Playing Location-based Games on Geographically Distributed Game Boards

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ABSTRACT

Virtually all multiplayer location-based games require the players to meet in the same geographic place during the same period of time. As a consequence, significant organizational effort is associated with setting up a game event. In this paper we show how players who are located in different places can nevertheless play a location-based game together. We discuss which characteristics make a multiplayer location-based game concept well-suited for spatially distributed gaming. Playing in two different places implies playing in heterogeneous worlds. We show how a simple measure can be used to determine the similarity of the static structure of real world game boards. With a case study of the distributed location-based Geogame CityPoker played in two cities separated by 500 km distance we demonstrate the feasibility of distributed location-based gaming. Finally, we discuss the requirements for an online match-making platform where players from all over the world can meet to play together.

Keywords

Location-based game, game design, Geogames, match-making, similarity measurement method

INTRODUCTION

Most location-based games described in the literature suffer from the high organizational effort (and costs) associated with setting up a game event. This applies to both, single and multiplayer games, but for different reasons: games such as Uncle Roy All Around You [2] require human supervision and assistance during the game itself. Other games have been designed for a specific geographic region making the transfer to different regions expensive (e.g. REXplorer described by [20]).

W argue that for multiplayer games, a substantial part of the organizational effort in current games is due to the fact that these games expect all players/teams to meet in the same gaming area. Game concepts such as Savannah [4] or PAC-LAN [16], illustrate this *requirement of identical location*.

Figure 1: Competing teams are separated by 500 km in the towns Bremen (left) and Bamberg (right)

Obviously, the requirement of identical location severely limits the occasions on which a multiplayer game can be played.

- Players need to make an appointment for the game (e.g. "meet at the central station at four p.m.").
- For some players a journey might become necessary to join the game event. Teams from the German towns Bamberg and Bremen, for instance, would have to travel 500 km to meet for a game.
- In a small town it might be difficult to find a sufficient number of players available for gaming at a particular period in time.

An online match-making platform based on a location-based game with a geographically distributed game board would easily resolve these problems. Matching establishes a logical connection between different geographic game boards. The difficulty consists in not inadvertently giving an advantage to one of the teams. Size, for instance, matters. A game where one team plays on a 1 km × 1 km board, the other on a 10 km × 10 km board could hardly be considered fair.

In this paper, we take the first step towards a systematic exploration of geographically distributed location-based gaming. Our main aim is measuring the similarity of two game boards' static structures to find a perfect logical mapping of game relevant locations between two cities. We describe properties that make a location-based game concept especially suited for being played geographically distributed. We report on our case study of a geographically distributed location-based game we arranged in the German towns Bamberg and Bremen (CityPoker).

Our larger vision is an online platform for location-based games where players upload their self-created game boards, each from their home region. The platform compares the game boards' structures and calculates similarity measures. Whenever a player logs on the platform, a match-making mechanism finds the optimal adversary among all other players currently online. Such a platform would allow for spontaneous game events, thus lowering the organizational effort currently associated with multiplayer location-based games. The social aspect of getting to know new people from all over the world during a game is also one main concern of this approach.

The rest of this paper is structured as follows: in the following section we discuss possible sources of game board heterogeneity and conclude why location-based games played with discrete locations are especially well suited for distributed gaming. Section 3 reports on a game event of CityPoker that was arranged in Bamberg and Bremen as a geographically distributed location-based game. In section 4 we present a method for measuring game board similarity and apply it to our Bamberg/Bremen use case. Finally, we conclude with a discussion of our approach in the context of related work.

GEOGRAPHICALLY DISTRIBUTED LOCATION-BASED GAMING

Playing in heterogeneous worlds

In the context of desktop computer games, playing a game together while sitting in front of different computers is certainly not new. Network gaming allows us to immerse into the same game world although we are in geographically distant places. Examples range from traditional board games (like chess) to massive multiplayer online role playing games (like World of Warcraft). Even sportive games that require physical interaction such as hitting a ball back and forth have recently been adopted to be played over a distance (see [13] or [14]). In their game "Airhockey over a Distance" two competing players hit a small physical object (called puck) back and forth. When the puck leaves player A's game table, its speed and angle are sensed and transmitted to player B who might be located miles away. On player B's game table another puck enters with the same speed and angle as the puck of player A left.

