because it requires less instances of object `QuadTreeNode`.

The multiquadtree is less efficient to search through than the depthcontrolled quadtree, because we must run through each quadtree individually.

Looking at the advantages and disadvantages of these quadtrees, we have chosen to implement the multiquadtree. We have done this because it is the drawing of the roads that slows our implementation. The efficiency of our program is not affected by the efficiency of the quadtree search. The efficiency of the map is affected because of the number of roads drawn.

## 4.6 Serialization

We observed that the user had to wait quite a long time for the program to start. This was because every time we start the program, we loop through the entire dataset given to us by Krak. This data-set is huge, and because of this

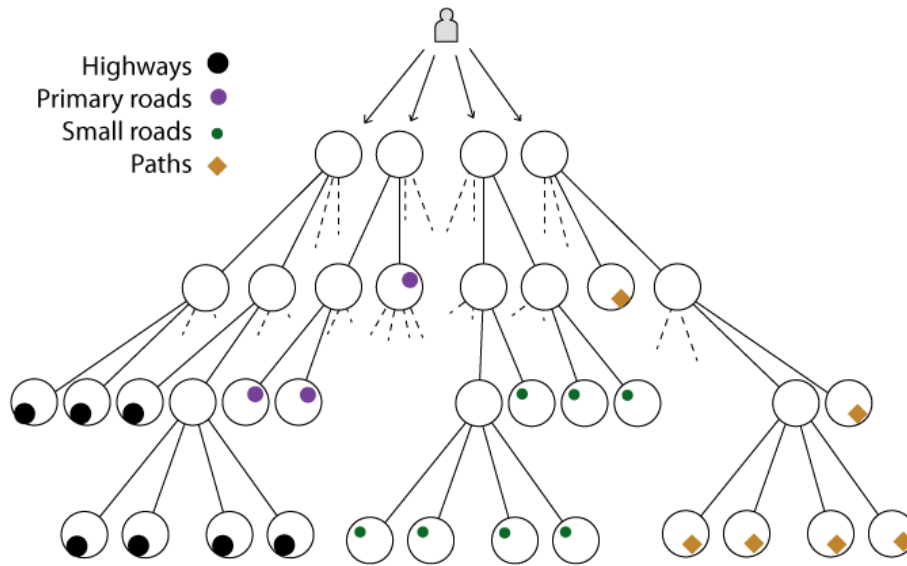


Figure 4.6: Multiple quadtrees. The user can choose which quadtrees to run through.

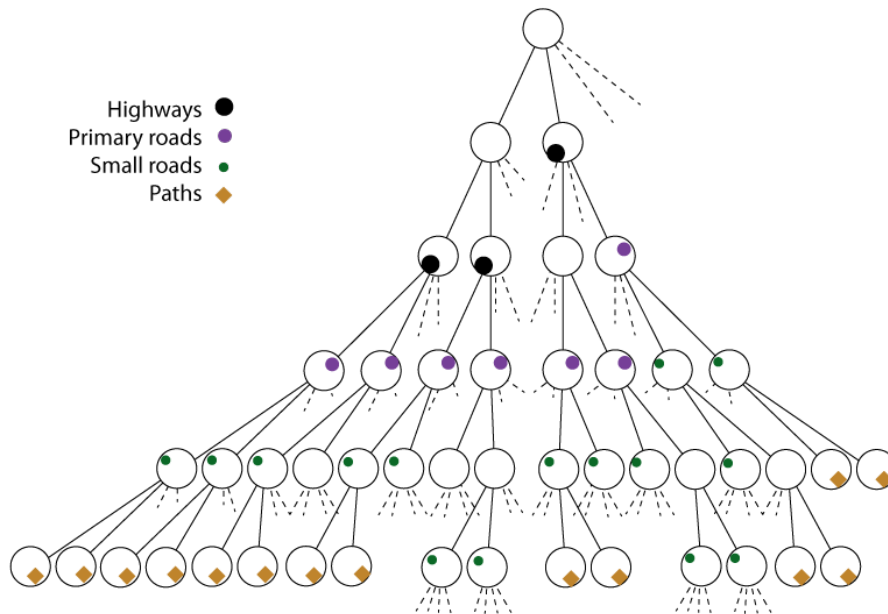


Figure 4.7: The depthcontrolled quadtree.

it takes quite a lot of time to start the program. Because we need to load all these data, the user is presented with a blank screen for a long time, before all these data are loaded and the program starts.

We started looking for a way to speed up the loading process, so the user has a map in front of him or her quickly, when the user starts the program. What takes the most time is looping through the data and creating the needed datastructures (quadtrees, the graph and so on), so if we could skip these steps or speed them up, we could save a lot of time.

This is where serialization comes into play. By serializing an object, you transform your object into something that can be passed around, through streams and such. So by serializing objects, you can save them to files. If the object to be serialized contains references to other objects, these will also be serialized (if they are `Serializable` / implements `java.io.Serializable`).

By doing this, we only need to build our datastructures the first time you start the program. After the objects have been created, they are been serialized and saved to files. The next time the user starts the program, we check whether the data has been changed. We check this by checking the MD5 checksum of the file, with `MD5Checksum`<sup>1</sup> (we didn't write this class ourselves). When we serialize the objects, we also save the checksum to a config file. If the data hasn't been changed (i.e. the checksum is the same), we load the objects that we saved, instead of making them all over.

We serialize all the quadtrees, the graph and the maxbounds-object (specifying the bounds of Denmark), as these are the objects we need for the program to run. When saved to the harddrive, it is around 65MiB, which is okay, given the sizes of harddrives today.

We save all these objects to one single file, in order to keep the references. If we didn't do this, the references will be ruined, which can break the program. We experienced problems with this, as nodes and edges is both stored in the quadtrees and the graph. If we serialized and saved the quadtrees in one file, and the graph in other file, a given node will be saved twice, and when we load the data from the serialized files, the node will exist twice, and it won't be the same node. But if we save the objects to a file through the same stream, we only get one of each, which leads to less RAM usage, less harddrive usage, faster loadtimes and fewer bugs.

### Threading

By serializing our main objects, we cut several seconds of our load times. But we can do it even faster. We are serializing several objects, but only few of them are needed right from the start of the program. So what we can do to speed

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<sup>1</sup>We borrowed this code from [3]



it up even more, is loading the few necessary objects, and then load the rest in the background. We do this with threads. We load the few objects we need from the start, then create a new thread to load the rest of the objects, and in the mean time, we create the window and draw the map.

The same goes for the first run. The user doesn't need to wait for the program to finish serializing and saving to files. By using threads, we can create the datastructures, and then immediately show the window to the user, while saving the objects to files in the background.

During load time (when loading from the serialized files, after the window is shown to the user) not all quadtrees are loaded. So we did encounter a problem when querying the quadtrees, when not all of them were loaded. We solved this by putting the querying in a try/catch, and when a problem occurred (index out of bounds, when trying to access a quadtree not yet loaded), we simply stopped looking through more quadtrees and just return what we found so far. Then later on, when all quadtrees were loaded, we could return all edges. The user wouldn't notice the lack of roads, as the user only sees a limited amount of roads anyway.

We did encounter another problem, when trying to use the graph (for pathfinding) when the graph wasn't done loading. We solved this by using a simple loop, that check if the graph was set. As long as the graph wasn't available, the main thread would simply hold and wait for the loading to finish. This is probably the only time where the user would notice that everything isn't quite loaded, but the loading happens so fast, that it probably won't be a problem anyway.

## Chapter 5

# UML-diagrams

Figure 5.1 shows our implementation of the MVC architecture. Because we have exactly one window, we chose to name our view and controller “View” and “Control”, respectively. The same goes for the models. We only have one data source (Krak’s data-set), and because of that our model is called “Model”. We could have named these three classes something different that may have been more meaningful in terms of the Map of Denmark context, but we chose these name in order to make our architecture clear.

We wanted to keep the models as “skinny” as possible, although our Model is quite long. But the amount of (public) methods is small, so looking at it from outside, it is a skinny model. The reason we wanted to keep the models skinny, is because it isn’t the model’s responsibility to deliver the same data in different ways, do a lot of calculations or stuff like that. It only acts like a “middle-man”, delivering data to other classes. If some class want the data in another way, they will need to convert it themselves.

Data processing takes place in Control. It translates data that the model can understand, to something the view can understand, and the other way around. For an example the view only knows about pixels, but it has no idea about UTM coordinates. The model only knows about UTM coordinates, but doesn’t know anything about pixels. So for getting these two to communicate, we need to convert pixels to UTM and vice versa.

We created some helper-classes (PointMethods and RectangleMethods), which are located in the utils package. These take care of checking whether a point is within the maximal bounds of the map, converting a pixel coordinate to a UTM coordinate and vice versa. We did this for being able to do this in several files, without the need to have duplicate code. For our program right now, this isn’t really a problem, as we only have one model, one controller and a view. But if we were to have more, we would either need to copy these helper-methods into

the other classes (BAD), or put them in a separate class. But even though we only have one of each, the helper-classes are still an advantage, as they make the code cleaner and easier to maintain and test, as we can test these helper-classes.

So in essence, we have two parts (the model and the view) that need to communicate somehow, in order to display the data on the screen. But they speak different languages, so we put in a middle-man (the controller), responsible for the communication between the two.

## 5.1 Control flow

The easiest way to understand MVC and how the individual parts talk together, is by using an example. Let us say the user has already clicked the map and placed a pin. Now the user clicks on the map again to place another pin.

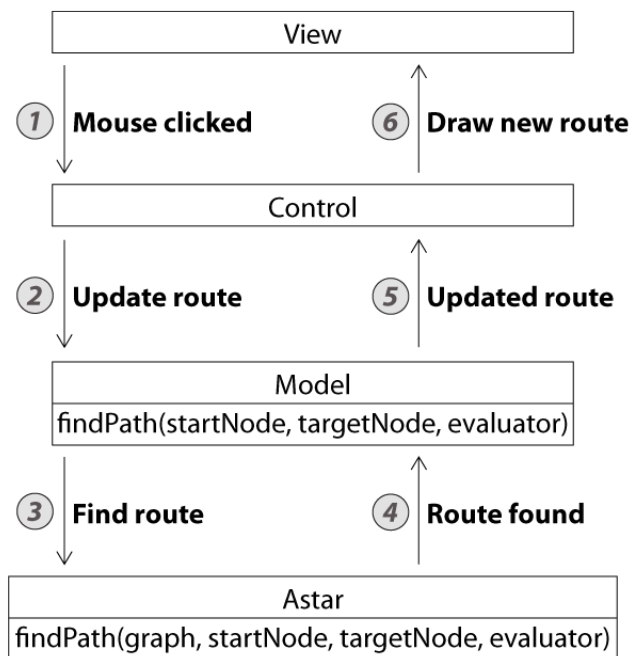


Figure 5.1: The basic control flow of our Map program

The controller has placed listeners in the view, so when a `MouseClicked` event is thrown, the controller is called. First it checks if there is another pin at the spot of the click. If there is, this will be removed, and the model is told to clear the route. If there is still over two pins placed, the model is asked to calculate a new route.

