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Software Architecture for Location-Based Games Designed for Social Interaction in Public Space

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Abstract. Location-based games (LBGs) are becoming increasingly more popular, especially those that focus on social interaction in public space. They have been successful to various extents at bringing players together to interact in public space; yet there is lack of knowledge and consensus on how to design these games from a technical perspective. This paper proposes a software architecture that stems from a cross-game analysis of representative games of this genre, in which 6 core architectural components are identified: **Augmentation**, **Navigation**, **Interaction**, **State Progression**, **Participation**, and **Administration**. These components support the game experience of players by enabling orientation and navigation of the players' own physical environment, their interaction with the game and other people, the traditional game-like experience, management of the entire game ecosystem, and the ability to allow players to fuel game play. An LBG prototype, *Secrets of the South*, is presented as proof of concept for this software architecture and its key components. This prototype shows that the identified components are pivotal to the gameplay of LBGs for natural interactions in public space and shows how practitioners can be guided in their preparation whilst maintaining their freedom to technically implement this architecture according to the given structure.

Keywords: Location-based games · Software architecture · Social interaction · Public space

1 Introduction

Location-based games (LBGs) are a type of games where the gameplay progresses based on the player's location. They offer unique gaming experiences when compared to traditional games, by effectively blending the real physical environment of players with a digital environment [1–3]. LBGs offer unique functionalities when compared

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to traditional games [1, 4, 5], and they have been shown to be capable of triggering engagement from players worldwide in playful ways [6]. Yet, designers and developers of games have no guidance on how to create such games from the perspective of system design. On the one hand, in the literature different components and names are used to describe similar functionality, which in turn leaves room for interpretation on the precise functionality provided. On the other hand, completely different components are proposed by designers and developers as key, causing lack of consensus on what is needed in an LBG at large. Plus, designers and developers discuss key functionality that are not key to the game architecture itself [7, 8], but to its application. And on top of this, LBGs can be defined differently across researchers, for instance including gameplays that make use of geographical information without any physical interaction of players [9].

This paper provides guidance to designers and developers on the functionality that LBGs must implement to be able to promote real social interaction in public space. Social interaction is a social exchange that supports more complex social phenomena, thus acting as a building block of society [10]. Promoting it can address known social barriers such as the feeling of "not belonging" in a neighbourhood, lack of engagement with the local environment and its citizens, and lack of wellbeing [11]. Digital LBGs are an established method to making citizens come together and turn their own environment into a playful experience [12–16]. The requirements for such LBGs are known [5, 17–19], and these mandate a specific software architecture and architectural components to be implemented. Yet, there is a lack of guidance on how to turn such requirements into a technological artifact (the LBG). To understand which architectural components must be implemented, this paper first analyses several existing LBGs. It identifies commonalities across these games and provides 1) a list of key components for LBGs for social interaction in public space, 2) a software architecture containing such key components, and 3) a proof of concept illustrating how this software architecture is instantiated in the LBG "Secrets of the South", a game that has shown to provide opportunities for players to come together and interact in their neighbourhood [5, 18, 20]. This paper complements prior research of the authors on meaningful social interaction through location-based games [3, 5, 17–23] by specifically focusing on requirements for a systems' architecture for LBGs for social interaction.

The next section reviews the literature on software architectures for LBGs and identifies a lack of guidance that designers and developers of LBGs currently face from a system's perspective. Section 3 presents the research methodology deployed, and Sect. 4 the data analysis based on the cross-game analysis performed. Section 5 proposes a software architecture for LBGs for social interaction in public space. Section 6 illustrates the use of this architecture on a proof of concept based on the LBG Secrets of the South, and reflects on limitations. Section 7 concludes this paper. Supplementary material to this article can be found in [24], containing both an extensive cross-game analysis, and the detailed game design of the proof of concept.

