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microm
Consumer Marketing

Area segmentation algorithms - A Geoinformatic approach to Geomarketing strategies

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Declaration

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Abstract

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1 Introduction

1.1 Definition and aim of Geomarketing

The term of Geomarketing has established more and more in the field of marketing within the last years. A first approximation to the notion of Geomarketing was done in 1995 by Frühling and Steingrube. They had explained that Geomarketing is just a genus for several instruments within the field of marketing. This shows that Geomarketing is no methodology but rather a discipline. Although some definitions had occurred in the 90s, the first use of Geomarketing analysis went back to the 50s. Already 1952 the first map showing the purchasing power of Germany was published. In 1982 several companies were founded, which have offered tools and possibilities for their costumers to practise geographic analysis so that these researches got easier more and more. Consequently the comprehensive application of Geomarketing was born [11]. Within the early 90s Geomarketing described approaches and fundamentals of geographic analysis and the governance of marketing and distribution. The central idea of Geomarketing is that marketing composed of price, product, distribution and communication will be complemented by space. Consequently operating numbers can change dependent on the spatial location by spatial phenomena of productions and logistics.

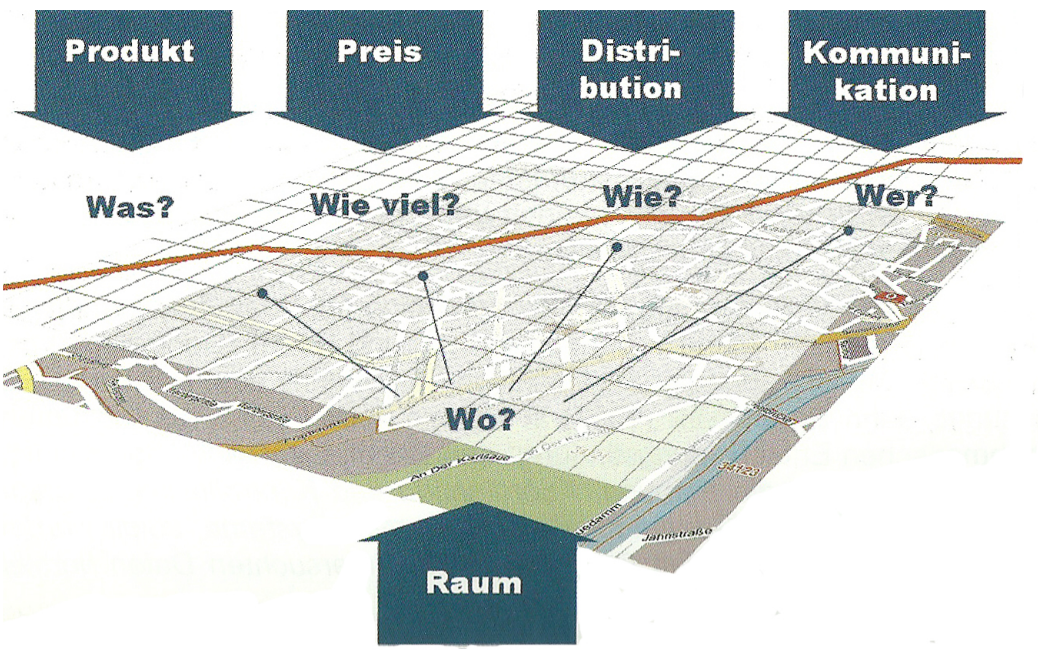
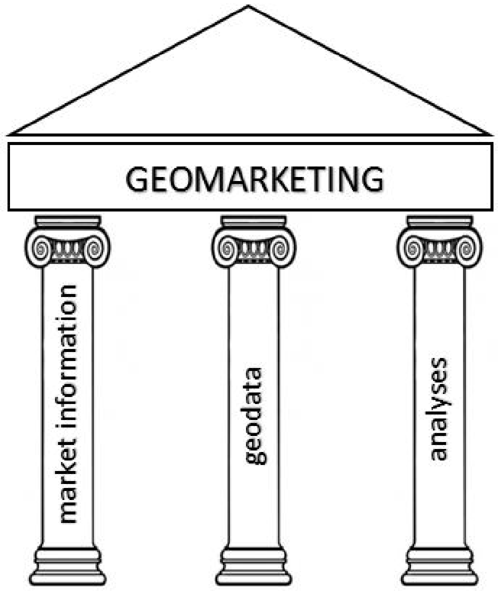


Figure 1 *Generic consideration of Geomarketing aspects complemented by space [11]*

Although the central idea of Geomarketing is known the definition of Geomarketing leads to some problems so that often incorrect explanations are written down. It is often readable that Geomarketing is a spatial analysis of the market using a geographic information system. But by particularly consideration it is recognizable that this statement is not correct because a geographic information system is just a tool which supports Geomarketing analysis to make them easier. Herter and Mühlbauer tried to find a definition of Geomarketing which fits best compared to other definitions. They have defined that Geomarketing analyses current as well as potential markets considering spatial structures to make the planing of product sales more effective and to control them quantifiable. That means that all available information about the market are connected to a spatial reference system to make dependences, potentials and other properties visible. The application of Geomarketing analysis have their origins in the minimization of entrepreneurial risks by making the market more transparent and acting purposeful. In the course of this Geomarketing has established as a sub-discipline of the field of marketing. During the application of Geomarketing analysis several benefits can be achieved. By knowing potential costumers and competitors the marketing and distribution of products from a company can be done more dedicated so that efficiency enhancement and cost reduction can be caused. Additionally advantages to the competitors are achieved by the analyses. Furthermore inquests of the market may be helpful during the planing of new locations to determine a site with a high potential so that the risk of a malinvestment can be minimized. It is recognizable that as higher as the number of costumers is, none the worse the benefit of Geomarketing analyses are. During the surveys of the market several principles are utilized. One of them is the spatial factor of the market. Using spatial data of costumers, locations, branch offices etc. important dependences can be visualized. The spatial data are almost given using addresses. Additionally a spatial heterogeneity can be recognized during analyses that means that the market differentiates in space. in conclusion a third principle is generated by that fact. It describes the spatial segmentation of the market. It is recognizable that a subdivision into homogeneous market segments is possible. Consumers in the western part and the eastern part of Germany differentiate to each other, but an identification of costumers with similar affectations within a small range of space is possible. From this it follows the neighbourhood principle which explains that neighboured customers have a similar behaviour considering marketing aspects as product purchase. This fact has two reasons. On the one hand costumers with an analogical lifestyle life in the same space and consequently show common characters in costumer behaviour. On the other hand these people share the same infrastructure which takes influences to their purchasing habits as well. Additionally the distance to the location of a company affects the costumers in their decisions going to it or not. Geomarketing is based on three stacks: information of the market, geodata and analyses.

Figure 2
Basic stacks of Geomarketing



Market information are qualitative facts about costumers, competitors etc. within a regional (economic) zone. The data contain information about their socio-demographic, psychosocial, economic and consumption properties like income, product affinity, gender and household size [25]. Geodata are information with a spatial reference like addresses, sales areas, locations and catchment areas. The boundaries of these regions may be administrative borders like federal states or townships as well as street sections, coordinates of houses and individual created areas per example a subdivision of postal code areas. By connecting market information with the help of geocoding to these geodata analyses are possible to obtain important knowledge about the market which are helpful to support companies in their marketing decisions. These facts show that Geomarketing is an instrument for analysing, planning, checking and controlling the market. In the meantime Geomarketing is grown up to one of the most important approaches within the field of Geomarketing to support companies while the accomplishment of their strategies. Consequently it is getting more and more essential to have systems providing functions and tools which making these analyses easier and more efficient.

1.2 microm Micromarketing-Systems and Consult GmbH

Microm Micromarketing-Systems and Consult GmbH is a company in Germany which provide Geomarketing analyses to their costumers. It was founded in 1992 and since 1997 it is a subsidiary of the Creditreform. During the last decades microm grew up to one of the biggest providers of micromarketing and Geomarketing within Germany. It offers possibilities and tools to do anaylses of Geomarketing data. With the help of projects company owners can give their data to microm so that the analyses will be done by them. This approach offers the advantage that the company can use all the knowledge which is provides by the employees of microm to control further steps of their marketing decisions. Besides that procedure microm offers additionally a web tool to their costumers so that they can do the analyses by their self. The software is called mapChart Manager and is accessible with the help of a web browser like Firefox or Google Chrome.