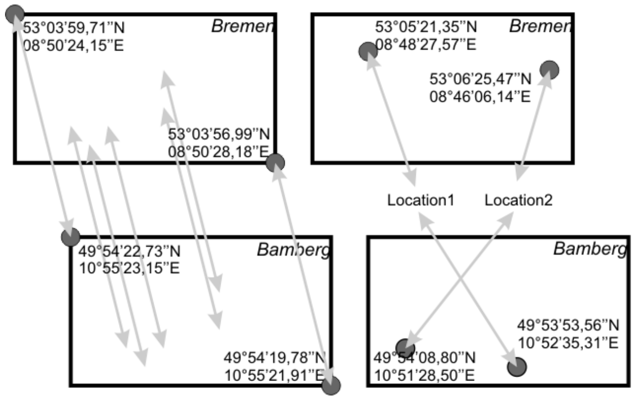


Figure 2: Logical connection between spatially continuous (left) and discrete game boards (right)

In all of these examples - chess, World of Warcraft, and Airhockey over a Distance - the two players' game worlds are structurally equal. For instance, the game tables in Airhockey are both rectangular areas with the same geometrical and physical properties. In chess both players have the same view on the board position and move according to the same rules. In contrast, a city-wide location-based game is not played in structurally equal worlds, but in different road networks under real world conditions.

In general, we can identify the following three kinds of sources of heterogeneity for real world game boards:

- Game boards may significantly differ in their *spatial scale*. This will probably lead to an unbalanced game. Note that it is not only the size but also the shape that may cause heterogeneity, e.g. the aspect ratio for rectangular game areas.
- A crucial source of heterogeneity is the game boards' *static structure*. This structure includes all environmental factors that influence the spatio-temporal game flow and that remain static from one game event to the next. Examples are the road network and the elevation profile. From the static structure we can estimate the time a player needs for moving from one place to another one.
- Finally, also *dynamic conditions* play an important role: these factors change from one game event to the next, e.g. traffic, weather conditions, and the network connection and localization possibilities (GPRS, UMTS, GPS). The static structure may favor or disfavor the occurrence of the dynamic conditions (e.g. narrow lanes disfavor GPS connection).

A distributed location-based game might to some degree benefit from the heterogeneity, because players might enjoy the additional degree of uncertainty ("What does the other road network look like? Is it raining in Bamberg?"). Future user studies should explore this issue. In the context

Figure 3: Overview map in the J2ME implementation of CityPoker showing the five cache regions in Bremen

of this paper, however, we assume that too much heterogeneity makes a game unfair and thus unpleasant to play. The match-making platform sketched in the introduction should find game boards that are as similar as possible. Comparing the spatial scale of two game boards is easy. Predicting the dynamic conditions is not our current concern. Thus, for the rest of the paper, we concentrate on the second source of heterogeneity, the static structure.

Connecting distant game boards logically

Location-based games overlay the real world with a virtual game layer. Through the game, places in the real world are assigned an additional meaning. A comparison of game boards must fail if we do not take this interconnection between game logics and real world places into account. For instance, one game board might have a hill in its elevation profile while the other one is rather flat. However, if the game logics of that specific game do not require players to cross the hill, the two game boards may still be regarded as similar. Thus, it is crucial to state which kind of game we are talking about.

Location-based games with many types of game logics exist not all of which are equally suited for being played in a geographically distributed way. The systematization for location-based games proposed by Kiefer et al. [9] helps to clarify the issue. Location-based games are either spatially discrete or spatially continuous. In a *spatially discrete game*, relevant game actions may take place at certain predefined locations in the game area. An example is GeoTicTacToe [19] where an X- or O-marker may only be set at nine discrete geographic positions. In a *spatially continuous game*, actions may occur anywhere on the game board, e.g. whenever one player comes close enough to catch the other (e.g. Can You See Me Now, [1]). Mixed forms exist, e.g. PAC-LAN [16] where certain actions (eating cookies) are restricted to predefined locations and others (catching a ghost) may happen anywhere.