If there isn't a pin where the user clicks, we place a new pin. If the user has placed two or more pins, the controller calls its own `findPath`-method from point 1 to point 2, point 2 to point 3 and so on. The `findPath()`-method tells the model to find a path between the two points given.

The model then asks a helper-class to find a path, using the A\* algorithm, and provides it with the graph and the two points. When a path is found, it is saved in the model, ready for use in the controller.

The final step is getting the view to draw the route. The controller gets ready for a repaint, by fetching the route from the model. Then it passes this route to the view's `repaint`-method, and the view paints the road.

# Chapter 6

## Tests

### 6.1 WhiteBox: closestEdge

A white box test is a test that is made with knowledge of the internal structure of the method, and uses this knowledge for making sure all flows through the method is covered. We are using the “getClosestNode” method for this test since it contains both loops and conditional statements. The method is supposed to find the closest **Node** to a given point. It accomplishes this by first searching another method for the closest **Edge** (which is trivial). This procedure is performed with greater and greater search radius until it finds something. When it has found an **Edge**, it will determine which end (**Node**) is closest to the point. In order to secure full coverage of the tests we have created the following scheme of tests and expected results (using our test graph seen on page 30).

| Part        | Case   | Input                      | Expected Output   |
|-------------|--|----------------------------|-------------------|
| while(once) | Some point that finds an <b>Edge</b> within the initial search radius    | 6000, 2000, Evaluator.CAR  | Node with index 2 |
| while(more) | Some point that has to widen the search radius in order to find anything | -200, -200, Evaluator.CAR  | Node with index 4 |
| if-block    | The first <b>Node</b> is closest   | 10000, 8500, Evaluator.CAR | Node with index 8 |
| else-block  | The second <b>Node</b> is closest  | 8500, 8500, Evaluator.CAR  | Node with index 7 |

This procedure is great for testing every corner of the code because we are mak-

ing a test for reaching all sections within if-statements and make sure we run while-loops zero, once and multiple times<sup>1</sup>. It should be noted that the white box tests should be accompanied by black box tests, because these tests uses the input needed for reaching a specific block. This means they don't check if invalid input breaks the program. Since some of the input overlaps with what is needed for the black box, tests they have been located in the same method in our Model Tests<sup>2</sup>.

## 6.2 JUnit

This section describes the JUnit tests we have made for our software. We have made tests for the public methods in `Model`, `PointMethods` and `RectangleMethods`.

### 6.2.1 ModelTest

The model class has some of the most interesting functions and algorithms of our program. The most advanced functions in the model are those regarding path finding. The task of finding a path from one node of the graph to another, takes many different kinds of input. The coverage table for the JUnit tests of the `Model` class can be found in appendix A.1.3 on page 48.

The tests are chosen so that they test for different input. But they are also chosen so that they test the logical problems our path finding algorithm might run into. In order to test these problems properly, we constructed some simple test data that we knew we could rely on:

The image 6.1 on page 30 is a visualization of the graph that we use in our tests. The graph is constructed so that we can test different problems that might occur in the graph our map uses.

### 6.2.2 PointMethodsTest

We have tested the public methods in `PointMethods` using JUnit testing. The complete coverage table can be found in appendix A.1.1 on page 46.

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<sup>1</sup>We can't run this while loop zero times since the loop runs when `edge == null` and the `edge` variable is defined as `null` just before the loop.

<sup>2</sup>In the `testGetClosestNode()` method, the first, third, fourth and fifth asserts.

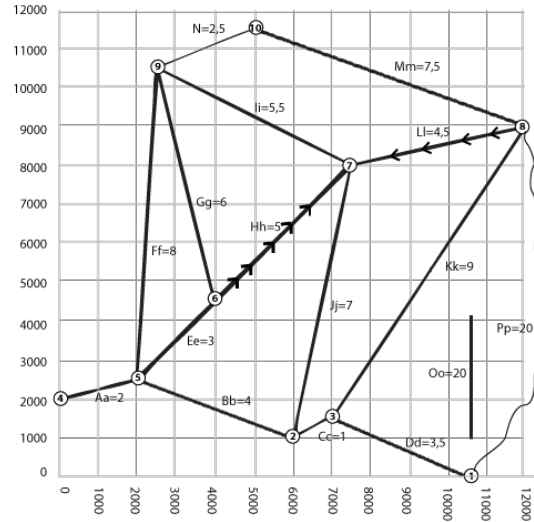


Figure 6.1: Test graph. The name and length of each edge is shown. The edge named  $Nn$  is a path and is therefore undriveable for cars. The lines with arrowheads are directed.

### 6.2.3 RectangleMethodsTest

As with the `PointMethods` and `Model` classes, we have created JUnit tests for the public methods in `RectangleMethods`. We considered doing more comprehensive testing of the “newBounds”, “fixByInnerBounds” and “fixByOuterBounds”, but since there are no checks for null or other types of bad input for these methods, we felt it was unnessecary. The coverage table can be found in appendix A.1.1 on page 46.

## 6.3 System test

We have written a number of system tests that needs to be performed by a user interacting with the program. These tests the basic functionality of the program as well as some advanced combinations of features. The System Tests are a necessary addition to the unit tests since many bugs are located in the interactions between algorithms and the user interface, and thus cannot be found through unit tests.

The tests have been divided into six groups that increase in complexity and the later tests may rely on success in previous tests. There are a total of 34 tests and the complete list and coverage table with instructions and expected results

can be found in appendix A.2 on page 51. All the tests in the coverage table have been done on a computer with the Windows 7 operating system.




# Chapter 7

## Manual

This manual will explain the basic use of the map, as well as its advances features. The images are from Mac OS X and might look different on other operating systems.

### 7.1 Navigation


At startup, the entire country of Denmark is shown. Now, we can move around the map with both the direction buttons in the top left corner, and the arrow keys. To move west, click the button  or press the left arrow key. This goes for all four directions.

### 7.2 Zoom

To zoom-in on the map, click the  button in the navigation panel.

To zoom-in on a specific area, click the mouse and drag a rectangle around that area on the map. A blue transparent rectangle will show you what you have selected. To zoom-in, release the mouse-button.

For example, if you want to zoom-in on Copenhagen, click the upper left corner of the city, and drag the cursor to the lower right corner.

To zoom-out of the map, click the  button. To return to the startup view (showing the entire map of Denmark) press the **ESC** button.

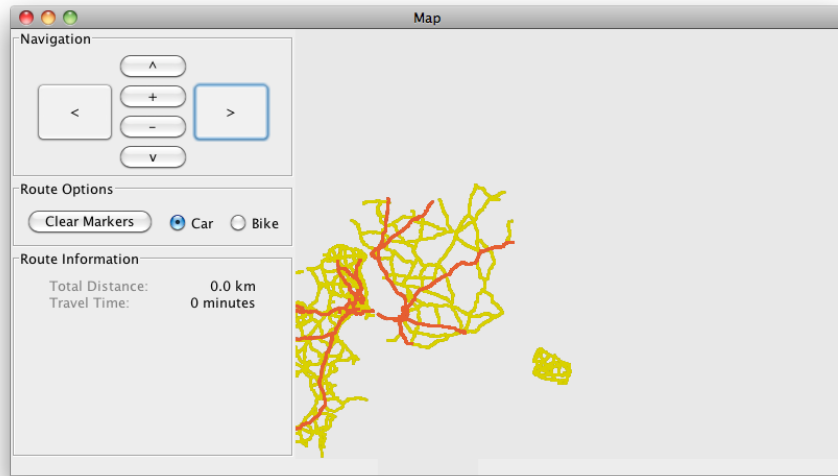


Figure 7.1: Moving the map

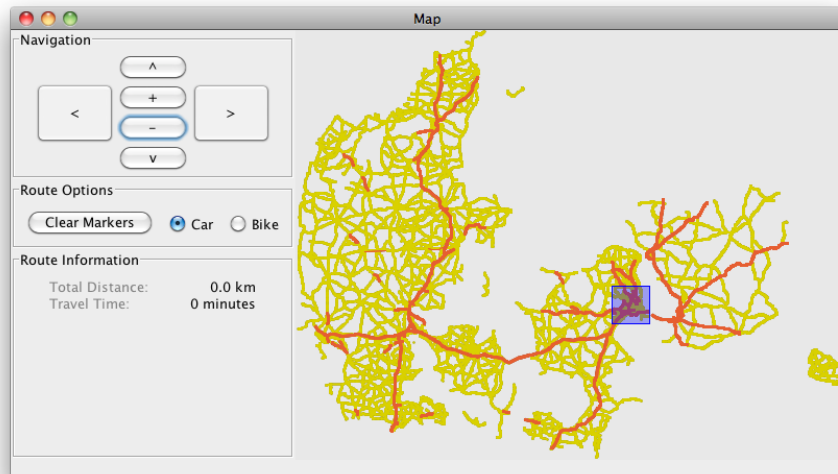


Figure 7.2: Zooming in on Copenhagen

## 7.3 Route find

To find a route from one point to another, you must specify a start and an end location. Click anywhere on the map to choose your start location. A light blue

marker will appear, containing the number “1”. To choose your end location, click at another location. A marker containing the number “2” will appear. The best route from 1 to 2 will be calculated, and shown on the map as a blue path. To extend your route with more markers, you can click at a new location on the map. You can repeat this an unlimited amount of times. You can delete one of your markers by clicking at its root. To delete all marker, click the button ‘clear markers’ or press c on the keyboard.

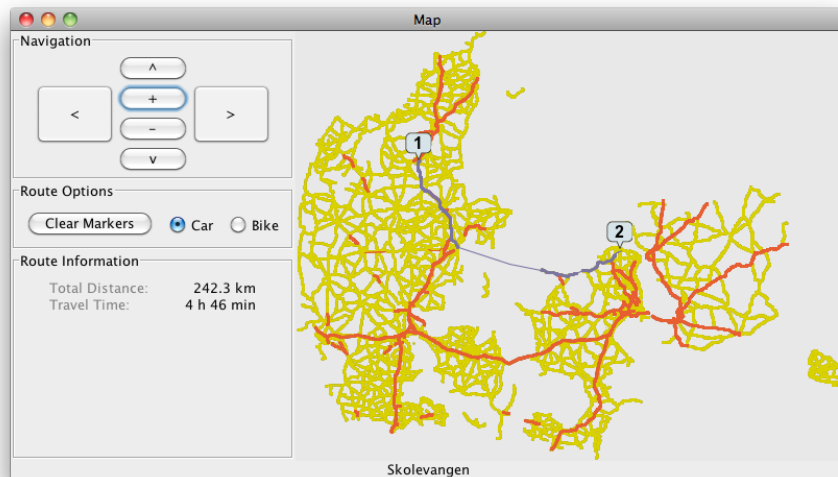


Figure 7.3: A route from 1 to 2 has been calculated

## 7.4 Bike/car

When calculating routes, it is important to specify which form of transportation you wish to use. Choose your preferred style of transportation by selecting the corresponding radio button.