2 Software Architectures for Location-Based Games

Research on software architectures for LBGs show a lack of consensus at various levels on what these should offer. A few architectural components are proposed consistently, such as the mobile device (and the application it runs), the servers supporting the game, and content management systems with authoring capabilities [6, 25–27]. Most of the components proposed, however, are either 1) unique when compared to components other designers and developers propose, 2) use distinct names for components that are nonetheless similar in functionalities, or 3) do not refer to the system's architecture. With regard to different components and names being used to describe similar functionalities, examples include: a content management system and authoring tools [25], game content generation [26], map-based authoring [6], or simply editor [27]. All four focus on management of the content provided by a game and the ability to author such content. However, these names leave room for interpretation on the exact functionality these components provide: is the content to be linked directly to a map and the surroundings of the player; is it superimposed on a map; is it some other type of information provided to players; or does it refer to game art? Examples of key components that have been proposed as such, but are not necessarily key to LBGs in general include client-server-middleware handling request management [25], and components to support multiple external service providers [6, 27].

Such lack of consensus leads to confusion on what is needed in an LBG at large. Several articles on LBGs focus on guidance but not from the system's perspective. These include 1) design frameworks, 2) design patterns, 3) game engines, and 4) functionality that is key to application design, not the system itself. Frameworks and patterns (1 and 2) guide game creators in selecting individual application related functionality [28] and knowing how to combine them to solve a particular problem [29–31]. With respect to game engines (3) the guidance provided is at the level of programming frameworks and software environments on the smartphone [26, 32–36]. With regard to functionality that is key to application design (4), several articles refer to functionality such as storytelling [7] and design and play setups [8, 37], which address the design of the application itself and not the overall software architecture.

As a result, descriptions of LBGs are not consistent on focus or terminology. With respect to the mobile device, for example, recent work either does not refer to the functionality needed/provided [25], or it refers to functionality to which other researchers do not refer (e.g. an interface, content, middleware, and positioning technology in [6], rendering, data exchange, and game input in [27], or simply GPS and internet in [38]). Descriptions of LBGs differ significantly with respect to the description of the servers involved: they can be centralized or dedicated [26], linked over a 'networking layer' [6, 27], and/or provide multiple services (e.g. management of missions, mechanics, messages, components, and players [6, 27, 38]). These different approaches to LBGs contribute to the misinformation and lack of guidance, for the multitude of approaches and different perspectives, different names used for similar functionalities, and unique functionality not stressed elsewhere, conceal what should really be offered in such games.

This creates a clear need for a software architecture that can guide game designers and developers in the creation of future LBGs. Such an architecture bears the ability to provide a high-level system's perspective of the design of LBGs and their key components. It also furthers existent knowledge on (the minimum of) what is required to be implemented by such games and why. In the following, this paper addresses this gap by enhancing the understanding of which key components are essential for a specific type of LBG: location-based games for social interaction in public space.

3 Research Methodology

This paper focuses on LBGs, i.e., games that use locative features of smartphones, and that potentially trigger social interaction (direct or indirect, offline, or digitally) in outdoor space. It starts off by selecting the games to be analysed (in the following section). The selection procedure started with an online search for lists of the best LBGs, containing reviews and public opinions of what players love(d) to play. The online search was conducted using DuckDuckGo© and Google© search engines, both with the queries "best location-based games" and "digital location-based games". Six websites with lists of games[1,2,3,4,5,6] with LBGs up to the period of 2022 were chosen. The following criteria were used to select a limited number of games from these lists: games displaying 1) strong potential for social interaction, 2) with millions of players, and 3) mentioned multiple times across these websites. The rationale for these criteria is that location-based games fostering interaction, particularly face-to-face, are the focus of this research. Games that can bring players physically together, either because they want to play together/against one another or because they need other people to explore new modes of play, bear a potential for games with more serious purposes. Games that contain millions of players, and are mentioned multiple times across the internet, show their success, and can highlight features that worked for them and might prove to be essential for the desired type of game play.

Regarding data analysis, the selected games were analysed with the focus of understanding their key functional components. The analysis focuses on 1) their goals, 2) prominent features, and, when possible, 3) choices at the software/system architecture level that are clearly needed to support the game. The next step consisted of cross checking the identified components across all analysed games, to identify commonalities in high-level functionality, as high-level features. These high-level features are then used to propose key components for a software architecture with a well-defined structure that allows developers to choose different ways of implementation. The analysis was done by one author and cross-validated by the two other researchers; contributions proposed in Sect. 6 also follow the same process. Given the size of the documentation of the game

[1] https://www.quertime.com/article/20-extremely-addicting-gps-location-based-mobile-games/, 20 extremely addicting LBGs, July 2018, last visited on 30-Jul-22.