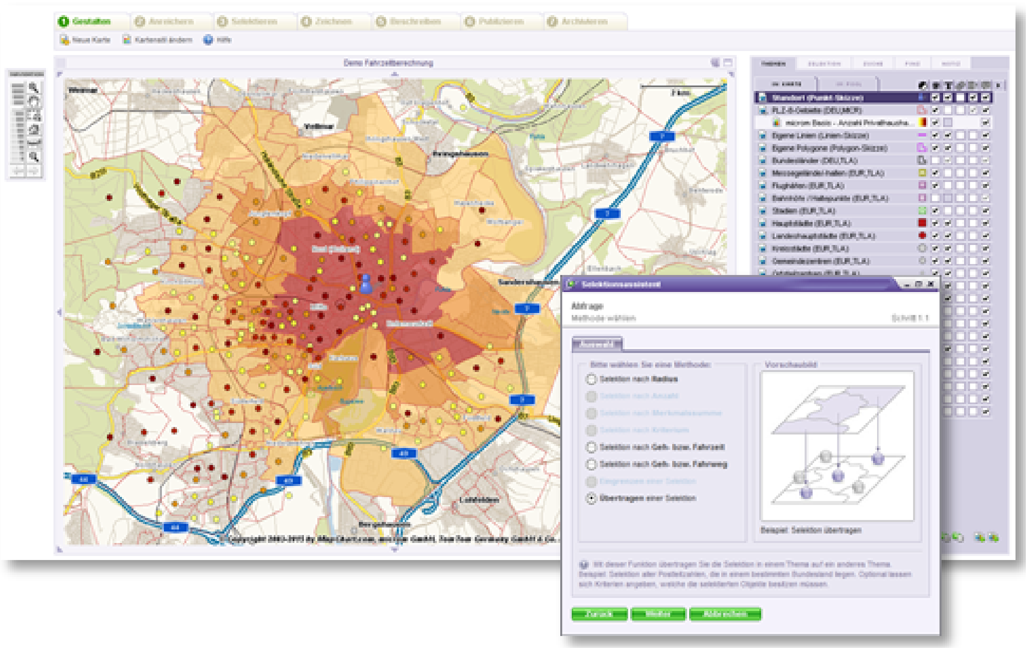


Figure 3 *Screenshot of the mapChart Manager*

The advantage of a web tool like the mapChart Manager is that the users can have access to their data and maps from all over the world. Consequently sharing results and working independently from a computer and location makes the application of Geomarketing analyses more easily. The mapChart manager offers such functionality like the import of data, geocoding of addresses and do anaylses like catchment areas and driving distance zones. To do all that analyses a lot of data is indispensable like routing networks or information about the behaviour of potential costumers. All these data are offered by the microm so that their costumers can buy the information they need. Doing so microm profits from their affiliation to the Creditreform, which collects costumer data from different resources among other things. As a subsidiary of the Creditreform the microm can sell all the information which the Creditreform have been collected.

1.3 Motivation and Research Question

1.4 Methods

blabla

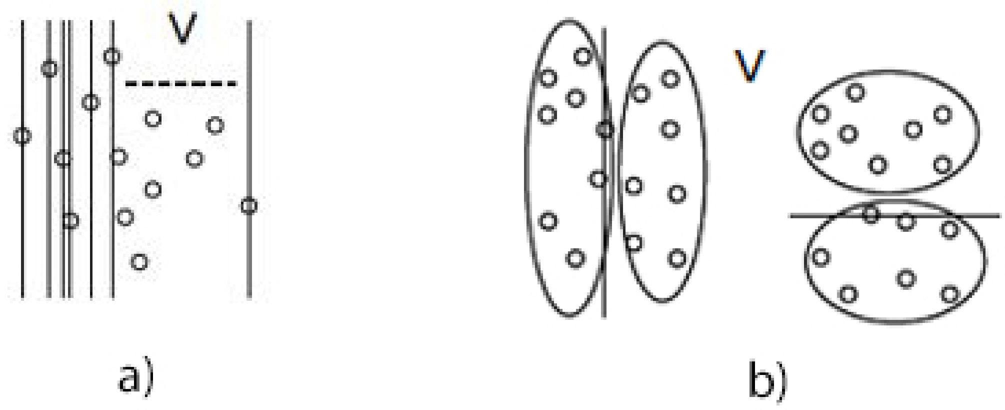
1.5 Outline

2 Related Work

2.1 KIT - Institute of Operations Research: discrete optimization and logistic

The Karlsruhe Institute of Technology (KIT) was founded in 2006 by the amalgamation of the university of Karlsruhe and the research center Karlsruhe. Together both institutes form one of the biggest research and education constitution in the world which concentrates on selected research areas. On the Institute of Operations Research the staff members delve into the field of discrete optimization and logistic which includes districting, too. In progress of studies they have been implemented a library called Lizard which includes an algorithm for the solution of area distriction problems. The library can be downloaded for free, so an execution on given example data is possible. In addition to this, it is implemented into a Geographic Information System in the web browser. The algorithm of Lizard is based on the so called "Recursive Partitioning Algorithm" which was designed by Kalcsics et al. [16]. The algorithm is a geometrically approach which divides the problem into sub problems to align territories that are balanced with respect to an activity value. the partition is done by placing a line into the dataset. Consequently a left problem (data left from the line) and a right problem (data right from the line) are created. Within the next steps additional lines are placed into the sub problems to divide them again into smaller ones. The number of sub problems depends on the number of distracted areas which should be created. The lines can have different directions which will be considered. These are all considered so that different partitions of sub problems exists. The sub problems are described by a binary tree whose root element complies the problem that should be solved. The different partition for the subdivisions are ranked by a heuristic measure for balance and compactness so that the partition with the best measure value can be chosen as result.

Figure 4
a) Possible partitions using vertical lines, b)Two possible partitions with different compactness [16]



The steps of the partitions are presentable within Lizard. The download package of the algorithm already includes such example files which can be executed. The examples contains either point coordinates which are connected to an activity or line segments to visualize street segments. These are linked to an activity value too. It is recognizable that no given centres exists. Consequently the area distraction is not done considering given locations like it will be done during the approaches of that thesis. Before the algorithm im Lizard can be started some parameters need to be chosen. There exist input options for:

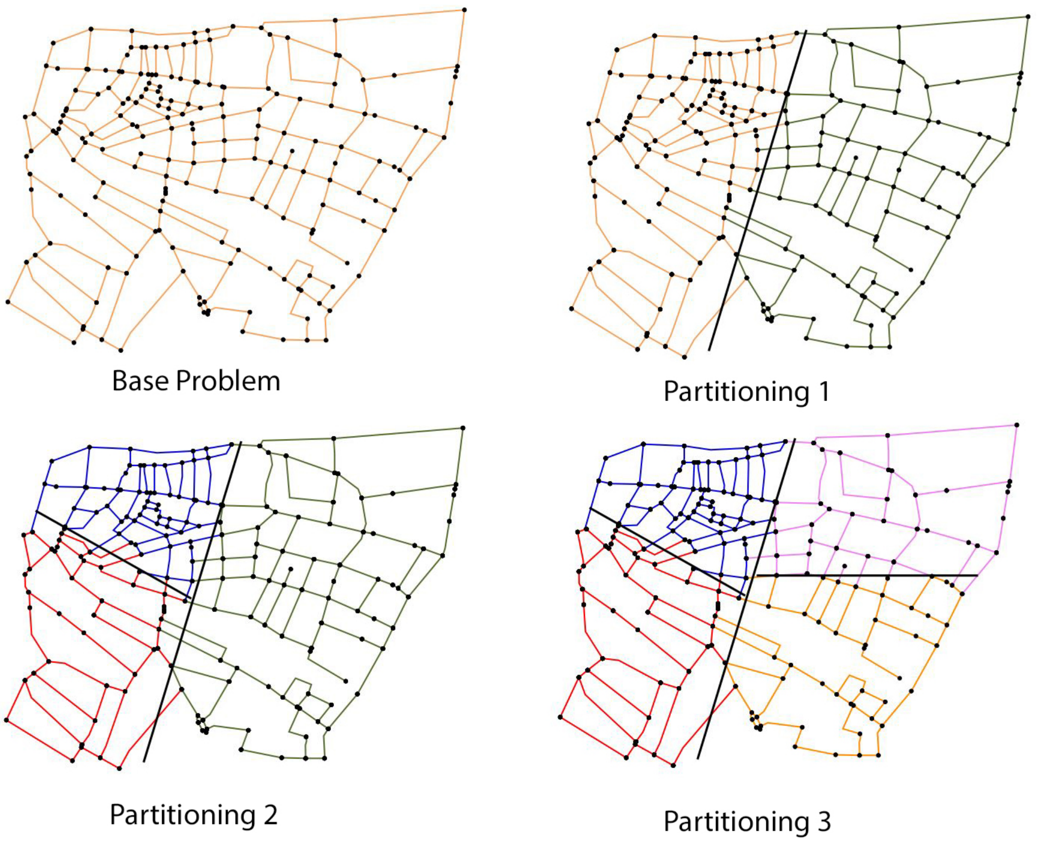
- Number of areas: This number defines how much parts should be created.
- Number of line directions: These are necessary to define the position of the line which will be placed into the problem to divide into smaller parts.
- Balance Tolerance: The value determines the range which needs to be satisfied comparing the activity of the areas.
- Weight Balance: The value needs to be between 0 and 1 to determine the importance of a balanced activity of the areas. In case of 1 balance is most important, in case of 0 the balance is not important. Instead of this the compactness is most important.
- Compactness Measure: There exist different options how the compactness value is calculated. Some of the options call ConvexHullIntersection, MaximumDistance and WeightedPairwiseDistance. ConvexHullIntersection par example uses the circumference of the convex hulls of all district during the calculation of the compactness [23]. Consequently every mentioned option defines another approach of the calculation of the compactness rate.
- Bisecting Partition: With the help of this option the geometric object which divides the problem is selectable. The predefined option are lines how it is defined within the "Recursive Partitioning Algorithm". Additionally FlexZone and a combination of both can be chosen.