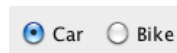


Figure 7.4: The radiobuttons

The form of transportation you use will have big influence on what route is calculated. If the car option is chosen, the route will be optimized for car transportation. If the bicycle option is chosen, the route will be optimized for bicycling.

## 7.5 Resize

To resize the map, drag the window as you would with any other application. The map will automatic adjust to the new size of the window.

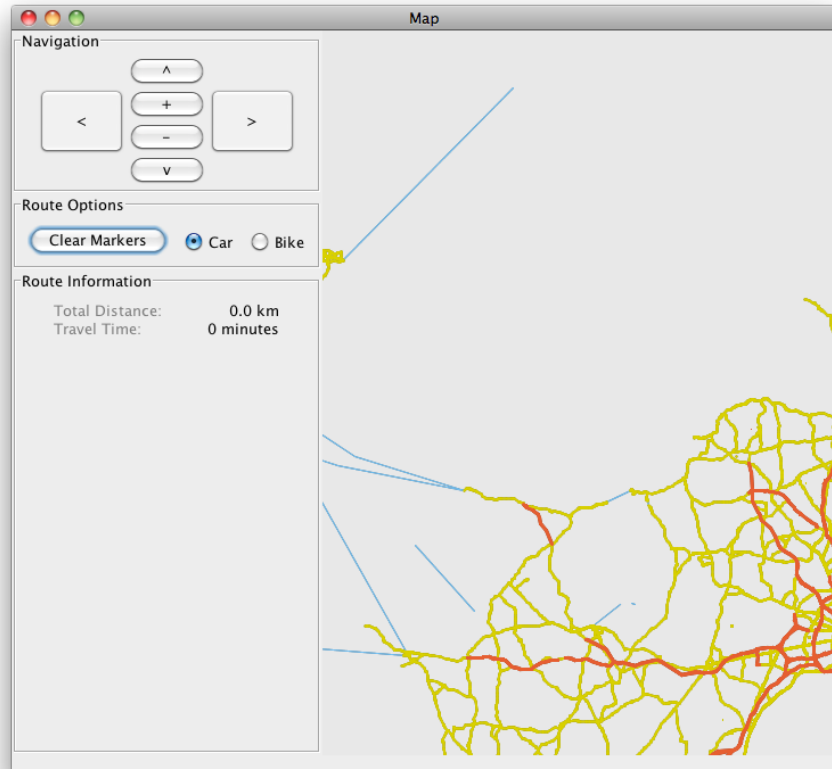


Figure 7.5: The map has been resized

## Chapter 8

# Product conclusion

We believe our product live up to the project requirements described in chapter 2 Background. Our program also runs fast enough when using the interface. We tested this on both a fast computer and an older, slower computer and we did not feel it was cumbersome to use the program, even on the slower computer. We did not thoroughly test this however, and we cannot guarantee that there will not be circumstances where our program will run slowly.

The system tests were done on a Windows 7 computer and because of this, we cannot be certain that all features work on other operating systems. However, two of our group members use Mac OS X and they have experienced no problems with our program.

We did all of our testing internally. For a even more thorough testing of our software, we could have asked other groups to test the software for us, so that we could get a different look on the tests. We did no usability testing throughout the project, and while our user interface is simple, we should have tested to make sure we designed our interface in the best way possible.

### 8.1 Issues in the software

We have discovered a few bugs our software that did not show itself through our testing, but instead manifested with regular use of the software.

We have a bug in our zoom-function, which enables the user to zoom very far in by zooming in, then resizing the window. This caused the program to be locked at a very far zoomed in view, but we chose to let the user zoom out when they are zoomed far in. The problem with zooming too far in can still happen, but the view is not locked when it happens.

## 8.2 Future features

If we had had time, we would have included more features in our program. We feel our program could still do with some fine tuning for it to be of real use outside of living up to the requirements. During development, we have focused on getting the basic requirements to work properly, before working at more advanced features. This have made our process more secure, because we were sure not to forget the important things. The advanced features that we would have like to implement is described here:

We would have liked to have implemented a “road search” function, enabling the user to search for the name of a road and place a marker there. In addition, we would have like to implement the option for the user to view a route description with turns. We were actually working on making route description, but we couldn’t get it nice and pretty enough in time, so we felt we would be better off without it.

To make the map look nicer, we attempted to implement a function for the map to create an outline of Denmark, separating the land from the sea, so that it was more obvious what is land and what is water. It would first of all make our program prettier, but with it we would be able to draw fewer roads when zoomed out, resulting in better performance. We would also have liked to make a logo for our program, but we did not get around to implementing it.

## Chapter 9

# Group norms

We wrote a constitution before we the project was handed out to us. In this constitution we describe what we require of eachother and ourselves in terms of working on the project. We felt we made some rather strict requirements so that we were sure to get some work done. We later changed them a bit once our schedule cleared up from lectures early May.

This is the requirement part of our constitution:

- Check mail at least once a day
- Tell the rest of the group in time if you have trouble getting things done on time.
- Admit when you are not done on time.
- Do not waste time when we have meetings.
- Respect that different people work in different paces and different ways.
- We need to evaluate often.

We also tried to get a mean of our level of ambition. Our goal was always to do what we could manage to do in the time frame that we had and without wasting time. In other words, we strived for being done early, by planning what we really wanted to have, and if we had time left, it was a bonus.

### 9.1 Meetings

We structured our work together in “meetings”. A meeting was whenever we were together working on the project - these were to be done at the ITU. The

structure of a meeting was simple:

- Leader of the meeting presents his plans, if any, he has for today.
- Leader selects someone to write down what happened at the meeting.
- What have we done since last time?
- Who does what today?
- Work today.
- Fifteen minutes before work ends: decide on homework for next time and select leader of the next meeting.

Before our lectures ended in early May, we had meets Tuesdays and Fridays from 10 AM to 4 PM. After lectures ended, we felt only meeting Tuesdays and Fridays would be too little time spent in meetings. So we decided to make our meetings one and a half hours shorter, but instead meet on Mondays, Wednesdays and Fridays from 10 AM to 2:30 PM.



## Chapter 10

# Diary

In this project we have kept two types of diaries. One type in our meeting documents and one in a spreadsheet. The meeting document diary was done from meeting to meeting, so that we kept track of what everyone had done before each meeting.

The spreadsheet diary was kept as a separate document where we wrote down whenever we had done something outside of meetings. We were not so dedicated to writing down everything we did in this diary, so it ended up being incomplete. We have included it anyway though, as we feel it has been a part of the process.

Our worksheets can be found in appendix B on page 56. They are written in Danish, as we had all of our meetings in Danish. The spreadsheet diary is in appendix B.2 Spreadsheet diary on page 81. The spreadsheet diary is also written in Danish.

## Chapter 11

# Worksheets

For this project we made a meeting document for all our meetings. We used these to make sure we kept to agreements, homework and had structured meetings. It was important for us to have these, because we wanted to have something to fall back on if we had disagreements and for us to have an easy way of being on top with everyone's homework. They are all written in Danish, because our meetings happened in Danish.

The documents are all structured in the following way:

- Leader of meeting
- Keeper of minutes
- Homework done before today
- Work to be done during the meeting
- Summary of the meeting
- Homework

All of our meeting documents can be found in appendix B.1 on page 56.

## Chapter 12

# Process description and reflection

As a group we have had some ups and downs during the last two and a half months we have been on this project. Filip from our group dropped out early May, so when we were about to start working on this report, we were down to four group members.

We kept a pretty tight structure as far as having meetings pretty often, but sometimes we got a bit unfocused during the meetings. We changed from meeting two days of six hours to three days of four hours once lectures stopped in early May, and this helped a lot. While our diary was not kept up-to-date properly, our meeting documents helped us have a good idea of what was going with everyone in terms of what they were doing on the project. The meeting documents can be found in appendix B.1 on page 56.

A lot of the work on the project - especailly writing this report and coding the program - was done at home. At meetings we discussed different solutions etc. and then we gave eachother homework until the next meeting. We were a bit sloppy getting things done on time, as there was rarely a day where everyone had done all of their “homework”. This was rarely a huge issue since the ones that missed their homework had reasonable excuses and were responsible enough to get it done quickly.

We had an internal evaluation where everyone got a chance to vent about how we were doing on the project, how we were working together as a group and if anyone had any problems with how the other members in the group worked, this was the time to say it. Doing this internal evaluation really gave everyone a chance to vent and it was also during this evaluation - where Filip was not present - that we decided that he really could not be part of the group if he

did not show for meetings. It was good for us to get these problems addressed before they got any worse and started affecting our work.

When we first sat down and created our “Group norms” (see 9 on page 38), we decided that we just wanted everyone to do their best. Even though we have members who are more dedicated and ambitious when it comes to this project, they respected that everyone had to work at their own pace and that working together on a bigger project like this was not something all members of the group were used to.

As previously mentioned we wanted to use the meeting documents to keep track of time and when we needed to be done with the different parts of the project. A bigger plan could have been a good thing to have had, so we did not suddenly get surprised by needing to have working code to hand in for the different parts of the project.

|||||| HEAD Not only did the meeting documents work as our diary, they helped us remember what we was currently working on. If a one of the groupmembers was not present at a meeting, he got updates about our work by looking at the document. Since we had described the homework each member had to do, there was no doubt about what you had to work on.

In the final part of the project, we decided that we wanted an, at least for us, early feature and code freeze, so that we could focus on getting the report done early. The schedule for the last week of the project can be found in appendix B.3 on page 83. The advantage of having an early code freeze was that we had a reasonable amount of time to polish the report. The disadvantage was that we did not manage to implement all the features we wanted to.

We are satisfied with how our project turned out. While we could have worked a bit more efficiently at times, the product turned out to be what we wanted. ===== From the beginning we had much focus on getting the basic requirements done before spending too much time on fancy features and found out this approach suited us well. With these priorities we managed to get a relatively low stress level before the small hand-ins and achieve a more polished product at the demonstrations. In the final part of the project, however, we decided that we wanted an, at least for us, early feature and code freeze, so that we could focus on getting the report done early. The schedule for the last week of the project can be found in appendix B.3 on page 83.