[2] https://www.pockettactics.com/guides/location-based-games-ios-android/, The best location-based & GPS games on mobile, Jan. 2020, last visited on 30-Jul-22.

[3] https://www.redbytes.in/gps-mobile-game-development-ios-android-2018/, Best GPS LBGs on iOS and Android 2018, Oct. 2017, last visited on 30-Jul-22.

[4] https://www.digitaltrends.com/gaming/best-location-based-gps-games/, 5 great location-based games that aren't 'Pokémon Go', Jul. 2016, last visited on 30-Jul-22.

[5] https://beebom.com/best-location-based-gps-games/, 8 Best location based GPS games you can play, Jul. 2017, last visited on 30-Jul-22.

[6] https://www.digitaltrends.com/gaming/best-location-based-gps-games/, The 10 best location-based games, May 16. 2022, last visited on 30-Jul-22.

analysis, and page limit for this paper, such cross-game analysis is available as supplementary material to this article in [24]. This article provides a summary of the detailed analysis found in such supplementary material.

4 Analysis of Location-Based Games Triggering Social Interaction

The purpose of this section is to analyse successful and representative games on their key functionalities, and architectural components supporting such functionalities. Based on the first criterion (heavy social interaction, preferably offline), *Geocaching*, *Recoil*, *Pokémon Go*, *Ingress* and *Orna* are selected due to their strong capacity to instigate dynamics of play with multiple people offline. *Geocaching* and *Orna* bring people together to form teams; *Pokémon Go* and *Ingress* offer events worldwide where people compete in-situ; and *Recoil* is a multiplayer-based game where people must come physically together to play. Regarding the second criterion (millions of players), *Pokémon Go* and *Parallel Kingdom* are selected, as the former reported 45 million players worldwide[7], and the latter 2 million[8]. Other potential choices could be *Ingress* and *Landlord*, both with little over 400 thousand players each, but no other game comes close to these numbers of players. Lastly, *CodeRunner*, *Ingress*, *Pokémon Go*, *Geocaching,* and *Orna* are selected because they are mentioned multiple times across the selected websites (at least 3 out of 6 times).

Based on the selection of all the criteria, 7 games were selected for the analysis: *CodeRunner*, *Geocaching*, *Ingress*, *Orna*, *Parallel Kingdom, Pokémon GO*, and *Recoil*. Other criteria and other games could be selected for this game analysis, yet the purpose is to understand what the essential building blocks for such games are to be successful from the design and software/system's perspective. This can be done, not by analysing an exhaustive list of games, but by selecting games that are different and vary from one another, and that were/are substantially played and enjoyed by large communities of players. Other literature reviews can be done, with different LBGs and for different purposes [39], but the game selection for this article reflects the adopted criteria. The analysis done was based on playtesting and on online reviews whenever possible.

4.1 Summary of Game Analysis

Table 1 depicts the key functionalities identified during game analysis, and shows if, and how often, these functionalities are implemented in the 7 games analysed.

[7] https://www.businessofapps.com/data/pokemon-go-statistics/, Pokémon Go revenue and usage statistics (2019), May 2019, last visited on 30-Jul-22.

[8] https://www.pocketgamer.com/games/004719/parallel-kingdom/, Parallel Kingdom, last visited on 30-Jul-22.

4.2 Data Analysis: Key Components for Location-Based Games for Social Interaction

The cross-game analysis that is summarized in Table 1 and detailed in the supplementary material [24], led to the identification of 6 distinct structural components: **Augmentation**, **Navigation**, **Interaction**, **State Progression**, **Participation**, and **Administration**. These are defined in Table 2.

These 6 key components have shown to be included in the 7 games analysed: positioning of players in their environment (***Augmentation***), direction and orientation of players in space through informational and visual cues (***Navigation***), multimodal interaction with other players and the environment (***Interaction***), progression of a game (***State Progression***), contribution and involvement of players both at the level of content and maintenance of game play (***Participation***), and the centralized orchestration and management of the game (***Administration***). As such, these components are argued to be essential for a high-level software architecture for location-based game designed to foster social interaction in public space.