Figure 4: Detail map of cache 2 in Bremen showing the current target cache (double circle) and the own position (cross)

Fig. 2 shows how distributed game boards can be connected for the two types of games: in the spatially continuous version we need to define a bijective mapping between the two-dimensional game areas that preserves neighbourhood, i.e. a homeomorphism. This bijective mapping defines how a player's position is interpreted on the other game board during the game. We could also say that each player has an avatar on the other game area that follows his (mapped) motion path. We would need to find a homeomorphism that does not distort the distances between points too much. Otherwise, the avatar would either move much faster than its real person, or even jump around. We can find such a mapping for non-city game boards (like empty sport fields), or for a simple city structure with rectangular street blocks. In the general case, for game areas with all kinds of obstacles or complicated road networks, such a mapping hardly ever exists.

In a spatially discrete game, the mapping issue is completely different. There are a limited number of discrete locations for which we need to identify corresponding locations on the other game board. For these reasons we restrict ourselves to spatially discrete games in the following.

In the systemization of Kiefer et al. [9] only GeoTicTacToe and CityPoker appear as purely spatially discrete games. Although only selected location-based games were analyzed, to our knowledge all other games are either single-player games, like the Journey series [8] or Backseat Gaming [7], or ones that do not feature a predefined spatial layout of the game board, like Feeding Yoshi! [5]. GeoTicTacToe and CityPoker are both instances of a class of location-based games called *Geogames* [18]. Games of this class are created by the metaphor of bringing a classic board game (including puzzles and card games) to the real world. The idea is to combine the strategic appeal of the board game with the real-time nature of a location-based

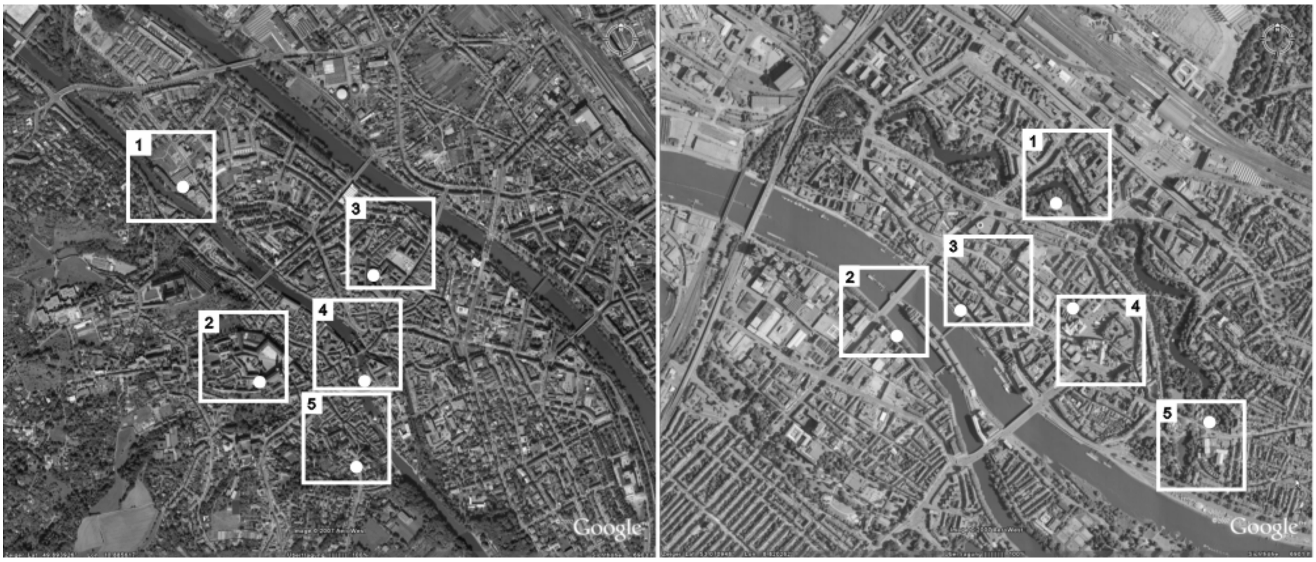


Figure 5: Game boards of our use case in the city of Bamberg (left) and Bremen (right), dots indicate the positions of the hidden poker cards

game. For this purpose, the turn-taking of the original board game is lifted so that a player may move twice if he is fast enough. The process of turning an original board game into a location-based game, and the problems that may occur in doing so, were described in [18].