All in all we feel pretty satisfied with how our project turned out. While we could have worked a bit more efficiently at times, we think we hit our level of ambition pretty well. The downside of having an early code freeze was that we did not manage to implement all the features we wanted to. ||||||| a17f3cc6e45fc23487b4713838d925218274f954

As mentioned in the product conclusion, there were several parts we could improve in terms of the product itself, but that is often the case with projects

## *12. PROCESS DESCRIPTION AND REFLECTION*

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like this.

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- [3] *MD5Checksum homepage*: <http://www.rgagnon.com/javadetails/java-0416.html> ; Date: May 23, 2011.

# Appendix A

## Tests

This section covers tables and other appendices for our **Tests** chapter in the report.

### A.1 JUnit tests

#### A.1.1 PointMethods test table

The table in this section shows the full extent of our JUnit test coverage of the `PointMethods` class. Any variable that is described in the example column in the row of the method name is used in all the tests for that method.

| Test description     | Example  | Expected Output | Actual Output  |
|----------------------|--|-----------------|----------------|
| testPixelToUTM       | view:(0, 0, 800, 600) model:(0, 0, 4000, 3000)<br>point(80, 350)               | (400, 1250)     | (400, 1250)    |
| testUTMToPixel       | view:( 0, 0, 800, 600) model:(0, 0, 4000, 3000)<br>point:(pixelToUTM(80, 350)) | (80, 350)       | (80, 350)      |
| testPointOutOfBounds | view:(0, 0, 800, 600)  |                 |                |
| Inside               | Point a:(100, 400)   | a = (100, 400)  | (100, 400)     |
| Far left             | Point a:(-100, 400)  | a = (0, 400)    | a = (0, 400)   |
| Far right            | Point a:(1200, 400)  | a = (800, 400)  | a = (800, 400) |

|                      |                      |                |                |
|----------------------|----------------------|----------------|----------------|
| Far up               | Point a:(100, -300)  | a = (100, 0)   | a = (100, 0)   |
| Far down             | Point a:(100, 2000)  | a = (100, 600) | a = (100, 600) |
| Far left & far south | Point a:(-100, -200) | a = (0, 0)     | a = (0, 0)     |

### A.1.2 RectangleMethods test table

The table in this section shows the full extent of our JUnit test coverage of the RectangleMethods class. Any variable that is described in the example column in the row of the method name is used in all the tests for that method.

| Test description         | Example   | Expected Output  | Actual Output            |
|--------------------------|---|--|--------------------------|
| testNewBounds            | old:(50, 50, 100, 100))                         |  |                          |
| Direction.WEST           | length: 0.5 Direction.WEST                      | (0, 50, 100, 100)  | (0, 50, 100, 100)        |
| Direction.EAST           | length: 0.5 Direction.EAST                      | (100, 50, 100, 100)  | (100, 50, 100, 100)      |
| Direction.NORTH          | length: 0.5 Direction.NORTH                     | (50, 100, 100, 100)  | (50, 100, 100, 100)      |
| Direction.WEST           | length: 0.5 Direction.WEST                      | (50, 0, 100, 100)  | (0, 0, 100, 100)         |
| Direction.OUT            | length: 0.1 Direction.OUT                       | (40, 40, 120, 120)   | (0, 50, 100, 100)        |
| Direction.IN             | length: 0.1 Direction.IN                        | (60, 60, 80, 80)   | (60, 60, 80, 80)         |
| testFixByInner-Rectangle | a:(50, 50, 173.94, 100) b:(50, 50, 139.45, 100) | Absolute value of (Ratio of a - ratio of b) less than 1e-9 | Value is less than 1e-9. |
| testFixByOuter-Rectangle | a:(50, 50, 633.51, 100) b:(50, 50, 293.57, 100) | Absolute value of (Ratio of a - ratio of b) less than 1e-9 | Value is less than 1e-9. |
| Mousezoom                | model:(0, 0, 1000, 750) view:(0, 0, 800, 600)   |  |                          |
| Standard mousezoom       | a:(80, 540) b:(480, 240)                        | (100, 75, 600, 375)  | (100, 75, 600, 375)      |
| Zoom too far on x-axis   | a:(130, 5) b:(140, 150)                         | (0, 0, 1000, 750)  | (0, 0, 1000, 750)        |
| Zoom too far on y-axis   | a:(130, 442) b:(340, 432)                       | (0, 0, 1000, 750)  | (0, 0, 1000, 750)        |
| testPoint2DToRectangle   |   |  |                          |



|                    |                         |                    |                    |
|--------------------|-------------------------|--------------------|--------------------|
| a.x<b.x && b.y<a.y | a:(50, 150) b:(150, 50) | (50, 50, 100, 100) | (50, 50, 100, 100) |
| a.x<b.x && b.y<a.y | a:(50, 150) b:(150, 50) | (50, 50, 100, 100) | (50, 50, 100, 100) |
| a.x<b.x && b.y<a.y | a:(50, 150) b:(150, 50) | (50, 50, 100, 100) | (50, 50, 100, 100) |
| a.x<b.x && b.y<a.y | a:(50, 150) b:(150, 50) | (50, 50, 100, 100) | (50, 50, 100, 100) |
| a.x<b.x && b.y<a.y | a:(50, 150) b:(150, 50) | (50, 50, 100, 100) | (50, 50, 100, 100) |

### A.1.3 Model test table

The table in this section shows the tests we have made as JUnit tests to cover the different methods in the **Model** class. Input for methods that take **Nodes** as input are given as their index in this coverage table.

| Test description | Example input   | Expected Output             | Actual Output |
|------------------|---|-----------------------------|---------------|
| updateBounds     |   |                             |               |
| null             | null  | NullPointerException        | as Expected   |
| Width negative   | Rectangle(0,0,-1,0)   | IllegalArgumentException    | As expected   |
| Height negative  | Rectangle(0,0,0,1)  | IllegalArgumentException    | As expected   |
| OutOfBounds      | Rectangle(-10,-10,100,70)   | IllegalArgumentException    | As expected   |
| GetBounds        |   | Rectangle(4, 5, 10, 10)     | As expected   |
| GetLines         |   | Collection with size 16     | As expected   |
| orinalBounds     |   | Rectangle(0, 0, 12.0, 11.5) | As expected   |
| UnreachablePath  | 1, 12   | NoPathException             | As expected   |
| UndriveableRoad  | 5,9   | Collection larger than 1*   | As expected   |
| ClearPath        | Find a path, see that it is not clear, then clear it and see that it is clear | Collection of size 0        | As expected   |
| Continuing path  | Evaluator.BIKE  |                             |               |

|  |                                       |                                  |             |
|--|---------------------------------------|----------------------------------|-------------|
|  | (1,3)                                 | Collection of size 1             | As expected |
|  | (1,3) + (3,2)                         | Collection of size 2             | As expected |
|  | (1,3) + (3,2) + (2,4)                 | Collection of size 4             | As expected |
|  | (1,3) + (3,2) + (2,4) + (4,7)         | Collection of size 7             | As expected |
|  | (1,3) + (3,2) + (2,4) + (4,7) + (7,9) | Collection of size 8             | As expected |
| OneWayPath: Drive with the direction                                       | (8,7)                                 | Collection of size 1             | As expected |
| Drive against the direction  | (7,8)                                 | Collection of size larger than 1 | As expected |
| Evaluator  |                                       |                                  |             |
| Route over a path  | (10, 9) + Evaluator.CAR               | Collection larger than size 1    | As expected |
|  | (10, 9) + Evaluator.BIKE              | Collection of size 1             | As expected |
| Different paths found for car and bike**                                   | (1,6) + Evaluator.CAR                 | Collection of size 1             | As expected |
|  | 1,6 Evaluator.BIKE                    | Collection larger than size 1    | As expected |
| ClosestEdge  |                                       |                                  |             |
| Find the edge closest to a point   | 10,10 distance: 200                   | The edge named "Mm"              | As expected |
|  | 5,8 distance: 200                     | The edge named "Ii"              | As expected |
| Make a search that is not wide enough                                      | 100,100 distance: 10                  | NothingClose-Exception           | As expected |
| ClosestNode  |                                       |                                  |             |
| Find the node closest to a point   | 6000 , 2000                           | Node with index 2                | As expected |
|  | 4000 , 7000                           | Node with index 6                | As expected |
| Find the node closet to a point, forcing the algorithm to widen its search | -200, -200                            | Node with index 4                | As expected |
| ClosestRoadName  |                                       |                                  |             |
| Get the roadname of the closest node                                       | 6050 , 1100                           | "Jj"                             | As expected |
| Make a search that is not wide enough                                      | 10000 , 5000                          | " "                              | As expected |
| RouteDistance  |                                       |                                  |             |

|                                     |       |      |             |
|-------------------------------------|-------|------|-------------|
| Make a path and find it's distance  | (1,4) | 10.5 | As expected |
| Find distance without a path        | -     | 0    | As expected |
| RouteTime                           |       |      |             |
| Make a path and find it's drivetime | (1,4) | 4    | As expected |
| Find drivetime without a path       | -     | 0    | As expected |

\* Cannot go direct way to target distination because it cannot drive on the road between the **Nodes**.

\*\* Car should take the fastest route, bike should take the shortest route.