5 Software Architecture for LBGs for Social Interaction

From the data analysis performed across the games mentioned above, and the 6 key components identified, a software architecture featuring these components can be defined. Figure 1 refers to a mobile computing device (MCD), services required to support the game, and a Portal. The hardware (including communication devices, memory, sensor, and actuators) and software (including an operating system and libraries) on the MCD can run a mobile game application (note – memory is not in picture). The portal refers to an interface (e.g., local, or web-based) that players can use to submit, and potentially also author content to the game.

The 6 key components are represented in Fig. 1 as follows: the first three components *Augmentation*, *Navigation*, and *Interaction* are inside the Game Application (under the same names); the components *State Progression*, *Participation*, and *Administration*, map respectively to **State Progression Service**, **Authoring Service**, and **Administrative Service**. The key components *Augmentation* and *Navigation* are supported by the **Positioning Service**, responsible for localization and context awareness services working in tandem with the locative features of the MCD. The **Authoring Service** powers the Portal, i.e., an interface (e.g., Desktop, or web) with a storage system that can capture the contributions of players, optionally authoring as well. The **Administrative Service** enables the access to any interface to manage the game.

6 Proof of Concept: The "Secrets of the South"

To illustrate the applicability of the software architecture, this section presents a proof of concept with the LBG Secrets of the South (SotS), which instantiates the proposed architecture. SotS was created by the authors to promote social interaction and provide opportunities for such social exchange to be meaningful to those interacting [3, 5, 17–23, 37, 40]. As part of a 4 year doctoral programme, initial design choices for the game were

Table 1. Summary of the game analysis. Grey boxes are features not common or apparently not included. Green check mark for games that include the feature. Vertical blue bars for the number of games sharing the feature.

Specific Features	**Commonalities (1-7)**	**CodeRunner**	**Geocaching**	**Ingress**	**Orna**	**Parallel Kingdom**	**Pokémon Go**	**Recoil**
Map (e.g. 2D, 3D)	7	✓	✓	✓	✓	✓	✓	✓
Game info on the map (e.g. icons)	7	✓	✓	✓	✓	✓	✓	✓
Info aligned with surroundings (e.g. portals at POI)	6	✓	✓	✓	✓	✓	✓	
Location usage to advance game play (e.g. GPS)	7	✓	✓	✓	✓	✓	✓	✓
Augmented Reality	2						✓	✓
Visual indications on where to go/navigate/orient (e.g. arrows)	5	✓	✓	✓	✓			✓
Touch, swipe, or hand manipulation (e.g. zoom out of a map)	7	✓	✓	✓	✓	✓	✓	✓
Players come together offline for interaction and joint game play	6		✓	✓	✓	✓	✓	✓
Interaction with real-world objects	2	✓	✓					
Special forms of navigation (e.g. slower the better, or tele transport)	2					✓	✓	
Game statistics, leader boards, resources, character level	6		✓	✓	✓	✓	✓	✓
Task completion, missions, puzzle solving	7	✓	✓	✓	✓	✓	✓	✓
Unlock new features, access to unique items, different modes of play	5		✓	✓	✓		✓	✓
Player contribution with new content, POI, challenges, or software	5	✓		✓	✓		✓	✓
Maintenance/enforcement of game play, game community, and values	2	✓	✓					
Peer review of players' contributions and conduct	3	✓	✓	✓				
Creation, management, and review of game content or players' contribution, made by the company	6	✓	✓		✓	✓	✓	✓
Centralized orchestration of game (e.g. events, community support, structure, API control, players, or target specific content)	5		✓	✓	✓	✓	✓	
Players administer game play	1							✓

1) to be played by children, 2) in their neighbourhood, 3) to involve everyone, and 4) to be fun [23]. Additional requirements were elicited from children during workshops designed to this purpose [17, 19]. The next stage explored the functionality that needs to be included in a design and implementation for the promotion of social interaction

Table 2. Definition of Key Components offered by the software architecture.