USE CASE: CITYPOKER IN TWO WORLD HERITAGE CITIES

For our study of a geographically distributed location-based game we chose two cities of historical interest. In fact Bamberg and Bremen are both listed as UNESCO World Heritage sites. We played the Geogame CityPoker, a location-based variant of Poker, which was first described in [17]. We briefly describe the rules of the game.

A location-based variant of poker: CityPoker

This Geogame is usually played by two teams of several players, whereas a team may also consist of only one player. The teams start with a given poker hand of five cards and try to improve their initial hand by changing cards at five geographical location (caches) which are scattered over a city-wide game area. Every cache holds two poker cards from which one may be exchanged with one card from the team's hand. As a further restriction, teams are only allowed to change once at every cache. The game ends as soon as every team has changed a card at every cache, or when a predefined time limit (e.g. two hours) has expanded. The team with the best poker hand wins. The hierarchical order of the poker hands for the final evaluation remains the same as in real poker (royal flush > four of a kind > … > one pair) with the simplification that the order of the colors is irrelevant in our location-based variant.

CityPoker is a full information game so contrary to normal poker we eliminated most of the chance element from the game to give it a more strategic nature. Each team always knows the current card distribution of the 20 cards on the game board, i.e. which cards are currently located in the caches and which cards are held by the other team (see e.g. Fig. 6). With this information players can plan their next moves ahead and do not have to cover unnecessary distance in search for the right poker card. While each card change action is communicated, the other team's exact position remains hidden, as reasoning about the opponent's next move is one crucial part of the game experience.

Currently, CityPoker is played with Nokia 6630 smart phones and external GPS receivers connected through Bluetooth. The exact coordinates for the caches are not known right from the start. In the beginning the game shows only rough areas in form of rectangular regions ("cache regions", see Fig. 3). When a team enters a cache region the device poses the team a multiple choice question with three possible answers to obtain the exact coordinates of the related cache (e.g. "*On which material is the fundament of the city hall of Bamberg grounded: 1.) on stones 2.) on sand 3.) on stakes*"). After selecting an answer the game shows a detail map of the cache region highlighting the coordinates associated with that particular answer (see Fig. 4). Depending on whether the chosen answer is correct or not, the team will either find physical poker cards hidden at the coordinate or waste their time at