## A.2 System tests

### Tests

- Navigation Buttons
  - Zoom in/out
  - Pan(north, south, east, west)
- Boundaries
  - Minimum zoom
  - Maximum zoom
  - Pan out of map(north, south, east, west)
- Hotkeys
  - ESCAPE (reset to full view)
  - C (clear all markers)
  - I (zoom in)
  - O (zoom out)
  - Arrows (up, down, left, right)
- Pathfinding
  - Place marker
  - Two markers
  - Two markers (same node)
  - Multiple markers
  - Clear markers (screen button)
  - Switch between modes (recalculate route)
  - Closest node (that fits current mode)
  - Cannot travel opposite on one-way streets
- Resizing
  - Narrower (add to the top and bottom)
  - Wider (cut top and bottom)
  - Shorter (add to the sides)
  - Taller (cut sides)
- Mouse zoom
  - Same ratio(show exactly what is marked)
  - High rectangle(add extra to fit ratio)
  - Wide rectangle(add extra to fit ratio)

### A.2.1 System test coverage table

| Test                  | Instruction   | Expected result  | Actual result |
|-----------------------|---|--|---------------|
| Zoom in               | Press the zoom in button on the navigation panel  | The map should zoom in on the center of the map  | As expected   |
| Zoom out              | Press the zoom in button on the navigation panel twice. Then press the zoom out button        | The map should out but have the same spot centered   | As expected   |
| Pan:north             | Press the up-button on the navigation panel   | The map should pan a bit to the north  | As expected   |
| Pan:south             | Press the down-button on the navigation panel   | The map should pan a bit to the south  | As expected   |
| Pan:east              | Press the right-button on the navigation panel  | The map should pan a bit to the east   | As expected   |
| Pan:west              | Press the left-button on the navigation panel   | The map should pan a bit to the west   | As expected   |
| Minimum zoom          | Press the zoom in button until it doesn't zoom in any further                                 | The view should still be far enough out to see a couple of roads (if there are roads in that area) | As expected   |
| Maximum zoom          | Zoom in <b>five</b> times and then zoom out until it doesn't zoom out any further             | The map should show the original view (max view)   | As expected   |
| Pan out of map: north | Zoom in <b>two</b> times and press the up-button on the navigation panel <b>seven</b> times   | The map shouldn't change on the last press, thus still showing some roads                          | As expected   |
| Pan out of map: south | Zoom in <b>two</b> times and press the down-button on the navigation panel <b>seven</b> times | The map shouldn't change on the last press, thus still showing some roads                          | As expected   |
| Pan out of map: east  | Zoom in <b>two</b> times and press the right-button on the navigation panel <b>six</b> times  | The map shouldn't change on the last press, thus still showing some roads                          | As expected   |
| Pan out of map: west  | Zoom in <b>two</b> times and press the left-button on the navigation panel <b>six</b> times   | The map shouldn't change on the last press, thus still showing some roads                          | As expected   |

|                         |   |   |             |
|-------------------------|---|---|-------------|
| Hotkey:ESCAPE           | Press the ESCAPE key on the keyboard  | The view should reset to the original view (max view)                 | As expected |
| Hotkey:C                | Place a marker on the map by pressing the left mouse-button somewhere on the map. Press the C key on the keyboard | The marker should disappear   | As expected |
| Hotkey:I                | Press the I key on the keyboard   | The map should zoom in on the center of the map                       | As expected |
| Hotkey:O                | Press the I key on the keyboard, then press the O key on the keyboard   | The map should zoom out to the original view (max view)               | As expected |
| Hotkey:ARROW UP         | Press the I key on the keyboard, then press ARROW UP  | With the last keypress, the map should a bit to the north             | As expected |
| Hotkey:ARROW DOWN       | Press the I key on the keyboard, then press ARROW DOWN  | With the last keypress, the map should a bit to the south             | As expected |
| Hotkey:ARROW LEFT       | Press the I key on the keyboard, then press ARROW LEFT  | With the last keypress, the map should a bit to the west              | As expected |
| Hotkey:ARROW RIGHT      | Press the I key on the keyboard, then press ARROW RIGHT   | With the last keypress, the map should a bit to the east              | As expected |
| One Marker              | Place a marker on the map by pressing the left mouse-button somewhere on the map                                  | You should see a marker where you clicked, but no routes              | As expected |
| Two markers             | Place a marker on the map by pressing the left mouse-button somewhere on the map, then another somewhere else.    | You should see two markers where you clicked and a route between them | As expected |
| Two markers (same Node) | Zoom in on a road. Place a marker on the map and another right next to it.  | You should not see any route.   | As expected |

|                                 |   |  |             |
|---------------------------------|---|--|-------------|
| Multiple Markers                | Place a marker on the map by pressing the left mouse-button somewhere on the map, then place two more at other spots.   | You should see three markers where you clicked, and the routes: first->second and second->third                        | As expected |
| Clear markers                   | Place a marker on the map by pressing the left mouse-button somewhere on the map. Press the Clear Markers button on the Route Options panel                     | The marker should disappear  | As expected |
| Change mode                     | Place a marker on the map by pressing the left mouse-button somewhere on the map, then another somewhere else. Then select Bike mode on the Route Options panel | The new mode should be shown as selected, and the route should be recalculated with the new mode and probably change   | As expected |
| Closest node                    | Place a marker far away from any roads, then another one near roads   | It should find a path from the closest node to where you clicked first, even though it is far away.                    | As expected |
| Closest node: relative to mode  | Place a marker close to a path and another some distance away.  | When in Car mode it should find the closest regular road to start from, when in Bike mode it should start at the path. | As expected |
| Right direction on one-way road | Place a marker near the beginning of a one-way road, and then place another near the end.   | The route should travel directly across the one-way road.  | As expected |
| Wrong direction on one-way road | Place a marker near the end of a one-way road, and then place another near the start.   | The route should not travel directly across the one-way road, but somewhere around it.                                 | As expected |

|                               |  |  |             |
|-------------------------------|--|--|-------------|
| Resize:Narrower               | Select the right border of the window and the window <b>narrower</b>   | It should show more at the top and bottom to adjust for the changed ratio.                                 | As expected |
| Resize:Wider                  | Select the right border of the window and the window <b>wider</b>  | It should show more at the top and bottom to adjust for the changed ratio.                                 | As expected |
| Resize:Shorter                | Select the bottom border of the window and the window <b>shorter</b>   | It should show more at the top and bottom to adjust for the changed ratio.                                 | As expected |
| Resize:Narrower               | Select the bottom border of the window and the window <b>taller</b>  | It should show more at the top and bottom to adjust for the changed ratio.                                 | As expected |
| Mouse zoom:<br>Correct zoom   | Drag a rectangle on the map with about the same ratio as the window, by pressing the left mouse-button somewhere and drag until having the right size. | The map should now show approximately the marked spot.   | As expected |
| Mouse zoom:<br>Tall rectangle | Drag a tall rectangle on the map   | The map should show what marked but show more at the sides to adjust for the difference in ratio.          | As expected |
| Mouse zoom:<br>Tall rectangle | Drag a tall rectangle on the map   | The map should show what marked but show more at the top and bottom to adjust for the difference in ratio. | As expected |



## Appendix B

# Worksheets

This appendix covers our meeting documents and our spreadsheet diary. We included these because they describe most of the work that we have done and when we did it.

### B.1 Meeting documents

We used these to keep track of agreements, what we did during meets, homework, etc. We made one for each meeting we had at ITU, where all of our meetings happened.

## Mødedokument

**Mødeleder: Jens**

**Referent: Jakob**

### Løste opgaver til i dag:

- Ingen

### Arbejde i dag:

- Lav mødestruktur
- Lav mødedokumentskabelon
- Start dagbog
- Lav aftaler
- Lav google docs
- Får oversigt over programudvikling

### Referat:

- Er gået i gang med at analysere problemet og vores klassesdesign. Vi har diskuteret hvorvidt vi skal benytte en database til at gemme Nodes og Edges i stedet for at få det hele ind fra KrakLoader hver gang. Vi har dog besluttet at det kan vente til vores avancerede implementation.
- Vi har besluttet for en MVC-struktur hvor Model taler med databasen (indtil videre bare KrakLoader), Controller som bindeled mellem M og V og er den som tager beslutninger omkring bruger-inputs, samt View som sørger for vinduet og components.

Projektet:

Maps-Program

Rapport(Latex)

Programudvikling:

1. Analyse af programmet
2. Klassesdesign

3. API
4. Kode
5. Fancy kode

### Hjemmeopgaver:

**Alle:** Læse de java filer vi har fået udefra, samt de dokumenter der følger med, desuden skal vi sikre os at vi forstår alle de ting fra tavlen. Så vi i teorien kunne skrive det på fredag.

**Emil:**

-

**Filip:**

-

**Jakob:**

- Studere billeder på dropbox

**Jens:**

-

**Niklas:**

### Næste mødeleder:

Jakob (Overtalt af Jens)

## Mødedokument

**Mødeleder: Jakob**

**Referent: Filip**

### Løste opgaver til i dag:

- Undersøgelse af kraktklasser

### Arbejde i dag:

- Færdiggørelse af klassesdesign
- Udarbejdelse af API

### Referat:

- Diskussion omkring klassesdesign
  - o Diskussion om hvorvidt mapklassen skal være singleton
    - Indtil videre beslutter vi at det skal være et normalt objekt
  - o Mapklassen skal gives til view ved opstart
- Fremlæggelse for Jonas
  - o Vi er velkomne til at ændre på kraktklasserne og lægge Map og Road ind i disse
  - o Quadrees – udsnit af to-dimensionel graf. Forelæsning på tirsdag.
- Diskussion om hvorvidt map og road skal lægges ind i graf og edge
  - o Argument for: bedre klassesdesign
  - o Argument imod: kræver meget refaktoring
  - o Konklusion: Modellen erstattes af Map. Graph lægges ind i Map som et felt.
- Design af GUI
  - o Jf. jpg af tavle.
- Design af API
  - o Jf. jpg af tavle.
- Uddeling af opgaver
  - o Jf. hjemmeopgaver.

### Hjemmeopgaver:

**Emil:**

- View paint roads

**Filip:**

- View buttons

**Jakob:**

- Control
- Smid JPG billeder i Dropbox

**Jens:**

- Map

**Niklas:**

- Refaktoring af kraktklasserne
- exclusion fil til git  
exclude .class files

**Næste mødeleder: Niklas**

## **Mødedokument**

**Mødeleder:** Niklas

**Referent:** Jens

### **Løste opgaver til i dag:**

- Alt er løst. Dog er map klassen stærkt simplificeret, og har stærkt brug for optimering. En stor del af projektet kommer til at foregå i i denne klasse.

### **Arbejde i dag:**

- Vi skal se et kort i dag
- Map

### **Referat:**

Vi har besluttet at når man trækker i vinduet skal kortet blive større men beholde aspektratio.

Vi har besluttet at bruge QuadTree.

Vi har ændret noget samspil mellem map og de andre klasser.

Vi har fået kortet til at indlæse data.

View er færdig.

VI SÅ CHARLOTTENLUND!!!!!!!!!!!! WEE!

### **Hjemmeopgaver:**

**Jakob:**

- Zoom rectangle

**Alle:**

Test klasser, styr på dem.

Skriv javadoc

Generalt gør dem smukke!

**JENS:**

Kortet er spejlvendt WTF??!

**Næste mødeleder:** Emil

## Mødedokument

**Mødeleder:** Emil

**Referent:** Jakob

### Løste opgaver til i dag:

- Jakob har løst rectangle
- Javadoc
- Kortet er rettet

### Arbejde i dag:

- Kortet er langsomt, når man navigerer – skal forbedres
- Tegn vejene i forskellige farver.
- Måske: Valg af vejtyper
- Måske: Målestok
- Mousezoom

### Referat:

Vi begyndte på mousezoom, men blev ikke færdig med at implementere det i Control. Vi lavede farver til vejene. Vi begyndte at kigge på forbedringer til QuadTree, så kortet ikke er så langsomt, når det er zoomet helt ud.