The visualisation of the result of the districting problem can be done step by step or showing just the final result. Showing the results in partial processes represents the approach of the algorithm dividing the problem into sub problems. The calculation of the tree is not recognizable, but the leaf with the best measuring value and thus the best calculation will be shown. Additionally information about other partition solutions are shown. In the following figure the algorithm is visualized for a districting problem where street segments should be divided into four balanced areas. The feasible balance tolerance is 0.1, the number of search directions are eight, the weight for the balance is 0.5 and the bisecting partition is done by a line. The results of the activity value for every sub regions are:

Table 1 *Activity values of resulting areas*

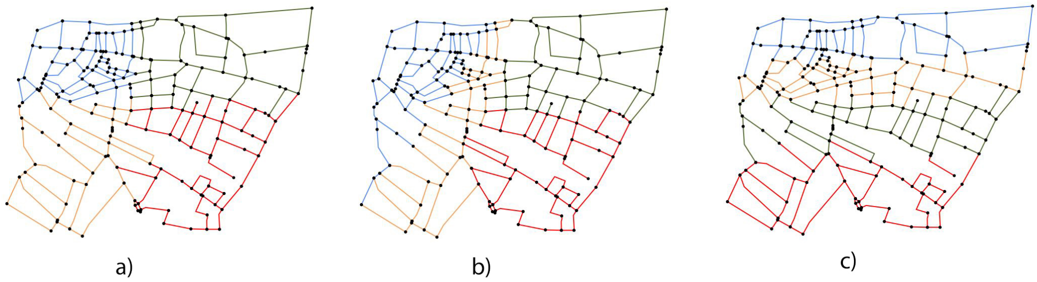
Blue area	Orange area	Green area	Red area
12224	12208	12216	12210

Figure 5 *Visualization of area districting in Lizard*



Dependent on different settings concerning the available options during the calculations different results can be achieved. Some examples are shown in the following figure. All calculations are done on the same data set as in the figure before. Just the settings where changed. In figure a) the importance of balance balance was set to 0, instead the compactness of the resulting areas should be most important. In figure b) the options is the other way around as in a), consequently the compactness is less important and the balance is most important. Figure c) shows th result of the disctricting problem if just one search directions are allowed for the lines which were put into the dataset.

Figure 6 *Results of the problem using different options*



2.2 Easy Map District Manager

The Lutum + Tappert DV-Beratung GmbH is one of the biggest companies in Germany which provide tools, data and services to do Geomarketing analyses. The company was founded in 1982.Consequently it was one of the pioneers in the German Geomarketing field. Already 1986 the first version of the Easy Map District Manager was sold. Thenceforth the software was emphasized by a lot of functions. Today Lutum + Tappert provide different attendances from the field of Geomarketing. The main field is the sale and application of their software Easy Map District Manager. With the help of this data of costumers, potentials of markets and data of the population can be visualized per example. Thus a costumized analyses is possible to realize marketing strategies, control the market and check some statistics. Additionally to the software Lutum + Tappert offer data which may be necessary to acquire new costumers or do more detailed analyses. Furthermore the offer services to help companies during their researches.
The most important tool for this thesis is the Easy Map District Manager.This one is provided in two different versions, which included different options and analyses functionality. The Easy Map Standard Desktop Edition is useful to create maps and do some geographically analyses. However the Easy Map District Manager Desktop Edition may necessary to do Area segmentation and planning of locations. Both editions are available as a demo version, consequently a deeper inside into the functionality of the software is possible. After the installing of the District Manager some sample data can be used to do some analyses. Therefore zip code areas of Hamburg and the neighbourhood of it are taken. The tool offers three possibilities to do area segmentation. The first one generates new areas if no distriction was done before. Within the test scenario a given number of areas are created by allocating the zip code areas to districts. The number of zip codes areas within every district should be as balanced as possible compared to the others. After the allocation is done locations are set into the middle of the area to show the position of possible new company sites. These approach is similar to the Greenfield analyses which will be explained later. The second functionality

uses an distribution of areas that already exists. The containing zip code areas in every superior area will be rearranged if it is necessary to get a balanced area segmentation concerning the number of zip code areas within every district. Existing locations within that dataset are not heeded during the rearrangement. The third option uses just existing locations. With the help of these sites the zip code areas are allocated in this way that every locations is placed within one district. Additionally every district should have the same number of zip code areas again. These two provided functions are both from the field of the optimization of area segmentation. In reality often additional data are used during the rearrangement per example the number of households or the purchasing power. These information are used during the area segmentation and are often the parameter which should be balanced. Such a use case was not possible to test because such data are not available for the chosen area. Nevertheless an analyses concerning the number of postcode areas can be done so that an inspection of the results can be done. It is recognizable that the resulting areas are mostly coherent but there is no need to get an absolutely coherent district. Especially at borders to other regions some postcode areas are located inside of the neighboured region. Consequently it is not connected directly to the superior district which it belongs to. Thus the conclusion can be achieved that no checking of coherence will be done. By that reason the islands of the north sea do not lead to some problems during the allocation.

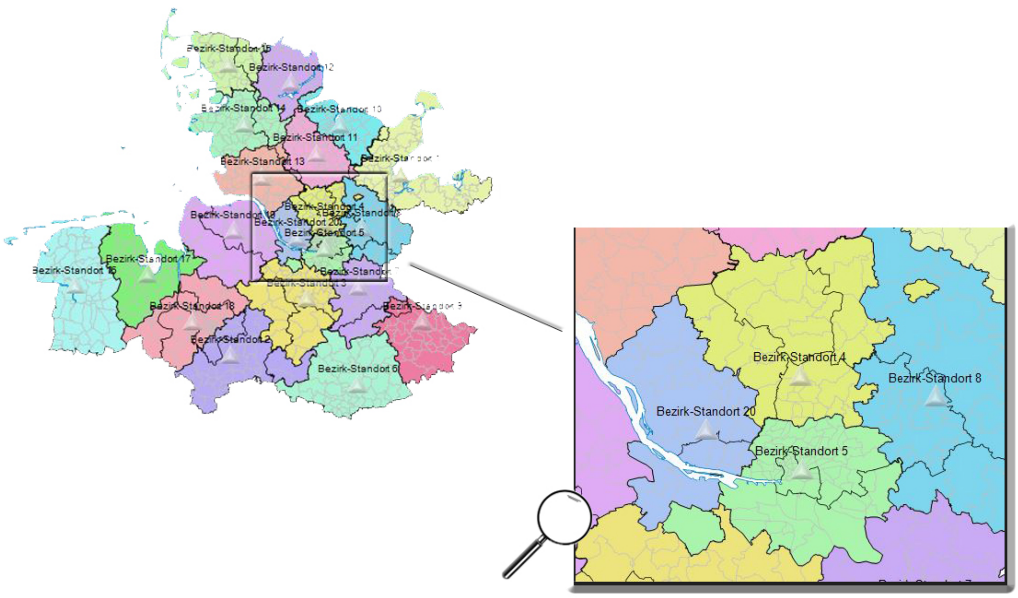


Figure 7 *Creating twenty areas with Easy Map District Manager concerning a balanced number of zip codes areas for each district. The clipping shows the creation of incoherent areas.*

After doing the area segmentation the locations are placed into the middle of the appropriate district. In this case no other placement can be chosen. Just if an

optimization of company sites should be done the locations can be placed into the weighted centroid of the district, too. Furthermore it is recognizable that no new locations can be added to the area where already a certain number of sites exist. But this will be necessary if a new company sites need to be opened. This fact will be described later on with the help of the term Whitespot analyses.
Nevertheless the Easy Map Manager offers a lot of possibilities to do some Geomarketing analyses. With the help of video tutorials on the website of the company working with the software is easy. Consequently no time consuming contraction is necessary.

2.3 SIM Tool

3 Fundamentals of area segmentation

Already for several decades people had been doing researches in the field of area segmentation approaches. The first important model for area alignment was implemented by Hess et al. in 1965 whose solving a center-seeking political distrciting problem[13]. Since then a lot of additional researches are done to acquire a lot of more possible approaches and to improve existing ones. The origin which created the need for area segmentation deal especially with marketing aspects or with political distriction. Per example demographic countries need to create constituencies for every election that will be done. Therefore the state or federal state needs to be divided into smaller sub parts. Consequently an area segmentation approach is necessary. Besides that example area design approaches are often used for sales districting. Within these two special fields different researches exists. But it is recognizable that just a few approaches exist dealing with other aspects from the field of Geomarketing. Nevertheless with reference to these examples it can be deduced that area segmentation is a grouping of small geographic units into larger cluster in such a way that the latter are acceptable according to one ore more relevant planning criteria [16, 27]. The smaller geographic areas are often called basic areas, the clustered units are mentioned as territories. Dependent on the context the relevant planning criteria may change. Per example if an economical context is used may be the number of costumers or the workload needs to be balanced. During the distriction several restrictions like compactness or contiguity needs to be satisfied. Such conditions will be explained in section 4.1 Planning criterias in more detail. Often a centre point is set into the units in the end if no one is given in the beginning.