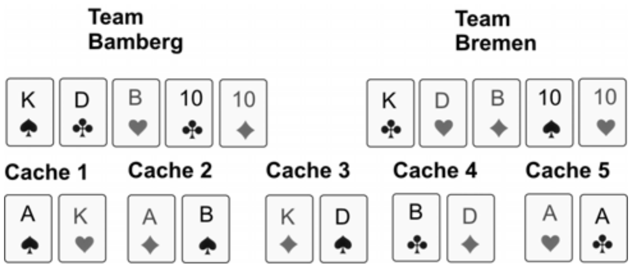


Figure 6: Initial card distribution for the CityPoker game Bamberg vs. Bremen

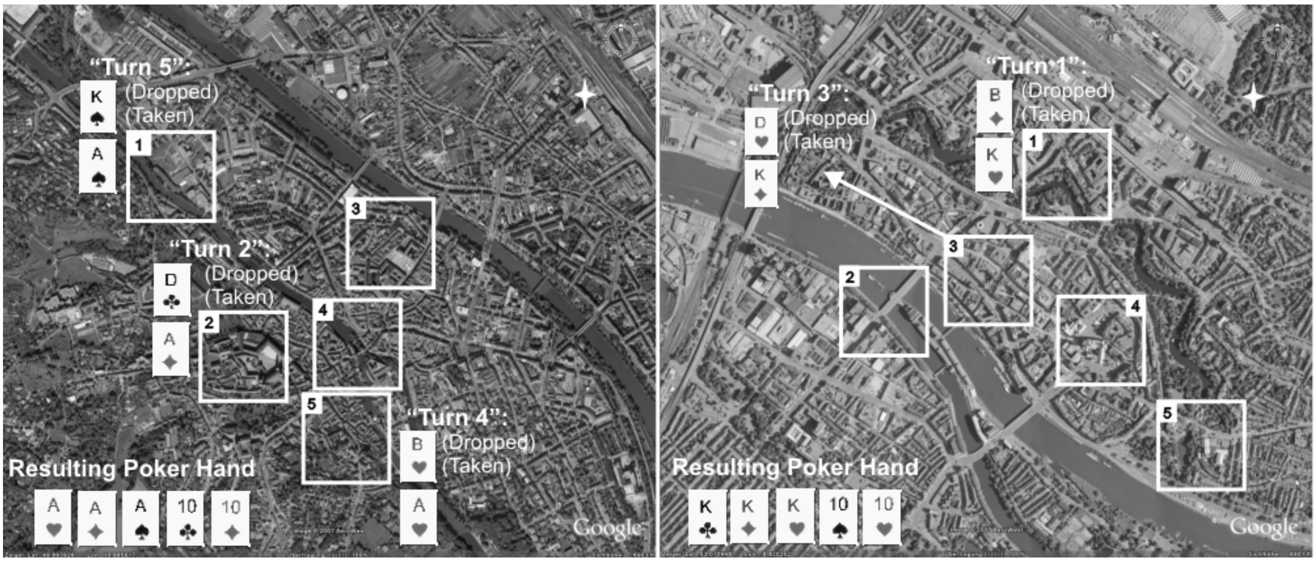


Figure 7: Course of the CityPoker game Bamberg (left) vs. Bremen (right). Stars indicate the teams' starting positions.

the wrong place. Answering the quiz a second or a third time is allowed and players are also encouraged to ask locals for hints for the quiz. Thus, in the worst case players have to search all three possible caches to find the hidden poker cards if they do not know the right answer and are unable to find external help.

As GPS localization is not exact enough to pinpoint little poker cards an additional hint is given (like "*the cards are hidden in a flower pot*") to ease the spatial search at a cache. The time needed for answering the quiz and searching the cards can be interpreted as a synchronization time interval (syncTime) in the general context of Geogames. Previous research showed that, in general, for Geogames a syncTime is needed to synchronize the spatio-temporal game flow and keep the game challenging (see [18]). The use of Geogames in edutainment – by integration the presentation of content about cultural into a game – was discussed in [10]. In short we can say, that the CityPoker - and Geogames in general - due to its geographically discrete nature coupled with the syncTime interval is well suited to integrate exploration tasks by integrating interesting cultural points of interest (POI) and educational or tourist content.

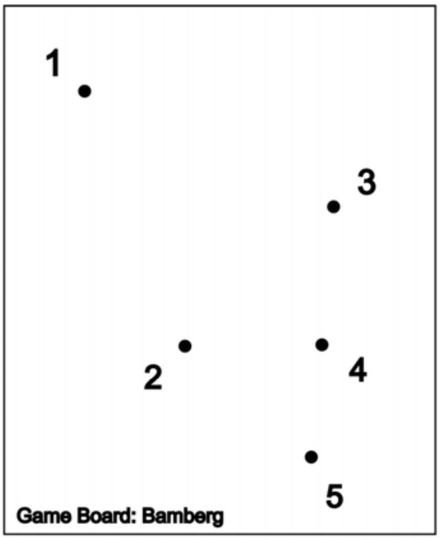
After changing a card, full information is reestablished automatically by the game client on the smartphones through an SMS-based communication protocol. We found that SMS communication is not only the most cost efficient method to use (no server infrastructure is needed) but is also sufficient enough for spatially discrete location-based games like CityPoker. As game actions can only happen at discrete points in space a continuous connection with a server is not necessary to adjust the game states on the game clients. This eases also the complexity to handle latency or other network based related consistency problems, which might occur when using a wireless network (e.g. GPRS or UMTS) to handle communication (see for example [6] or [12]).

The distributed CityPoker game: Bamberg vs. Bremen

In February 2006 a distributed CityPoker game was played between teams located at Bamberg and Bremen respectively. Two teams tried to collect the best poker hand.

Both cities have various cultural points of interest, such as a cathedral and a historic town hall which provide a game designer with a rich pool of educational content for the quizzes. The players of the two teams where composed out of six research assistants, four male and two female, from the laboratory for semantic information technologies in Bamberg and the cognitive systems group in Bremen. They ranged in age from 28 to 36. None of the players is author of this paper and none of them was involved in the development of the game. Both teams used bicycles as means of transportation. The players were accompanied by at least one observer who took photos and/or recorded video material for later evaluation purposes.