Vi nåede ikke målestok og valg af vejtype.

### Hjemmeopgaver:

**Emil:**

- Lav componentListener

**Filip:**

- Overvej egne farver vs. Javas farver – og ARGUMENTER FOR DET.
- Find ud af, om det er muligt at booke lokale på nettet.

**Jakob:**

- Implementer mousezoom i control.

**Jens:**

- Push din kode, tak.

**Niklas:**

- Sammenlign vores implementation af QuadTree sammenlignet med Lars Birkedal's
- Evt. søg på nettet for bedre QuadTrees?
- Ret fejl, hvis du finder dem

**Næste mødeleder:** Filip

## Mødedokument

**Mødeleder:** Filip

**Referent:** Jakob/Emil

### Løste opgaver til i dag:

- Jakob har lavet mousezoom i control, men har ikke kunnet teste det.
- Emil har lavet sin canvasMouseListener
- Har tænkt over det.

### Arbejde i dag:

- componentListener på canvas til resize.
- Implementer resize.
- Vejfarver. Brug Javas farver.
- Visning af veje afhængig af zoomniveau
- Fix zoom
- Optimer ram forbrug

### Referat:

- Vi har valgt at anvende Java's farver, men vi kan altid gå tilbage til vores anden ide via GitHub!
- Filip lavede vejfarver.

### Hjemmeopgaver:

**Emil:**

- Tegn vejenavne, når musen er i nærheden.

**Filip:**

- Dele samtlige veje i ind i grupper.

**Jakob:**

- Mousezoom

**Jens:**

- Quadtree inddeling af veje.

**Niklas:**

- Optimer Quadtree (hastighed? Giv et svar på hvorfor den er så langsom)

**Næste mødeleder:**

Jens

## Mødedokument

Mødeleder: Jens

Referent: Niklas/Filip

Løste opgaver til i dag:

- 

Arbejde i dag:

- Profilerings af RAM & tid
- Inddeling af veje
- Quadtree-optimering

Referat:

Nice to have opgaver:

- Udregning af zoomniveau

- Select specific types of roads

Need to have:

- Forberede præsentation af projekt

- Document (about 2 pages) describing our features and why we have them

- Document (about 4 pages) describing implementation of our system

- Diagram showing conversion from x,y to UTM

- Test af metoder

Hjemmeopgaver:

Emil:

- Fix vejMouseOver

Filip:

- stresstest

Jakob:

- 

Jens:

- Quadtree (inddeling af veje)

Niklas:

- Ram optimering

Næste mødeleder: Jakob

Alle: Emils computer tegner langsomt – gør andres også det?

## Mødedokument

Mødeleder: Jakob

Referent: Niklas

Løste opgaver til i dag:

- Niklas: Optimeret RAM forbrug
- Emil: Mouseover på veje, semi-transperant firkant ved zoom, escape går tilbage til start-zoom
- Filip: Fik ikke stress-testet
- Jakob: Forsøg stress-test, har kigget på LaTeX
- Jens: Ikke noget siden sidst

Arbejde i dag:

- Vindue skal skjules indtil kortet er tegnet
- Splash-screen (?)
- Under optimering, har vi observeret at float giver en væsentlig forbedring i RAM forbrug på visse maskiner. Vi har desuden observeret at Rectangle2D.Double faktisk giver et bedre, og mere ensartet, RAM forbrug end Rectangle2D.Float.

Referat:

- Vi beholder vejnavne i bunden af vinduet
- Splash screen udsættes
- Vi har prøvet at optimere RAM forbruget - fandt ikke yderligere optimeringer.
- Vi har optimeret på hastigheden af programmet, ved hjælp af flere roots i QuadTree / flere QuadTrees.
- Vi er begyndt at skrive rapport i LaTeX, og har besluttet at skrive på dansk.

Ønskede features / ændringer:

- Bestem zoomlevel
- Gemme zoom-niveau / start bounds

Hjemmeopgaver:

Emil:

-

Filip:

-

Jakob:

- Kommentarer i kode

Jens:

-

Niklas:

Alle:

- Skriv rapport (Afsnit er delvist uddelegeret i .tex dokumentet)

Næste mødeleder: Emil



## Mødedokument

Mødeleder: Emil

Referent: Filip

Løste opgaver til i dag:

- Niklas:
- Emil: Kommentarer er indført i control
- Filip: Har skrevet om Line
- Jakob: Har skrevet rapport
- Jens:

Arbejde i dag:

- Skrive afsnit
- Gennemlæse / rette egne afsnit
- Gennemlæse / rette andres afsnit
- Helhedsvurdering

Referat:

- Alle opgaver blev udført

Ønskede features / ændringer:

- jf. TODO.xls i dropbox

Hjemmeopgaver:

Emil:

-

Filip:

-

Jakob:

- Korrektur på rapport

Jens:

-

Niklas:

Alle:

-

Næste mødeleder: Emil

## Mødedokument

**Mødeleder:** Niklas

**Referent:** Emil

### Løste opgaver til i dag:

- Jakob: Korrektur af rapport, done.
- Emil & Jakob sidste minuts-ændringer i funktionaliteten så vores resize virker efter requirement.

### Arbejde i dag:

Se nedenfor

### Referat:

- **Opgaver:**
  - o **Emil:** Modelfunktionalitet i QuadTree skal flyttes til Model
  - o **Niklas:** Mødedagbog/-referat + serialisering
  - o **Jens:** Map skal renames til Model (da det er lettere at forstå klassens funktion + JUnit til Model
  - o **Filip:** Skrive tekst om vores indledende process med opbygningen af vores klasser, da det var en spændende og lang snak hvor vi kom ind på mange forskellige implementationer og endte ud i én (den vi bruger).
  - o **Jakob:** Refaktoring af Control klassen, således at alle logiske beregninger flyttes til util metoder i en hjælpe-klasse, dette gør det også muligt for ham at lave JUnit-tests af disse metoder.

Disse opgaver går videre til hjemmeopgaver hvis de ikke er løst inden kl 16:00. Alt dette skal være færdigt til på fredag, hvor vi går igang med at implementere pathfinding.

Nedenfor ses en liste af ”nice to have” funktioner og rettelser, det er noteret hvilke som bliver klaret denne gang, resten vil blive gemt til hvis vi har tid efter implementationen af pathfinding.

- Refactor Control (**uddelt**)
- Serialisering af QuadTree (**uddelt**)
- Zoomniveau.afhængig vejtykkelse
- Pretty Roads

- Jens' logo

### Hjemmeopgaver:

Alle skal læse kapitel 4.3 og 4.4 i Algorithms bogen (BADS) og forstå hvordan implementationen fungerer og ser ud på kode.

Derudover skal alle lave deres opgaver færdig (se ovenfor).

**Emil:**

-

**Filip:**

-

**Jakob:**

-

**Jens:**

-

**Niklas:**

-

**Næste mødeleder:** Filip

## Mødedokument

**Mødeleder:** Philip

**Referent:** Jens

### Løste opgaver til i dag:

- Test af Model, som er den nye map
- Test af Control og refaktorisering

### Arbejde i dag:

Se nedenfor

### Referat:

- **Opgaver:**
  - o **Emil:** Ændret view så den kan lave pins og så den kan tegne ruter + tegnet pin
  - o **Niklas:** serialisering via buffer, og ordnet git repository
  - o **Jens:** Kigget på dijkstra og forstået a\*star. Implementeret algoritmen i vores program
  - o **Filip:** Fået github til at virke, fået graph til at returnere antallet af noder.
  - o **Jakob:** Gøre actionlisteners i core klar til at man kan klikke for at finde en rute

Nedenfor ses en liste af ”nice to have” funktioner og rettelser, det er noteret hvilke som bliver klaret denne gang, resten vil blive gemt til hvis vi har tid efter implementationen af pathfinding.

- Refactor Control (**uddelt**)
- Serialisering af QuadTree (**uddelt**)
- Zoomniveau.afhængig vejtykkelse
- Pretty Roads
- Jens’ logo

### Hjemmeopgaver:

Alle skal læse kapitel 4.3 og 4.4 i Algorithms bogen (BADs) og forstå hvordan implementationen fungerer og ser ud på kode.

**Emil:** Forsøger at få vejene til at blive real size når man zoomer langt nok ind.

-

**Filip:** Læs 4.3 og 4.4

-

**Jakob:** Fortsætter med actionlisteners

-

**Jens:** Går i gang med at lave findPath() metoden der skal returnere nogle lines.

-

**Niklas:** Fri

-

**Næste mødeleder:** Jens

## Mødedokument

Mødeleder: Jens

Referent: Niklas

Løste opgaver til i dag:

Arbejde i dag:

- Serialisering af graph
- Placering af pins
- Path finding

Referat:

- Emil kan være her til kl. 13 på fredag.
- Vi har arbejdet på at placere pins (er så godt som færdig nu)
- Serialisering er (igen) tilføjet til modellen, og der er desuden blevet arbejdet på at indlæse filer i baggrunden.
- Path-finding kan nu visualiseres, men virker ikke helt efter hensigten.

Hjemmeopgaver:

Emil:

- Kaste exceptions
- Metode til at lave en popup-boks dialog

Filip:

- A\*

Jakob:

- Få Jens' nye metoder til at virke

Jens:

- Path-finding algoritme til at virke

- Undersøg om vi skal bruge reverse edges

Niklas:

- Multi-threading

Næste mødeleder: Jakob

## Mødedokument

Mødeleder: Jakob

Referent: Filip

Løste opgaver til i dag:

Arbejde i dag:

- Placering af pins + gui
- Undersøge reverse edges
- Path finding

Referat:

Hjemmeopgaver:

Emil:

- A\*

Filip:

- findNode, support til at søge i større område

Jakob:

- remove pins

Jens:

- Testgraf

Niklas:

- Comparators

Næste mødeleder: Emil

## Mødedokument

Mødeleder: Emil

Referent: Filip

Løste opgaver til i dag:

A\*

Arbejde i dag:

Referat:

Uddeling af opgaver:

Rapportskrivning: Emil, Jakob

Fremlæggelse: Filip (ansvarlig), Jens, Niklas

Req.:

Find shortest path

Display path – in blue puts a pin at clicked spot

Optional:

Multiple pins – finds path from 1 til 2, 2 til 3, 3 til 4.

Removes a pin and calculates a new path

Total distance – Total distance on the shortest path

Estimated time

Remove all pins

Hjemmeopgaver:

Emil:

- Skrive: Model, View, Car/Bike routes

Filip:

- Forbered oplæg

Jakob:

- Skrive: Features, Control

Jens:

- Skrive: Dijkstra

Niklas:

- Serializing skal virke eller fjernes

Næste mødeleder: Jakob

## Mødedokument

Mødeleder: Jakob

Referent: Niklas

Løste opgaver til i dag:

- Jakob: Har skrevet det han skulle.
- Emil: Har skrevet det han skulle.
- Niklas: Har fundet problemet med serialisering af objekter, men har ikke kunne løse det.
- Jens: Har ikke skrevet det afsnit han skulle.