Considering the researches which were done during the last decades it is recognizable that the most of the acquired approaches are optimization models. Three types of models can be identified: location-allocation approaches, set-partitioning approaches and heuristic methods. The location-allocation technic uses two steps to achieve a territory alignment. Therefore no centre points are given in the beginning which should be used for the creation of the clustered territories. Consequently in first step the centres of the territories need to be chosen. This stage is called location phase. Within the second step, the allocation phase, the small geographic units, called basic areas, are assigned to these centres. Both steps are iteratively performed until a satisfactory result is obtained [16]. During the location-allocation stages it is tried to balance a relevant planning criteria. In some case no centres need to be determined, if there already exist ones. Per example this is the case if a sales districting should be done where already salesman exist whose homes should be the centres of the territories. In such a case just the allocation phase needs to be done. The location-allocation approach was used by Hess and Samuels[12],

Zoltners and Sinha[27],George et al.[8] and Schröder[24] per example.
Second there exist so called set-partitioning approaches. These methods is based on the process to generate cantons as a subdivision of all geographical units. These cantons are considered as aspirants to achieve a satisfying area segmentation. After this step is done a partition of the overall content should be done using such cantons to get a well balanced result [24]. Consequently two steps are necessary again as it was also done in the location-allocation approach. Both steps are performed consecutively or simultaneously as it was done in Garfinkel and Nemhauser[7], Nygreen[22] and Mehrotra et al.[17] per example.
As a third type of optimization models heuristic approaches exist. Contrary to the other two model types this one considers no processes of mathematical programming during the alignment.
All three applied types of models own advantages and disadvantages which make them more or less useful to implement them for geomarketing strategies. These will be explained in more detail in section 4 Selecting approaches for implementation.

3.1 Notions and criterias

Every area segmentation process is subject of several parameters that should be considered. In the case of political restriction one parameter may be a balanced distribution of the population in every created area. Besides a balanced criteria there exist a lot of more parameters and conditions which can be borne in mind. In the following section the most typically parameters will be explained in more detail. However at first some important notions are mentioned which are correlated with every territory alignment approach.

3.1.1 Basic areas

Every area segmentation problem consist of a set V of areas to which the alignment should be done. These areas are geographical objects in the plane consequently it my be points (e.g. addresses of costumers), lines (e.g. street-sections) or polygons (e.g. districts). These areas are called basic areas. Let B denotes a basic area then:

$$B_1 \cup B_2 \cup ... \cup B_n = V$$

In the case of that master thesis all implementations will be done to zip-code areas which will be represented by polygons. Further information can be found in section 5 Implementation of area segmentation approaches. Every basic area is linked with one or more quantifiable attributes which should be considered during the distriction. That attributes may be the number of households, the workload or the purchasing power.

Figure 8
Zip-code areas from Dresden as basic areas using in an area segmentation process

3.1.2 Number of territories

The number of territories defines how much higher ranking areas will be created using the basic areas. The number of territories will be given by the user in case of that master thesis. Some approaches like it was done in Kalcsics et al. [16] the number of territories was handled as a planning parameter. Let B denotes the basic areas again and T denotes a territory then:

$$B_1 \cup ... \cup B_n = T_1 \text{ and } B_{n+1} \cup ... \cup B_m = T_2 \text{ etc.}$$

$$T_1 \cup T_2 \cup ... \cup T_n = V$$

3.1.3 Territory centers

Usually a created territory is associated with a territory centre. If the area segmentation was done without centres which had exist already pre the calculation the centres are often located afterwards into the geographical centre of the territory. In other cases already centres exists. These will be the origin from that the alignment will start. Let T denotes the territories again and Z denotes a territory centre then

$$Z_1 \in T_1 \text{ and } Z_2 \in T_2 \text{ and ... and } Z_n \in T_n$$

3.1.4 Unique assignment of basic areas

A determined condition during the application of an area segmentation is the unique assignment of basic areas. This means that every basic areas is exactly allocated to one territory centre. Consequently no basic area exists which is not assigned to any territory centre. At the same time no territory centre exists which shares one basic area with another territory centre. Let B denotes a basic area and T denotes a territory consisting of several basic areas then:

$$B_1 \cup B_2 \cup ... \cup B_n = V \text{ and } T_i \cap T_j = \emptyset, i \neq j$$

3.1.5 Additonally Planning criterias

Area segmentation processes are done to group small geographical units into larger clusters. Thereby often at least one planning criteria will be considered during the alignment. The planning criteria depends off the context for which the territory distriction will be done, consequently there exist several different criteria. The most common will be explained in that section.

3.1.5.1 Balance

In the most of the cases a activity measure value should be during the area segmentation process. Consequently the created cluster needs to be created in such a way that the sum of the activity measure of the containing basic areas is similar comparing to the other territories. Let B denotes the basic areas, then the total activity measure of one territory can be formulated as:

$$w(T_i) = \sum\nolimits_{B \in T_i} w_B$$

Considering results of area segmentation processes a perfectly balance of the activity measurement can not be accomplished. This is caused by the discrete structure of the problem and the unique assignment assumption [16]. The activity measure value depends on the context for which the planning distriction should be done. Either it may be economical origin like purchasing power and working load or it comes from demographic origin like the number of households and the number of population. Furthermore several activity measure values can be considered at the same time too. Instead of an activity measure it also may be possible to regard just the size of the area. Per example every territory should contain a similar number of zip-code areas.

An example of territories which are not balanced considering a activity measure and which are better balanced is shown in the following figure. The area segmentation process is done to zip-code areas from Dresden and its neighbourhood. The used zip-code areas are more detailed as the common ones which contain 5 numbers, for more information about the used data see section 5 Implementation of area segmentation approaches. In this case the activity measure are the number of households.

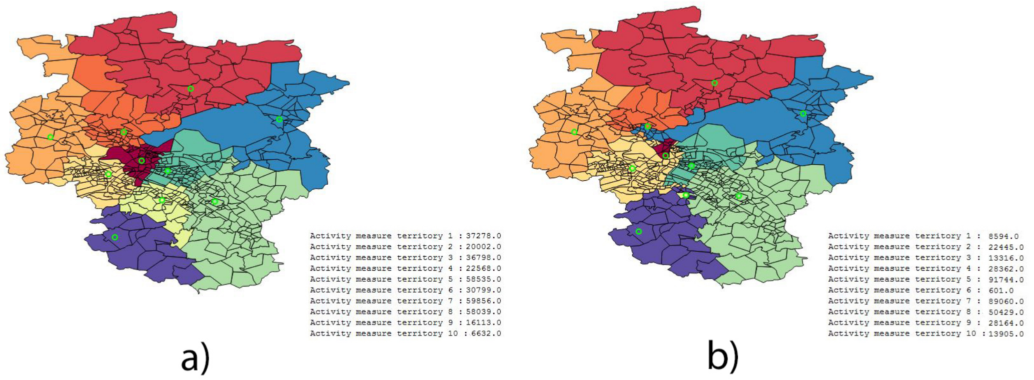


Figure 9 *Comparison of different results concerning balance of activity measure. a) Better balancing of activity measure. b) Poor balancing of activity measure*

3.1.5.2 Contiguity

Often a constraints for the created territories is the contiguity of them. This means that every basic area that is contained in a territory is directly neighboured to one other basic area of the territory set. Therefore explicit neighbourhood information of the basic areas are required. For satisfying the condition neighbourhood graphs may be used in the algorithm. In the following figure coherent territories are confronted with not coherent territories.

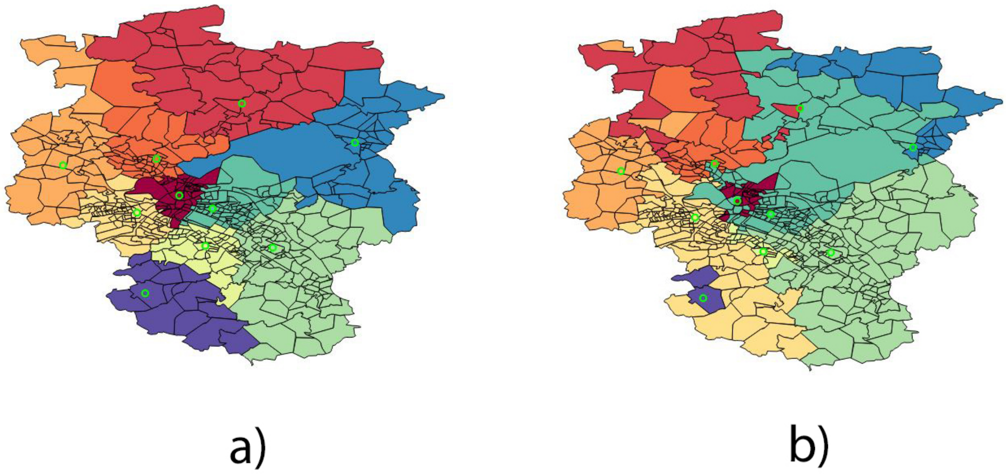


Figure 10 *Comparison of different results concerning contiguity a) Coherent territories. b) No full coherence of the territories.*

3.1.5.3 Compactness

In economical and demographical context the resulting territories often need to be compacted. In such cases compactness describes a "fine" and "meaningful" shape of the territory boundary, per example the shape ought to be round or quadratic. Young defines a compact figure as "homogeneous and in a limited space located figure which is not scattered over a spacious area" [26]. In case of a economic context a round shape of the territories is defined as compact to minimizes the access route starting from the territory centre per example. The compactness can be calculated with the help of different compactness measures like the compactness measure of Cox or the one of Harris. Additionally the weight of the euclidean distance can be used to define the compactness rate. In the following figure two examples are shown with different compactness of the territories.