The game was played with a two hour time limit, the card distribution shown in Fig. 6, and the game boards illustrated in Fig. 5. The spatial layout of the game board in Bamberg had been used in several non-distributed CityPoker games before. Thus, we took the Bamberg game board as our reference spatial layout and tried to design the Bremen game board accordingly. For this use case study we modeled the game board by hand around the most important cultural POIs. This modeling process can be performed by non-experts as well by using "lightweight" Geo Information Systems (GIS), like Google Earth. As a last step, the allocation of the hidden card pairs (Fig. 6) to cache regions was conducted manually too. In the next section we will show that such a hand made solution is



	1	2	3	4	5
1	0	762	775	987	1217
2	762	0	578	393	487
3	775	578	0	409	719
4	987	393	409	0	315
5	1217	487	719	315	0

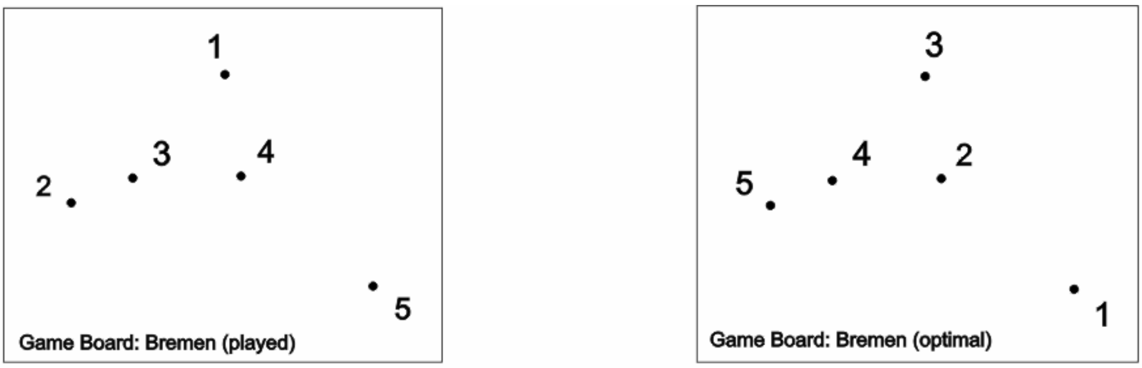
Figure 8: Distance matrix and spatial layout for the logical mapping chosen in Bamberg

likely to result in a playable but not optimal arrangement of cache regions given a predefined spatial layout.

The game client automatically logs all relevant game events. This allows us to reproduce the course of the game (see Fig. 7) and illustrate the kind of strategic elements Geogames try to bring to location-based gaming.

The two teams started the game at the stars pictured in Fig. 7. The Bremen team aimed right from the beginning at a royal flush of hearts although they knew they would need the jack of hearts from the Bamberg team to achieve their goal. Team Bamberg planned to be more independent of the other team's strategy by trying to get a full house or four of a kind. Team Bremen managed to make the first move by changing their jack of diamonds for the king of hearts in cache one. Team Bamberg now realized the intention of team Bremen and concluded that they could prevent team Bremen from reaching their intended royal flush of hearts by dropping their jack of hearts at cache one. But as team Bremen already had changed cards at cache one, they could first strive for their winning poker cards. Again they chose a strategy independent from their opponents' moves: a full house with three aces. For this they needed to get the ace in cache two. With team Bremen not aware of this strategy they managed to trade their queen of clubs for the ace of diamonds at cache two. Although team Bremen now realized their lingering defeat, they hoped to cross this plan by collecting four kings. While they got their third king at cache three, the remaining one was dropped by team Bamberg in cache one after they had got their second ace in cache five. Although the jack of hearts was available now in cache five, team Bamberg could not realize a royal flush with only three change options left. So they gave up and congratulated team Bamberg to their victory.