Key component	Description
Administration	Management of the state of the game and all its components, from statistics, players, and game content. Also included is community support, event creation, mediation of conflict between players, control of the access to the game through APIs, targeting of content to players, and the release of new features and updates. If players contribute content, that content is approved, rejected, or curated here
Augmentation	Enhancement of players' perception on their real-world surroundings and the digital game state: their positioning and representation regarding the real world, other surrounding players, and areas in the real world where they should go to advance
Interaction	Mechanisms used by players to control or interact with the digital game world. This component supports the components of augmentation and navigation, and can be based on, for e.g., human-computer interfaces, multimodal interaction, AI, tangible interfaces, and multi-player features
Navigation	Support to player navigation from its current position to another location. An effective guidance at providing players with the correct orientation and that disappears when not needed
Participation	Contribution made by players towards the game, whether it is the content (storyline, individual tasks, or physical objects), community maintenance, or game art media. Players can create/manage their contributions via a digital authoring service or tool
State progression	Game mechanics and elements that support gameplay throughout time: task completion, game statistics, character levels, acquired (rare) items, different modes of play, and the counting of resources found in the real/digital world

in public space through LBGs. This stage consisted of iterative software development and play test sessions during the process [18, 20]. The proposed software architecture (Fig. 1) comes right from early stages of the iterative process and is therefore implemented in all developed prototypes. As last stage, further workshops were done with children/teenagers (10–16 age group) to 1) jointly create content for the game that not only is appropriate but also appeals to this target group, and 2) validate the game in its capacity to provide opportunities that promote meaningful social interaction [5]. The game has shown to be successful at creating opportunities for social interaction (within a group of friends, with strangers, and with the environment) through co-located challenges of different types and difficulties, which, in turn, provides a game play experience that children enjoy and that is positive to them (i.e., bears meaning to them) [5, 18]. For this reason, this game is selected as a proof of concept for this architecture.

Figure 2 shows screenshots from the SotS[9]: a LBG that uses smartphones to mediate outdoor activities (called challenges) for social interaction. Players are presented with

[9] https://play.google.com/store/apps/details?id=com.Xav13rua.SecretsOfTheSouthv2, Secrets of the South mobile application, last visited on 30-Jul-22.

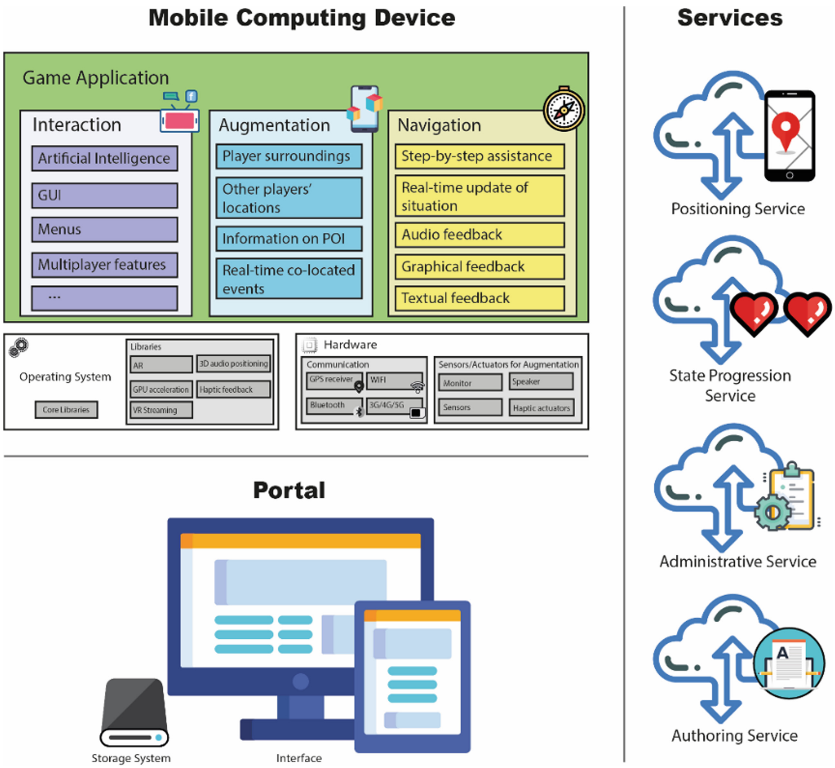
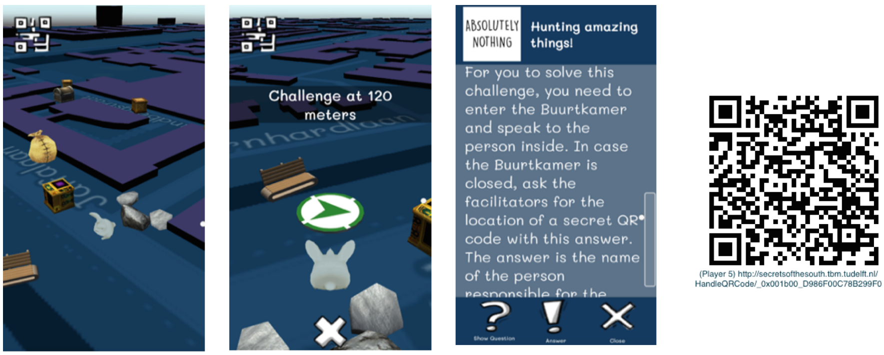