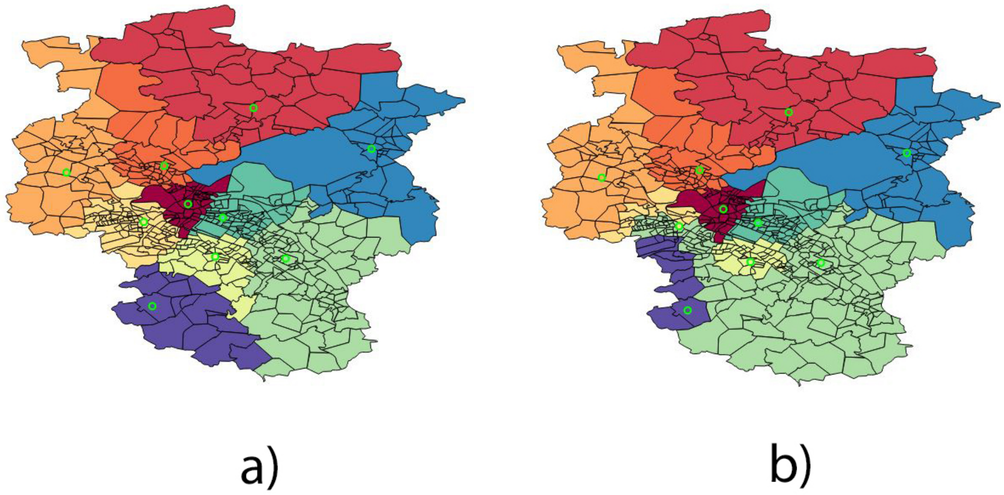


Figure 11 *Comparison of different results concerning the compactness a) More compact territories. b) More scattered territories.*

3.2 Use cases

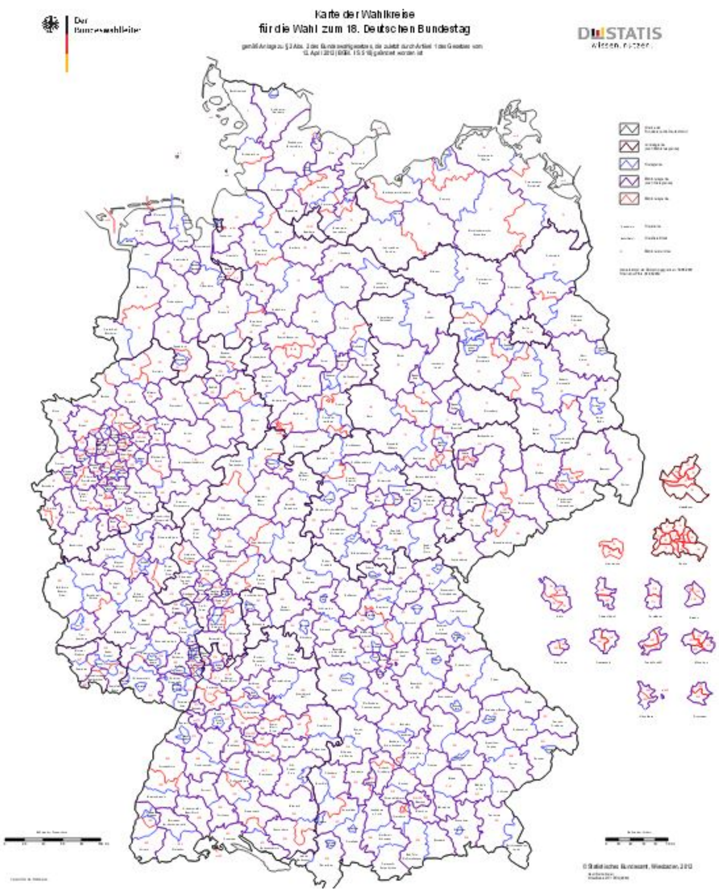
3.2.1 Political Districting

Within determined time intervals elections are done within a country to vote for persons who wants to be the representatives of a country, federal state etc. Therefore the area have to be divides into sub parts, so called constituencies. Every constituencies nominees one candidate who will be elected directly into the parliament, this districting problem is called the "one man-one vote" problem. A democratic elections is based one the same weight of every voting that is why some restrictions have to be followed during the political distraction. In Germany these conditions are set down into the Federal Electoral Law §3 Art. 1. It determines that the creation of constituencies should be done in this way that the number of constituencies within the federal state should be agree with the part of the population [3]. This means that every constituency should hold a similar number of voters compared to other constituencies. The number of inhabitants of Germany is used as stipulation to satisfied that condition. During the distraction the boundaries of townships, districts and cities should be preserved as much as possible. Considering different uses cases of political distriction three essential characteristics of districts can be defined:

1. The created constituencies should have nearly equal populations in order to respect the principle.
2. The created constituencies should be coherent.
3. The created constituencies should be geographically compact

Before an election can be carried out the constituencies has do be proofed and adapted if it is necessary because local alteration of the population can be recognized over the time. A commission will do this in front of every voting. The figure below shows the political distraction in 2013 fr the parliamentary elections.

Figure 12 *Politicial Districtings in Germany for parliamentary elections in 2013 [3]*



3.2.2 Sales Districting and optimization

One of the most common tasks of marketing organization is the arrangement of areas of operation for the branch offices as well as the organisation of the costumer care within these areas of operation. In every company which deals with branch offices this planning task is important and needs to be done periodically. During the planning process several territories are created which contain costumers. For each territory one salesman is responsive for. Historically the sales districting was done with the help of a paper map, some pins, string and adhesive label. Already today some companies are doing it this way. The fixedness of that approach is obvious, additionally it is really fault-prone during a new alignment or a rearrangement of the sales distriction.

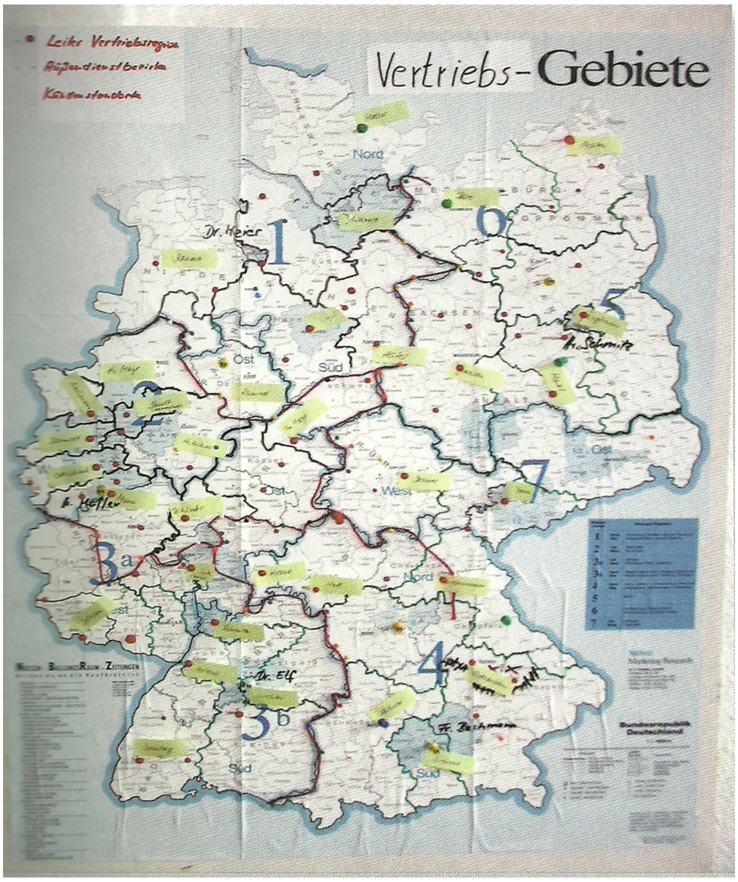


Figure 13 *Historical sales distriction with map, pins and strings [25]*

More and more companies recognize the advantages of software tools are to do such sales distriction. During the alignment and optimization several criteria may be kept in mind. It is necessary to know how much territories should be created (dependent on the number of salesman) per example. Furthermore the territories need to be compact and coherent to minimize the travelling time for each salesman. In addition to cost and time saving by having well formed sales distriction a lot of more advantages are given by that approach. Per example an unequal work load or territory potential compared from one salesman to another can lead to low morale, poor performance, a high turnover rate, and an inability to assess the productivity of individual territories or districts [12]. Additionally some costumers may be unattended by too much workload of a salesman or by no definite allocation to one territory. With the help of visualising of existing costumer data an incorrect assignment of costumers to a salesman can be demonstrated. These ones may be owing to a historically growth because every salesman amplifies its stock of costumers. By a reallocation of that costumer data the territories can be redefined so that the work load and the travelling time can be optimized.