After the game the teams were asked to fill out a short questionnaire. The answers showed that all players had a great time playing CityPoker in this special set up. On the other hand, the aspect of social interaction in this distributed game was reported differently: one participant



	1	2	3	4	5
1	0	774	529	368	1000
2	774	0	243	617	1180
3	529	243	0	410	1058
4	368	617	410	0	708
5	1000	1180	1058	708	0

	1	2	3	4	5
1	0	708	1000	1058	1180
2	708	0	368	410	617
3	1000	368	0	529	774
4	1058	410	529	0	243
5	1180	617	774	243	0

Figure 9: Spatial layout and distance matrix for the logical mapping used in the case study in Bremen (left, [1,2,3,4,5]) and the proposed optimal logical mapping (right, [3,5,4,2,1])

Rank	Permutation	Similarity
1	[3, 5, 4, 2, 1]	231,38379
2	[2, 5, 4, 3, 1]	287,6839
3	[5, 3, 4, 2, 1]	332,38226
4	[3, 5, 2, 4, 1]	380,1876
...	...	...
41	[1, 2, 3, 4, 5]	739,78235
...	...	...
119	[2, 3, 5, 1, 4]	1020,984
120	[5, 2, 3, 1, 4]	1026,8076

Table 1: Similarity measures for different logical mappings (varying Bremen)

said it was interesting to play against a team in another city because he lacked the knowledge of the spatial layout of the underlying road network the other team used. This fosters our assumption that a fair amount of heterogeneity makes a distributed location-based game exciting for the players. Another player noted that he had the feeling to play against a computer-simulated team and not a real one. The same player also indicated that he would have felt quite different if the game would provide a possibility to communicate with the opposite team during the game (e.g. to taunt the other team trough text messages or an audio chat). Further it was observed negatively that the game offered no pre-game and/or post-game meeting with the other team like a video conference or a chat room. This also decreased the feeling to play against a human team for some players.

SIMILARITY OF GAME BOARDS

When we first designed our Bremen/Bamberg game, we only considered spatial scale of the game boards as as a source of heterogeneity. Accordingly, the two rectangular areas displayed in Fig. 5 are almost of same size. We chose five cultural POIs as caches for each city and modeled the rectangular cache regions around these POIs. We kept these sets of POIs fixed, i.e. we did not throw away the "cathedral-POI" in Bamberg and choose the "marketplace-POI" in Bamberg instead. The logical identification, i.e. the assignment of numbers 1-5 to the caches, was done intuitively yielding in an almost North-to-South pattern (cache 1 is the most Northern one, cache 5 the most Southern one, see Fig. 8 for Bamberg, Fig. 9 left for Bremen). After the game we wondered if the logical identification of caches was really chosen optimally. This leads us to a general mapping problem:

We analyze a spatially-discrete location-based game with n game-relevant locations (caches). Given n POIs in city1, and n POIs in city2, as well as all distances between the POIs in each city (two distance matrices), we aim at finding the optimal logical mapping of POIs to caches. Note that a POI denotes the real coordinate (latitude and longitude) while a cache is defined from an abstract game logics view (e.g. "the location where the ace of spades can be found"). We keep the mapping of POIs to caches fixed for city1 and permute the mapping in city2, i.e. exchange rows and columns of the distance matrix in Fig. 9 (left). We do not need to permute the mapping of city1 because on this level of abstraction the cache numbers are just labels to make them distinguishable. The real game logics with cards, X/O-markers, or whatever, cannot be considered for an arbitrary game. The mapping for Bremen used in our case study is denoted as [1, 2, 3, 4, 5]. For all other permutations we change the numbers in this array, e.g. [1, 2, 3, 5, 4] means that we change 4^{th} and 5^{th} row and column. Obviously, we get n! possibilities to map n POIs in city2 to the five caches (120 for our use case). For each permutation we calculate a similarity measure. The mapping with the minimal similarity measure is defined as the optimal one. We chose the following similarity measure: As a first step, we calculate for each of the n rows in the matrices a Euclidean distance measure. Finally, we get the similarity measure with an arithmetic mean over all row-averages. The values for $c_{n,row,col}$ are taken from distance matrix of city n. In our analysis, we chose air line distances for simplicity reasons. Certainly, we could as well use shortest paths in a road network.

Note that this measure not only includes the similarity of the static structure, but also automatically the scale of the game boards. Other aspects of the static structure than distances, like for example the elevation profile, is not explicitly covered by this measure. However, we could include the elevation profile by using asymmetric matrices that contain the time needed for traveling (instead of distances).