Arbejde i dag:

- Niklas: skriv rapport om serialisering + fjern serialisering.
- Emil: Skrive rapport + action-listener til radio-knapper.
- Jakob: Find ny rute efter klik på radio-knapper + skrive rapport.
- Jens + Emil: Skrive rapport-afsnit om Dijkstra.
- Emil + Jakob: Forberede fremlæggelse.
- Alle: Evaluering.

Referat:

- Serialisering af objekter bliver fjernet i denne omgang, da vi ikke kan nå at få det til at virke efter hensigten.
- Radiobutton-listeners er lavet, og der udregnes ny rute når der skiftes.
- Den generelle fremlæggelse er blevet planlægget og uddelegeret.
- Vi har implementeret A\* algoritmen.
- Jens har forberedt demo af vores program.

Hjemmeopgaver:

Emil + Jens:

- A\* + Dijkstra tekst

Filip:

-

Jakob:

- Stavekontrol

Niklas:

- Forberede fremlæggelse

Næste mødeleder: Niklas

## Evaluering:

Produkt:

Jakob:

+ Vi har nået meget - specielt med tanke på at vi holdt fri i påskeferien.

+ Vi nåede mere (af optional) end vi havde regnet med.

- Vejtykkelser

Jens:

+ Vi har fokuseret på de rigtige ting

+ A\* virker

- Vi har desværre ikke noget de niceness-ting, som kunne være fede at have med
- Bedre navigering (knapperne fungerer ikke så godt)(mousezoom, piletaster osv)
- Serialisering virker desværre ikke

Niklas:

+ Vi har nået det vi skulle

- Desværre ikke nogen niceness ting
- Koden blev ikke helt så awesome (pga. tidspres)

Gruppe 12

KF04 – Førsteårsprojekt 2011

29/4-2011

Emil:

Agrees with everybody

Proces / Gruppearbejde:

Jens:

+/- Bedre flow her til sidst

- For meget spildtid

Niklas:

- For casual med at møde til tiden

+ God arbejdsfordeling på trods af at folk er gået tidligere

Emil:

- Ærgerligt at folk skulle gå tidligere

- For meget arbejde mod slut

+ Vi har været gode til at arrangere lokaler

Jakob:

- Mødtes for meget

+ Godt ambitionsniveau

Os selv:

Niklas:

Selv:

- For lav prioritering af projektet

- For mange individuelle opgaver / ikke involveret nok i selve projekter

De andre:

- Lidt for separete opgaver

+ Kunne regne med ham / tingene blev lavet

Side 3 af 5

Gruppe 12

KF04 – Førsteårsprojekt 2011

18/3-2011

+ Møde til tiden

Jens:

Selv:

- Ked af sin egen rolle / slacket lidt for meget på dette projekt / prioriteret projekt for lavt

- Haft svært ved at arbejde med koden / at arbejde sammen kode-mæssigt (er nyt)

- Kommer for sent

+ Glad for opgaven pga. positiv fremgang

De andre:

+ Engageret

+ / - stædig i diskussioner

- Debatteret "uetisk" / ignorerede andres pointer / døv diskussion

Emil:

Selv:

- Påtaget sig mødeleder-rollen når ikke var mødeleder (Overtaget leder-rollen)

- Har stået for for meget af koden

+ God til at lytte

De andre:

+ Projektet er i sikre hænder hos Emil

+ Møder for det meste til tiden

+ Meget engageret

- Lavet for meget

Jakob:

Selv:

+ Møder til tiden(!)

Side 4 af 5



- + Sparringspartner i diskussioner
  - Irriteret over at gå tidligt tirsdag
  - Nogen gange for stædig

De andre:

- + Møder til tiden(!)
- + Stabil
- + Lavet opgaverne
- + Engageret i diskussioner og projekt
- + Sørger for samspil i kode og rapport
- + Tog ansvar for opgaven
  - Skriver utrolig skråt
  - Irriterende med tirsdag
  - / + Stædig

Filip (ikke til stede):

De andre:

- Vi har ikke inkluderet ham nok / trukket ham nok frem.
- Havde svært ved byde ind selv.

## Mødedokument

**Mødeleder:** Niklas

**Referent:** Emil

### Løste opgaver til i dag:

- **Jakob:** Rettet 2. dels rapport og afleveret denne.
- **Niklas:** Fikset Serialization og ryddet op i koden (så det ser pænt ud)
- **Jens:** Fortsat på test-graf og fundet bug mht ensrettede veje.
- **Emil:** Mindre systemtest af vores program for at finde eventuelle bugs.

### Arbejde i dag:

- Gennemgang af arbejde
- Mødetider
- Bugs
- Features
- Uddeling af opgaver til næste gang

### Referat:

- Revurdere arbejdsdage/timer.
  - o Besluttet at vi mødes 3 dage om ugen istedet for 2 fordi vi mener det er bedre med flere møder af kortere duration. Desuden er der et fastsat tidsrum de andre to arbejdsdage hvor vi sætter møder hvis nødvendigt.
  - o Mandag, Onsdag, Fredag: **10:00 - 14:30**
  - o Tirsdag, Torsdag (mulige ekstra dage): **10:00 - 12:00**
- Bugs:
  - o Ensrettede veje – Jens (test) og Emil (programmering)
  - o Find nærmeste Node (Evaluator skal med) – Emil
- Features (muligheder, skal evalueres til næste gang):
  - o Vejtykkelser/outlines
  - o Vejnavne/bynavne
  - o Navigation: Drag

- o Navigation Mousezoom (scroll)
- o Vej søgning
- o Pæne farver
- o Anti-alizing
- o Logo
- o Vejdybde

### Fra Lars' papir

- o Kystlinjer
- o Rutebeskrivelse
- o Traveling salesman
- o Vej til/fravælgning
- o Dynamisk vejfinding (fra et klik til hvor musen er)
- o Turns (fra fil)

### Hjemmeopgaver:

Alle: Gennemgå de foreslåede features og vurdere hvilke man syntes er vigtigst og skal laves.

#### Emil:

- Fikse bug med ensrettede veje og finde nærmeste node ud fra nuværende drive mode.

#### Filip:

-

#### Jakob:

- Skrive rapport skabelon og forslag til opdeling af siderne (prioritering)

#### Jens:

- Lave flere tests til at forsøge at finde bugget i ensrettede veje.

#### Niklas:

- Teste om man kan få AA til at virke.

#### Næste mødeleder:

Fredag d. 6: Jens

## Mødedokument

**Mødeleder:** Jens

**Referent:** Jakob

### Løste opgaver til i dag:

- Jens: Set på quadrees. Messet med rigtig mange ting i projektet.
- Niklas: Antialiasing
- Emil: Kigget på ensrettede veje. Fundet problemet.
- Jakob: Begyndt på Latex skelet.

### Arbejde i dag:

- Beslut features vi skal tilføje.
- Fix ensrettede veje.
- Lav skelet til rapport færdig.
- Tests

### Referat:

- Ensrettede veje **BUG**
- Skrevet mail til Filip

|                            |  |                             |
|----------------------------|--|-----------------------------|
| Features, vi vil inkludere | Features, som vi inkluderer, hvis vi får tid | Features, vi springer over. |
| Vejtykkelser               | Logo   | Mouse drag navigation       |
| ”Vejdybde”                 | Søgning på veje                              | Vejnavne/bynavne            |
| Min/max zoom               | Kystlinje                                    | Traveling salesman          |
| Flere quadrees             | Rutebeskrivelse                              | Turns                       |
|                            |  | Vej til/fra-valg            |
|                            |  | Dynamisk vejfinding         |

### Hjemmeopgaver:

**Emil:**

- Vejtykkelser
- Vejdybde

- Quadtree

**Filip:**

- 

**Jakob:**

- Latex skelet
- Hotkeys til gui
- Tegne den nye pin når man sætter en, før den begynder at finde den nye rute

**Jens:**

- Tests

**Niklas:**

- Tests
- Måske rutebeskrivelse

**Næste mødeleder:**

Jakob

## Mødedokument

**Mødeleder:** Jens

**Referent:** Jakob

### Løste opgaver til i dag:

- Jens har lavet tests og er i gang med shape-algoritmen
- Niklas har ikke fået lavet tests, men har fået kigget på rutebeskrivelsen
- Jakob: Latex skellet er lavet, men smooth scrolling lader ikke til at kunne lykkes.
- Emil: Vejdybte, tykkelse og et ekstra quadtree.
- 

### Arbejde i dag:

Jens og Niklas skal lave tests. Jens og Niklas laver tests af hjælpemetoderne pointMethods og rectangleMetode. Jens laver skemaer over testene. Jakob og Emil har truffet beslutninger om hvordan rapporten skal deles op, og deler desuden opgaver ud.

### Referat:

Vi har diskuteret situationen med Filip. (Han har ikke været til møderne meget længe) Vi har besluttet at skrive til Lars Birkedal og lade ham vurdere hvad vi skal gøre ved situationen.

Grafikken til pins er blevet ændret, og er nu en del pænere. Der er blevet rettet en bug der gjorde at man kunne køre på lukkede veje. Vi har diskuteret hvordan vejene skal ligge i quadrees. Alle rectangle.doubles er blevet ændret til floats for at kører en mere konsistent stil. Der er blevet rettet en bug i model som gjorde at testgrafen ikke fungerede. Vi har aftalt hvordan vi skal arbejde tirsdag.

### Hjemmeopgaver:

**Emil:** Problem area og Datasæt (UTM) og graph

**Jakob:** Hotkeys, min/max zoom, Pins, Navigation og Bike/Car, reference genveje til kapitler og sections.

**Jens:** Comment dijkstra, Our requirements to features, og hastighedskrav – Kigger på shapealgoritmen hvis han får tid

**Niklas:** MVC struktur og mål med det

**Næste mødeleder:** Emil

## Mødedokument

Mødeleder: Emil

Referent: Niklas

Løste opgaver til i dag:

- Jens: Har kommenteret Dijkstra. Har skrevet requirements. Har kigget på shape-algoritmen
  - fandt en bug i den.
- Niklas: Har skrevet MVC.
- Jakob: Min/max zoom. Har opfundet nyt afsnit til rapporten.
- Emil: Har skrevet problem-område + data-set.

Arbejde i dag:

Referat:

Vi har debatteret et problem i min/max zoom / forhindring af at flytte kortet for langt ud til siden, hvor der er grænse-tilfælde hvor det kan forbigåes.