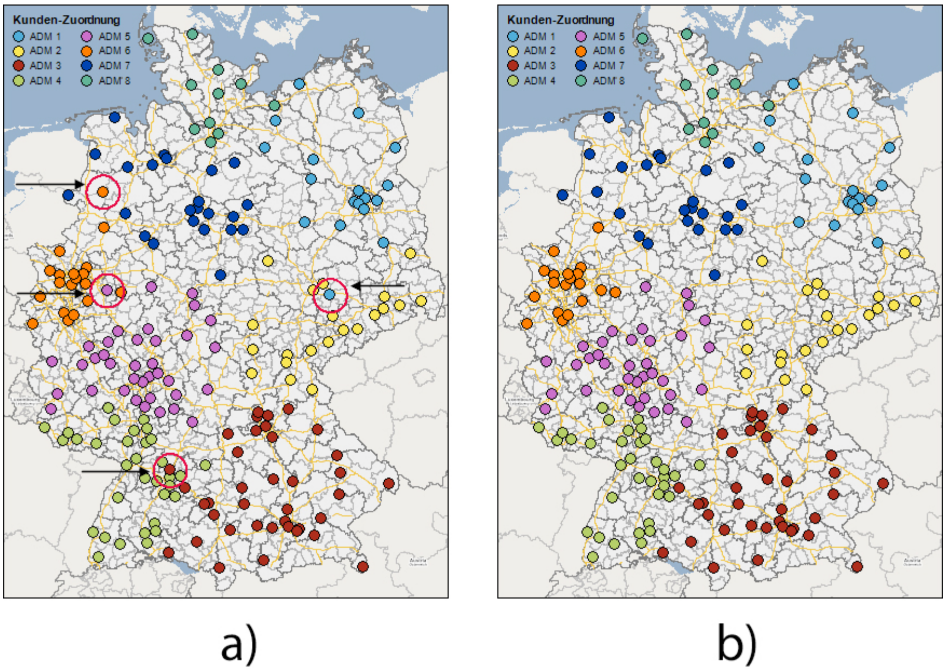


Figure 14 *Redefinition of affiliation of costumers. a) Faulty allocation of costumers. b) Redefined assignment. [14]*

Additionally to work load, travelling time etc. the potential value of every territory should be balanced. As it is shown in the following figure this is not the case in figure a).Consequently an area optimization needs to be done to balance the potential value of both areas.

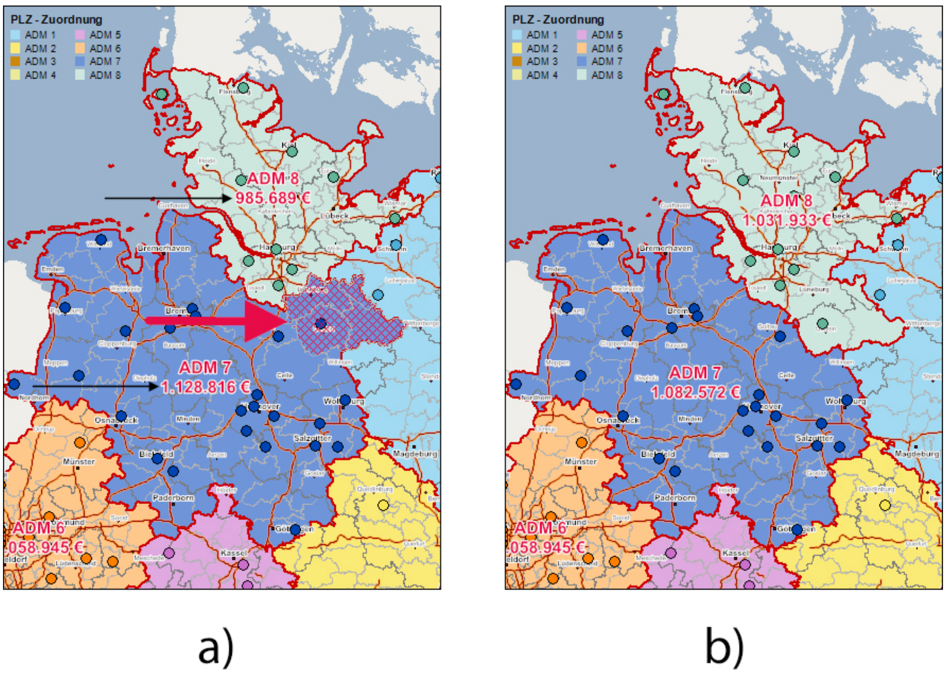


Figure 15 *Unbalanced potential value within different territories a) Existing situation of unbalancing. b) Territories ater optimization. [14]*

3.2.3 Whitespot analysis

The most of the companies aspire for expansion to raise their profit. For this step it is necessary to know where unexploited potentials of markets exists. Therefore the so called white spots of a map need to be determined - this process is called whitespot analysis. Every white spot contain costumers which may not be bonded to a competition company so that they receive the potential for more profit of a company. The following figure shows an example of the natural gas network in Germany. The white spots are communities which are not connected to the integrated network. Consequently these areas are interesting for other thermal care systems like oil or coal.

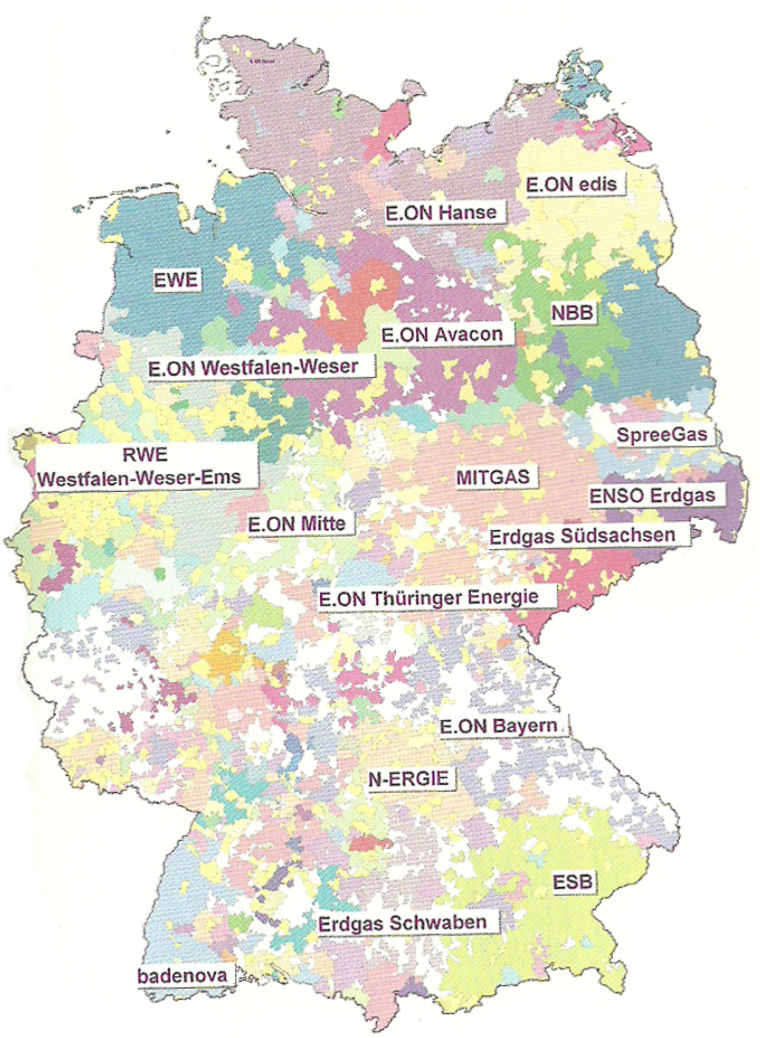


Figure 16 *The map shows the natural gas network in Germany. The white spots are communities that are not connected to the integrated network. [25]*

4 Selecting approaches for implementation

4.1 Requirements of approaches considering geomarketing analyses

For the application of area segmentation approaches to geomarketing analyses some dedicated requirements are need to be kept in mind to get an useful result. Possible planning criteria where already explained in detail in section hyperref[criterias]Additonally Planning criterias. It was mentioned that contiguity, balance and compactness may playing a huge role during the distriction. considering geomarketing aspects all three planning criteria are need to be satisfied. Taking the example of sales territories owing a certain number of sales man shows that a not balanced alignment yield to an imbalance concerning work load of the employees. This could lead to disaffection. Additionally the territories need to be compact to making the sale process more effective by minimizing travelling time.
The area segmentation in this case study will be done to already existing territory centres consequently a determination of new centres in the beginning will be not necessary.
All these requirements and conditions needs to be kept in mind during the comparison of model types and the selection of promising algorithm for the implementation.