For our Bamberg/Bremen use case we found our intuitively chosen mapping on rank 41 (see Table 1). The optimal mapping [3, 5, 4, 2, 1] is displayed in Fig. 9 (right). This visualization reveals that our first mapping (Fig. 9, left) is suboptimal and the proposed optimum certainly supreme. However, for a normal game designer, without a similarity measure and an appropriate tool, the optimal mapping is not an obvious choice.

$$similarity = \frac{1}{n}\sum_{row=1}^{n}\sqrt{\sum_{col=1}^{n}(c_{1,row,col} - c_{2,row,col})^2}$$

DISCUSSION AND RELATED WORK

In this paper we evaluated the first steps necessary to realize geographically distributed multiplayer location-based gaming on a worldwide scale. It is important to note that the focus of this paper was neither on how to create sophisticated game content nor on an explorative game experience. The concepts presented are not restricted to our example CityPoker but intended to be adaptable to any other spatially discrete game. We argued that spatially discrete location-based games are particularly well suited for distributed play. For this sort of location-based games the configuration and orchestration challenges, as Benford et al. [3] entitled them, is better manageable than for spatial continuous ones. E.g. in CityPoker the orchestration of the game is accomplished solely by the game client on the smart phone and the configuration of the game board can be accomplished by the players themselves, using free "lightweight" GIS tools like Google Earth for example. To foster this claim we conducted a geographically distributed CityPoker game in the world heritage cities of Bamberg and Bremen. The results showed that we are heading into the right direction with our approach. The players only criticized the rough communication ability of our current implementation.

Furthermore, we presented a simple method to compute the similarity of user-generated game boards. This could be used to match players wanting to play a location-based game from all parts of the world on an online match-making platform, similar to game matching services for PC or game console players (e.g. Microsoft's XBOX Live Service).

A few location-based games are already played geographically distributed. Feeding Yoshi!, as an example, [5] is a game where teams of players in different cities are searching for open and close W-LAN hotspots in order to harvest fruits (close hotspots) and feed them to Yoshis (open hotspots) to gain points for that task. But here the game actions of one team have no further effect on the game actions a team in another city takes. The scores of the different teams of a Feeding Yoshi! session are compared to determine the overall winner at the end of a session. Consequently, the game lacks the interaction possibilities of games that have a logical connection between the distributed game boards, like CityPoker or other Geogames.

An example for a spatially continuous location-based game featuring geographically distributed game play with logically connected game boards is described in [1]. In Can You See Me Now? (CYSMN), players moving physically on the streets compete against online players, who move their virtual avatars by keyboard strokes on a shared virtual map of the game area. The street players must catch the online players by moving close enough to an online player's avatar. However, this game is one well-known example of a cross-media game, which try to highlight the possibility to design exciting new pervasive games by the mixture of different media technologies (here online vs. location-based play) and not one in different cities. Online and street players are playing in structurally equal worlds so that CYSMN does not have problems with structural real world heterogeneity.

Also a few commercial multiplayer location-based games exist; Botfighters (see [19]) is a representative example for a mobile MMORPGs. But here interaction between players only happens if two or more players meet on the same game area, making the game play not geographically distributed.

A lot of research is done to explore the social impacts of computer gaming. Williams [21], for instance, argues that "[t]he demand for human connection has been static but stymied by the real, it has moved into the virtual. […] As one of the most popular online functions that bring people together, games are a particularly important site of activity to consider." We believe that distributed multiplayer location-based games have at least the same social benefits as normal online network games. Future research should explore this issue.

As future work we plan to implement the discussed online matching-platform to enable a more detailed evaluation of the user experience in geographically distributed location-based gaming. An appropriate way of supporting the social interaction in distributed games needs to be found. Furthermore, we will investigate more sophisticated methods to measure game board similarity. Other interesting fields of research include automatic methods for the configuration challenge [3] in distributed play. Imagine, for example, both cities in our use case would have provided more than five POIs as possible locations for the caches in a CityPoker game. In this case we would face not only a permutation problem, but also a selection problem. A last aspect in our future work is using the geographic data that is provided by the users for the match-making process for non-gaming services. This includes, for example, integrating the data in traditional location-based services. Further, the building of road networks for cyclists or pedestrians could be accomplished by making further use of the GPS generated game tracks in a spatial community platform (see [11 or [15]).

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