Hjemmeopgaver:

Emil: Implementation: Dijkstra vs A\* + Evaluator

Jakob: Implementation: UTM conversion, Mousezoom. - UI analyse.

Jens: Test: Coverage tables (+ expected). JUnit.

Niklas: UML: MVC.

Næste mødeleder: Niklas

## **Mødedokument**

**Mødeleder:** Niklas

**Referent:** Jakob

### **Løste opgaver til i dag:**

- Jakob: Skrevet UI analysis, ikke skrevet i implementation, lavet max, min zoom og move bounds
- Emil: Skrevet det han skulle
- Jens: kigget på shape og lavet tests.
- Niklas: Skrevet det meste der sker skrives om UML-MVC

### **Arbejde i dag:**

- Feature freeze: 16/5-2011
- Code freeze:
- Niklas og Jakob kigger på hinandens skrevne ting til i dag, Jens og Emil gør det samme.

### **Referat:**

- Vi dropper shape, da det er for dyrt.

### **Hjemmeopgaver:**

**Emil:**

- Whitebox test (closestNode)

**Jakob:**

- Features not implemented, JUnit-point+rectangle

**Jens:**

- Manual, Quadtree

**Niklas:**

- Serialization, UML

**Næste mødeleder:** Jensi-man.

## Mødedokument

**Mødeleder:** Jakob

**Referent:** Emil

### Løste opgaver til i dag:

- **Jakob:** Lavet det han var bagud med, JUnit tests til rect methods, har ikke nået at skrive om JUnit testene.
- **Emil:** Skrevet "white box" tests til getClosestNode og tekst dertil.

### Arbejde i dag:

- **Emil:** Tjekker kode igennem for comments, og stuff (oprydning)
- **Jakob:** Begynder at skrive på process delen.

### Referat:

- Vi vil meget gerne have code freeze på onsdag. Derfor er det ikke særlig godt vi mangler to idag, og de ikke har lagt det op de har lavet til idag.

Små-opgaver der skal ordnes:

- Fjerne bluej filer fra workspace (hvorfor er de der overhovedet?)
- MD5 skal dokumenteres ikke er vores, ellers har vi lavet plagiat.

Folk skal være forberedte på at vi **måske får brug for at mødes torsdag.**

### Hjemmeopgaver:

**Emil:**

- Coverage table til System tests & hovedrengøring af koden.

**Jakob:**

- Går igang med strukturering af Process delen af rapporten (og evt begynder at skrive). Tables til tests.

**Jens:**

- Skrive manual til rapporten (dvs gennemgang af de forskellige features med billeder og

beskrivelser)

**Niklas:**

- **Jar** (skal kunne virke ifht cd), skrive tydeligt at MD5 ikke er vores (i tekst og .java fil)

**Næste mødeleder:**

Emil

## Mødedokument

Mødeleder: Emil

Referent: Niklas

Løste opgaver til i dag:

- Jakob: Er gået igang med proces-delen af rapporten. Har styr på hvordan han skal lave tabeller til test. Har lavet et appendix-afsnit.
- Emil: Har læst alt koden igennem. Har skrevet javadoc. Har løst en bug. System-test (coverage tabel osv).
- Niklas: Læst koden igennem - rettet små-fejl, fjernet unødvendig kode, færdiggjort javadoc osv. Har flyttet Evaluator til "pathfinding"-pakken. Har skrevet om serialisering og threading.
- Jens: Har lavet manual.

Arbejde i dag:

- De sidste kode-rettelser inden code-freeze.

Referat:

- Code-freeze

Hjemmeopgaver:

Emil:

- White box, system test

Jakob:

- JUnit tests

Jens:

- JUnit tests

Niklas:

- .jar (+ kør fra CD), MD5 referencer, UML

Næste mødeleder: Jens



## Mødedokument

**Mødeleder:** Jens

**Referent:** Emil

### Løste opgaver til i dag:

- **Jakob:** Ikke fået lave tabel til system test, eller skrevet mødedokumenter ind. Men lavet alt andet han havde til idag.
- **Jens:** Rettet test diagram til.
- **Emil:** Skrevet WB test færdigt og rettet lidt i System Tests og udført system tests.

### Arbejde i dag:

- Fjerne det som gjorde æ,ø,å virkede på mac, men ødelagde det på PC.
- Vi skal have skrevet de 3 introduktion-, konklusions- kapitler.

### Referat:

Dette er sidste mødedokument da vi efter idag sætter hele rapporten sammen og begynder at rette.

### Hjemmeopgaver:

**Alle:** Rette hele den samlede rapport igennem for indholdsfejl, gentagelser og flow.

**Næste mødeleder:**

## B.2 Spreadsheet diary

This appendix covers the diary we made in spreadsheet format in the time working on this project. It is not a complete diary, as we did not always keep it up to date.

| Dato      | Medlem | Løst opgave                                    | Personlig note  |
|-----------|--------|--|---|
| 3/8/2011  | Jakob  | Oprettede dokument                             |   |
| 3/14/2011 | Niklas | Lavede .gitignore, refaktorede kode(+prettify) |   |
| 3/15/2011 | Emil   | Implementeret QuadTree                         | Der er noget galt i Map, da op/ned scroll virker omvendt, desuden en mystisk implementation i Direction Enum'et, det skal ændres til en switch direkte i Map. |
| 3/17/2011 | Jakob  | Fixede merge problems i control                | Forstår ikke helt det med file. Skal have det forklaret på mødet. Skal bede Niklas om ikke at lave min hjemmeopgave for mig! :D                               |
| 3/22/2011 | Jakob  | Lavede noget på mouse-zoom                     |   |
| 3/24/2011 | Emil   | Vejnavn ved klik                               | Er stadig nogle bugs der skal fixes   |
| 3/25/2011 | Emil   | Resize og thickness                            |   |
| 3/27/2011 | Emil   | Vejnavn...                                     | Der står nu ingen tekst nedest når man har musen over 200m fra en vej, desuden ser firkanten en del federe ud (gennemsigtig blå) når man er ved at zoome      |
| 3/28/2011 | Jakob  | Testede på hjemmecomputer                      | Begyndte at kigge på LaTeX. Mulighed for at zoome ud til start ville være bonus mega awesome!   |
| 3/28/2011 | Niklas | Optimerede RAM forbrug                         | Double ->Float  |

|               |        |  |  |
|---------------|--------|--|--|
| 3/31/<br>2011 | Jakob  | Tegnede hvordan vi laver pixels om til UTM og skrev det meste af det jeg skulle skrive | Vi har nem mulighed for at lave god formatering af vores tekst - skal huske at vise hvordan fredag. Ville være fantastisk, hvis vi kunne få lagt tingene ind i ordenlige packages - so much shit in default package! Diskuter PixelToUTM e.x/width*width |
| 3/31/<br>2011 | Filip  | Skrev afsnit om Line og tilføjede tykkelser på veje i map                              |  |
| 4/5/<br>2011  | Emil   | refactoring  | Flyttet noget logik fra QuadTree til Model   |
| 4/7/<br>2011  | Jakob  | Refactorede control og oprettede nye klasser - lavede JUnit                            |  |
| 4/12/<br>2011 | Niklas | Tilføjede multithreading loading af serialiserede filer.                               | Langsomme computere kan lave forespørgelserne i nogle af quadtrees før de er loadet. UPDATE d. 15/4/2011 - det er fixet, ved at returnere de edges og nodes som er fundet i de fundne quadtrees.   |
| 4/23/<br>2011 | Jakob  | Lavede clearpins   |  |
| 4/28/<br>2011 | Niklas | Lavede en default evaluator  | Hidtil var der ikke nogen bestemmelse om hvad der skulle ske, hvis der ikke var valgt en evaluator. Jeg har nu lavet en Evaluator.DEFAULT, der bare refererer til Evaluator.CAR. Hvad skal der ske hvis brugeren skifter evaluator, efter ruten er lagt? |

|               |        |                          |   |
|---------------|--------|--------------------------|---|
| 4/30/<br>2011 | Niklas | Fixede serialisering     | Det hjalp at serialisere til samme fil, med samme stream. På den måde opstår der ikke dublikater. Desuden er fylder dataen mindre, det går hurtigere, og bruger væsentligt mindre RAM (550MiB =>260MiB) |
| 5/1/<br>2011  | Niklas | Forårs-rengøring af kode | Har flyttet klasser rundt til de rigtige pakker. Har desuden gennemgået koden sammen med FindBugs, og ryddet op i koden.  |
| 5/5/<br>2011  | Niklas | Tilføjede anti-aliasing  | Problemet var at vi tilføjede anti-aliasing på baggrunden også, og derfor kørte det langsomt. Prøvede kun at bruge det på stregerne, og det fungerer ganske udemærket, og er stadig hurtigt.            |
| 5/6/<br>2011  | Emil   | Skønhed                  | Implementerede "tykke" veje med outline og et mere differencieret quadtree PS: jeg har glemt at skrive herinde en masse gange   |
| 5/8/<br>2011  | Jakob  | LaTeX                    | Arbejdede med LaTeX og med smooth scrolling   |
| 5/14/<br>2011 | Emil   | White Box Test           | Har skrevet white box tests til getClosestNode metoden, mangler dog at lave det til JUnit da jeg skal vide hvordan jeg loader test-grafen, de andre tests der bruger den virker ikke ved mig            |

### B.3 Plan for last week of project

The plan for the last week of the project. We wanted to finish early, so that we did not need to stress before hand-in.

To be done before meet:

| Thursday                                  | Friday                                 | Satur/Sunday                         | Mandag | Tirsdag                    | Onsdag |
|---|--|--------------------------------------|--------|----------------------------|--------|
| Whitebox(Emil)                            | Manual(Jens)                           | Read through report                  |        | Spelling and grammer check |        |
| Write about JUnit(Jakob + Jens)           | UML (Niklas)                           | (Only content, not grammar/spelling) |        |                            |        |
| Write last part about system tests (Emil) | Worksheets(Jakob)                      |                                      |        |                            |        |
| Tests from WB to JUnit (Emil)             | Convert tables to LaTeX tables (Jakob) |                                      |        |                            |        |
| Jar (Niklas)                              |  |                                      |        |                            |        |
| CD (Niklas)                               |  |                                      |        |                            |        |

Things to be done at the meeting:

| Thursday | Friday             | Satur/Sunday | Mandag                        | Tirsdag       | Onsdag  |
|----------|--------------------|--------------|-------------------------------|---------------|---------|
|          | Preface            |              | Discuss corrections           | Check quality | Hand-in |
|          | Product conclusion |              | Write corrections into report | Print         |         |
|          | Process reflection |              |                               | Burn CD's     |         |