4.2 Comparison of model types

In section 3 Fundamentals of area segmentation it was mentioned that there exist three different type of models which where applied in history for distriction processes. The first model type is location-allocation approach and is the one that is mostly used. Within the location-allocation process in the location phase territory centres are chosen. In the second step the basic areas are assigned to these centres. Both steps are done iteratively until a satisfying result of the area segmentation is achieved. For selecting approaches for the implementation within that master thesis that method will be analysed in more detail to determine whether it will be used for that thesis too. The first model of the location-allocation approach was developed by Hess et al. [13] in 1965 to solve a political distriction problem. Due to application of the model to sales districting hess model was enhanced by Hess and Samuels [12] and has established known as GEOLINE model. After the implementation they admit that their GEOLINE approach "does not provide optimal sales territories" [12]. Additionally the gained solution my be not well balanced and coherent. Consequently the practical use of this model is fairly limited. That is why Fleischmann and Paraschis [4] developed a modified solution of the GEOLINE model, but their approach demonstrates the same disadvantages like the one of Hess and Samuels. The difficulty of the solution of the capacitative transportation problem is the assignment of portions of basic areas to more than one territory centre to satisfy the balancing constraint. Consequently these so called split areas require a more detailed consideration. Hess and Samuels [12] tried to achieve a well balanced solution using a so called AssignMAX approach. Within the alignment they had district the split areas to the territory centres which "own" the largest share of the split area [12, 16]. But Fleischmann and Paraschis [4] had proofed that this approach leads to very poor results for their application. Consequently they tried to implement an improved solution of the alignment of split areas but the solution could not resolve all splits automatically thus it was necessary to do some manual post processing [4, 16]. Due to these problem different improvements were developed to find a good split solution. Schröder [24] tried to find a optimal split resolution using tree decomposition. With the help of that approach the best area segmentation in the system of the equations can be determined. Contrary to solving a transportation and split problem Zoltners and Sinha [27] implemented an approach using sub gradients. The advantage of that method is the calculation of several possible area segmentation solutions. From this amount of solutions the best one can be chosen. But comparison to the approach implemented by Schröder show that the calculation time using the approach of Zoltners and Sinha is higher then the one using Schröder algorithm [24]. Additionally Zoltners and Sinhas approach needs territory centres which are well distributed to achieve a good solution of the calculations. Consequently the algorithms indeed provides coherent areas, but the resulting territories may not be well balanced. Considering all mentioned approaches it can be recognized that no one yields to optimal results considering the area segmentation process. Either the created territories are not coherent or they are not well balanced. Additionally due to the complexity of the split resolution the calculation time is still too high if large scale problems need to be answered [16]. Furthermore the location-allocation approach is not owing to the linear terms of the equations that need to be answered. Consequently the application of measures of compactness will be constrained considerably. Considering all these problems location-allocation approaches seem to be inapplicable for the application to geomarketing analyses. Consequently such approaches will not be considered in that master thesis.

The second type of model is called set-partitioning approach and was implemented Mehrotra et al.[17] per example. During the set-partitioning method subdivision of all geographical units will be created. Accordingly these ones will be used to get a balanced result by a partition. Compared to location-allocation methods a major advantage of set-partitioning is the higher flexibility concerning a satisfying result of the area segmentation. In contrary to only limited use of criterion in the location-allocation methods in this approach any criterion can be applied on the generation of candidate districts [16]. Nevertheless at the same time this advantage is a disadvantage too because the huge flexibility causes a raising combinatoric complexity. That is why the set-partitioning approach can be only used for smaller problems. It have not been used with more than 100 basic areas [16]. Compared to the location-allocation approaches this method is more ineffective, cumbersome and computationally unattractive [27]. Considering that statement it is obvious that the set-partitioning approach can not be applied to geomarketing analysis to achieve satisfying results. Additionally geomarketing analysis are mostly done to huge area segmentation problems containing a lot of basic areas. Consequently the set-partitioning method can be seen as unusable for that application.

The third type of models are heuristic approaches. These ones do not need any solver for linear problems like set-partitioning and location-allocation approaches use. Instead just some mathematical programming is necessary. The main advantage of heuristic methods is the huge flexibility concerning the integration and observance of one or more criterion. At the same time a forecast of the quality of the created territories may be difficulty previously. Normally the quality will be measured afterwards comparing different solutions. Consequently just a relative rating of the quality is possible [24]. Nevertheless compared to the disadvantages of location-allocation and set-partitioning methods heuristic approaches seems to be the most promising ones to apply for geomarketing analysis. By comparing different heuristics it will be tried to find an algorithm with a high quality of the alignment results. To making the algorithm more dependable different heuristics will be combined. Additionally some completely new heuristic approaches will be implemented. In the following table an overview of the advantages and disadvantages of all three types can be found.

Table 2 *Comparison of different types of models*

	location-allocation	set-partitioning	heuristics
short explanation	first chose centres, Second assign basic areas to the centres	using subdivisions and partition	mathematical solution of problems
advantages	• chooses best solution of several calculations	• high flexibility	• huge flexibility • do not need a solver • easy to implement • usable for one or several criterion
disadvantages	• territories may not well balanced or not coherent • calculation time still too high caused by split areas • just one criterion applicable	• useable just for small problems	• difficult to determine a forecast about the quality of the result previously

4.3 Heuristic approaches

During the last decades several heuristic algorithms were implemented to solve area segmentation problems. The common one will be considered in that section to chose the approaches that will be taken within this master thesis.
Mehrotra et al. [17] per example developed an algorithm called **Eat-up**. During the Eat-up approach one territory after the other is extended at its boundary by adding yet unassigned basic areas to the territory successively. This will be done until the territory satisfying the criteria that need to be balanced. The algorithm was implemented for political distriction with the goal "to develop a districting method that provides population equality and contiguous and compact districts while retaining jurisdictional boundaries of counties or other political subunits insofar as possible" [17]. Within their case study of political distriction in South

Carolina they conclude that their implemented algorithm is "an effective way of generating high quality districting plans" [17]. Consequently the Eat-up approach may be one of the potential methods used in that master thesis.
Deckro [2] implemented an algorithm called **Clustering**. That approach treats each basic area initially as a single district. After creating a ranking of neighboured basic areas pairs of districts are merged together iteratively so that a new bigger territory will be created. During the creation of the districts a particular criterion is considered and needs to be satisfied within a range of acceptable variation [2]. The districts are merged together until the number of prescribed territories is reached. It was not possible to find further examinations of the usability of that approach. Although it seems to be promising it is not applicable for the area segmentation processes that needs to be done for this master thesis because the distinction will be done using existing territories centres. But the clustering algorithm do not use any centres.
The Multi-kernel growth approach was used per example by Bodin[1] in 1977. This method is made up of two steps. In the first step a certain number of basic areas are determined as centres of the territories that should be created. After this step to each centre neighbouring areas are successively added. The neighboured areas are added in order of decreasing distance to the centre. The alignment of basic areas is done until the desired territory size is reached. The second step of this approach is similar to the **AllocMinDist** method which was implemented by Kalcsics et al. [15] where the basic areas are allocated to the closest territory centre like it is done in the Multi-kernel growth approach. They conclude that the AllocMinDist algorithm leads to "disjoint, compact and often connected, however, usually not well balanced territories as the balance criterion is completely neglected when deciding about the allocation" [15]. Nevertheless they have mentioned that "the attractiveness of this method [...] lies in its simplicity and computational speed [15]. Consequently these results are also adaptable to the second step of the multi-kernel algorithm. The first step can be ignored because in the application of that thesis territory centres are already given. Owing to the mentioned advantages of the allocMinDist algorithm this one may be useful during combining different heuristic approaches. That is why it will be tested during the implementation. Additionally it will be proofed whether the same results of the allocMinDist algorithm are achieved like in the application of Kalcsics et al..
Another developed approach for optimization is the so called **local search**. Within that method the basic areas of neighbouring territories are shifted to minimizing a weighted additive function of different planning criteria [16]. Consequently an area segmentation needs to be done at first so that the local search can be applied to the solution. Under this aspect local search may be a promising method for combining different heuristics. Per example at first the allocMinDist algorithm may be

applied accordingly the local search approach.
Another approach that needs to be mentioned is the algorithm which is implemented within the Lizard Library of KIT (see section 4.3 KIT - Institute of Operations Research: discrete optimization and logistic for more information). The **Recursive Partitioning Algorithm** divides a problem into smaller sub problems until each sub problem satisfies the considered criteria. A similar approach was implemented by Forrest [5]. Problems of the Recursive Partitioning Algorithm were already mentioned in section so that this approach will not be used within this thesis. Although the created territories seem to be well balanced, they not need to be coherent after the calculation. Additionally the algorithm is based on no territory centres, but the geomarketing application which will be considered first provide existing centres.
Considering all mentioned approaches it is recognizable that just some methods seem to be promising while other do not. In conclusion three approaches will be used during the comparison. These approaches are Eat-up, AllocMinDist / Multi-kernel growth and local search. Additionally some further algorithms are developed. Related to the AllocMinDist approach the same will be done considering only the given criteria that should be balanced. This approach is called AllocCrit in the following. In addition to this several approaches are implemented combining different methods. The first one is appropriated to the AllocMinDist combining with the consideration of the activity measure of the basic areas. Therefore to every territory centre the basic areas are assigned iteratively considering the activity measure of the centre. That means that the centre with the smallest activity measure gets the nearest basic area that is not assigned yet. These steps will be done for each territory centre until all basic areas are allocated. This approach will be called SmallestCritGetsNearest. An improvement of that approach is called SmallestCritGetsTrueNearest which considers neighbouring relationships in more detail. The procedure of the algorithm is similar to SmallestCritGetsNearest but the nearest neighboured basic areas is just allocated if it is really the nearest one to this territory centre. If it is not the case another basic area will be taken.
Researches during the last decades show that algorithms that raise the size of the territories from centre may yield to bad results concerning the coherence of the territories. That is why algorithm were implemented where the starting point of alignment lies at the boundary of the observation area. Consequently such a heuristic is implemented within that master thesis too. But this one is combined with the SmallestCritGetsNearest algorithm to yield to better results. Because of the combination of two heuristics the algorithm contains two steps. In the first one all outer territories which lie on the border are allocated to territory centres if they are nearest to one centre. To consider also territories which may be allocated to different territory centres, similar to split areas, a coefficient is used,

which should be satisfied for allocation. If the assignment of outer territory centres is done the second step will be initialized which is the SmallestCritGetsNearest approach. The whole algorithm will be called OutsideSmallestCritGetsNearest. The next chosen algorithm is a combination of the Eat-up and the AllocMinDist approaches. Within the Eat-up algorithm each territory centre gets basic areas until the termination criterion build up from the planning criteria is reached. This allocation determines no relationship which basic area will be chosen for the assignment. Within the improved algorithm just the basic areas are allocated which are nearest to the territory centre. The algorithm will be called EatUpMinDist. Furthermore to the mentioned algorithms a combination of AllocMinDist and local search will be implemented too. The algorithm contains two steps similar to the OutsideSmallestCritGetsNearest approach. At first the AllocMinDist processes will be applied. Afterwards the assigned basic areas are rearranged again using local search to create a balanced resolution. Consequently this algorithm is called AllocMinDistLocalSearch

All algorithm are implemented with the aim of finding an usable calculation procedure for area segmentation processes for the implementation to geomarketing analyses. All approaches will be compared to find the most promising one. For summarizing the used algorithm they will be shown in the following table again.

Table 3 *Overview about selected heuristic approaches for implementation*

	short explanation
AllocCrit	Assigns basic areas to each territory centres dependent on the activity measure of the centre achieving by the sum of the activity measures of the assign basic areas.
AllocMinDist	Assigns the basic areas to the territory centre which is closest.
Eat-up	Extends one territory centre after the other at its boundary by adding yet unassigned basic areas to the territory successively.
SmallestCritGetsNearest	Combination of AllocCrit and AllocMinDist: Assigns the closest yet not assigned basic areas to each territory centres dependent on the activity measure of the centre.
SmallestCritGetsNearest	Improvement of SmallestCritGetsNearest: Process is similar to SmallestCritGetsNearest but the allocation of the closest basic area will be done only if it is the closest territory centre at all.
OutsideSmallestCritGetsNearest	Assigns first basic areas at the boundary of the area under investigation. Accordingly SmallestCritGetsNearest is applied.
EatupMinDist	Combination of Eat-up and AllocMinDist: During the Eat-up approach just basic areas are allocated which are close to the considered territory centre.
AllocMinDistLocalSearch	Combination of AllocMinDist and local search: At first the AllocMinDist will be applied. Afterwards a rearrangement is done using local search to achieve a well balanced solution.

5 Implementation of area segmentation approaches

The comparison of different optimization models in the section before shows that heuristic approaches seems to be the most promising methods for the application of that master thesis. That is why 8 different approaches were be chosen which will be implemented. The results of all algorithm will be compared to find the most usable algorithm of that amount.
Section 3.1 Notions and criterias shows the fundamentals and necessary notions doing an area segmentation.

einleitung: welche daten, plz gebiete (bild welche eigenschafte, wie repräsentiert), hinterlegt mit einem attribut, nicht mehr attribute, warum wahl des testdatensatzes...

5.1 AllocCrit

5.2 AllocMinDist

pdf gebietoptimalaufteilen, S 150 Ausgehend von den Punkten lassen sich nun Entfernungen div zwischen Zentren und KGE berechnen. Hierfur gibt es verschiedene Vorschlage in der Literatur. Wir besprechen kurz die wichtigsten. Euklidische Distanzen. Die Entfernung zwischen Zentrum i 2 I und KGE v 2 V ist $div = (Ostiostv)2+(Nordinordv)2_1 = 2:$ Dies entspricht der Luftlinienentfernung und stellt eine plausible Art der Entfernungsmessung dar (Cloonan [25]). Quadrierte euklidische Distanzen. Hierbei ist die Formel zur Berechnung der Distanz $div = (Ostiostv)2 + (Nordinordv)2$ Diese Art der Entfernungsmessung erscheint zunachst merkwurdig, da sie kaum als tatsachliche Entfernung interpretiert werden kann. Dennoch wird sie von vielen Autoren verwendet (Fleischmann und Paraschis [35], George et al. [42], Hess et al. [50], Hess und Samuels [51], Hojati [52], Marlin [68]). Nach Einschatzung des Verfassers gibt es dafur zwei Grunde. 1. In locationallocationModellen ist der location Schritt besonders einfach umzusetzen, wenn mit quadriert euklidischen Distanzen gearbeitet wird (vgl. 9.1.1.1). Diese Begrundung wird in der Literatur haug zugunsten dieser Art der Distanzmessung vorgebracht. 2. Ebenso wichtig erscheint aber eine Beobachtung, die in 7.3.2 herausgearbeitet wird, und die auch im allocation Schritt fur die Verwendung von quadriert euklidischen Distanzen spricht. In diesem Fall namlich wird die Ebene in Gebiete aufgeteilt, die konvexen Polygonen entsprechen und damit eine Tendenz zur Bildung von Bezirken, die der intuitiven Vorstellung von kompakter Form entsprechen, geschaen.

dist: He concludes that the success of squared Euclidean distances depends on the ability to redefine territory centers and is not appropriate for the case of fixed centers

In most cases, the problem of allocating basic areas to territory centers is formulated as a capacitated assignment problem, see e.g. Hess et al. [HWS+65] and also Section 5. While the balancing requirement is generally included as a side constraint, compact and contiguous territories are tried to be obtained by minimizing the sum of weighted distances between basic areas and territory centers. For political districting problems, authors tend to use squared Euclidean distances (e.g. Hess et al. [HWS+65], Hojati [Hoj96]), whereas for sales territory design problems, largely straight line (Cloonan [Clo72], Marlin [Mar81]) or network distances (Segal and Weinberger [SW77], Zoltners and Sinha [ZS83]) are employed

5.3 Eat-up

5.4 SmallestCritGetsNearest

5.5 SmallestCritGetsTrueNearest

5.6 OutsideSmallestCritGetsNearest

5.7 EatUpMinDist

5.8 AllocMinDistLocalSearch

6 Problems of the implemented approaches

6.1 Performance

6.2 Requirements from the field of Geomarketing

6.2.1 Incoherent areas

6.2.2 Inhomogeneous distribution

beiden subsubsection darunter gehören eigentlich mit zu diesem Gebiet

6.2.3 Rearrangement / Infinite loops during rearrangement

6.2.4 Need of threshold Values

7 Comparison of implemented approaches

7.1 Performance

7.2 Problems

7.3 Requirements

7.4 Conclusion

8 Application of algorithm XYZ to Geomarketing analysis

benachbarte gebiete haben eine gemeinsame kante

8.1 Optimization of Areas

8.1.1 Conditions and Aims

8.1.2 Approach of algorithm

8.2 Greenfieldanalysis

8.2.1 Conditions and Aims

8.2.2 Approach of algorithm

8.3 Whitespotanalysis

8.3.1 Conditions and Aims

8.3.2 Approach of algorithm

9 Realworld scenario: integretaded Algorithm to the mapChart Manager

10 Evaluation

11 Discussion and Perspective

11.1 Summary

11.2 Limitations

gemeinsame kante für anchbarschaftsbeziehungen evtl ungeegeignet, da dabei keine geographischen grenzen wie flüße oder gebirge beachtet werden

11.3 Comparison to related work

zu algorithmus von kit vergleichen: vorteil: beste lösung wird ermittelt nachteil: bei viele daten expoentiell großer baum, nur auf gebietsverteilung ohne standorte, um rechenzeit einzsuchränken nur limitierte anzahl an richtungen der Linien + nur geraden, somit leidet die Kompaktheit, außerdem verschnitt auf PLZ-Gebiete notwendig

11.4 Perspective

vergleichen zu algorithmus von gebieteoptimalaufteilen

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