Fig. 1. Software architecture for an LBG for social interaction. Monochromatic colour scheme represents layers usually not built during game development, Polychromatic scheme otherwise.



a) b) c) d)

Fig. 2. Secrets of the South. a) 3D map with challenges, b) compass and text navigation towards a challenge, c) a game challenge, and d) an example of QR code for interaction.

tasks in outdoor public space that require them to engage with strangers, friends, and other players, while searching for solutions for the challenges and advance in the game. Different types of challenges are distinguished:

- Quiz challenges require players to answer a closed question to get points.
- Multiplayer challenges require players to form or join a team, and performance is assessed by an evaluator.
- Hunter is like Quiz (closed question), providing the possibility of solving a challenge through hunting for and scanning a QR code in the environment.
- Voting challenges require players to take and upload a picture.
- Timed Task enables players to solve a task within a time period.
- Open Quiz challenges pose open questions to collect information.

6.1 Architecture of the Secrets of the South and the Key Components

By implementing all services and key components of the software architecture (Fig. 1), it was possible to build an LBG that can promote social interaction in public space. Figure 3 illustrates the outcome of this implementation, showing the game application and the game portal on the upper part, and detailing how the services were implemented more specifically on the lower part.

The mobile computing device in Fig. 3 contains the **Augmentation, Navigation,** and **Interaction** key components, and requires support from the services indicated in the same figure. The **Augmentation** and **Navigation** key components are supported by the *Positioning Service*, that provides a 3D map and 3D buildings. The game sends the GPS coordinate of a smartphone to this service, which returns a stream of map tiles covering hundreds of metres in every direction of the player's location. This is used by the game to position a player and surrounding challenges and enable the location-based game play. The **Interaction** key component is implemented in the game application and is supported by the *State Progression Service.* The GUI focuses on the 3D representation of the surroundings and enables map manipulation: players can use their fingers to interact with the 3D world. The *State Progression Service* presents the challenges and supports indirect interaction between players (e.g., to attach pictures taken during a challenge, to view other players' pictures, and to vote for them). The **State Progression** key component is supported by *State Progression Service.* The SotS provides players with a personal area containing gameplay statistics and ranks.

The SotS game portal implements the **Participation** and **Administration** key components as follows. The **Participation** key component is implemented by the *Authoring Service.* Players can access the online game portal, which, after the login, provides a private area. There they have access to a world map and a list of challenges. Both the map and the list show all the playable challenges in the game. The map enables users to acquire a general perception of where the challenges are located (where they can be played). The list of challenges also indicates which challenges were created by the logged player and can be edited and deleted.

Lastly, the **Administration** key component is implemented by the *Administrative Service.* The game is managed in 3 possible ways: 1) the online system (or at the database level), 2) the PlayFab service, or 3) in the mobile game. In 1), a user with administrator

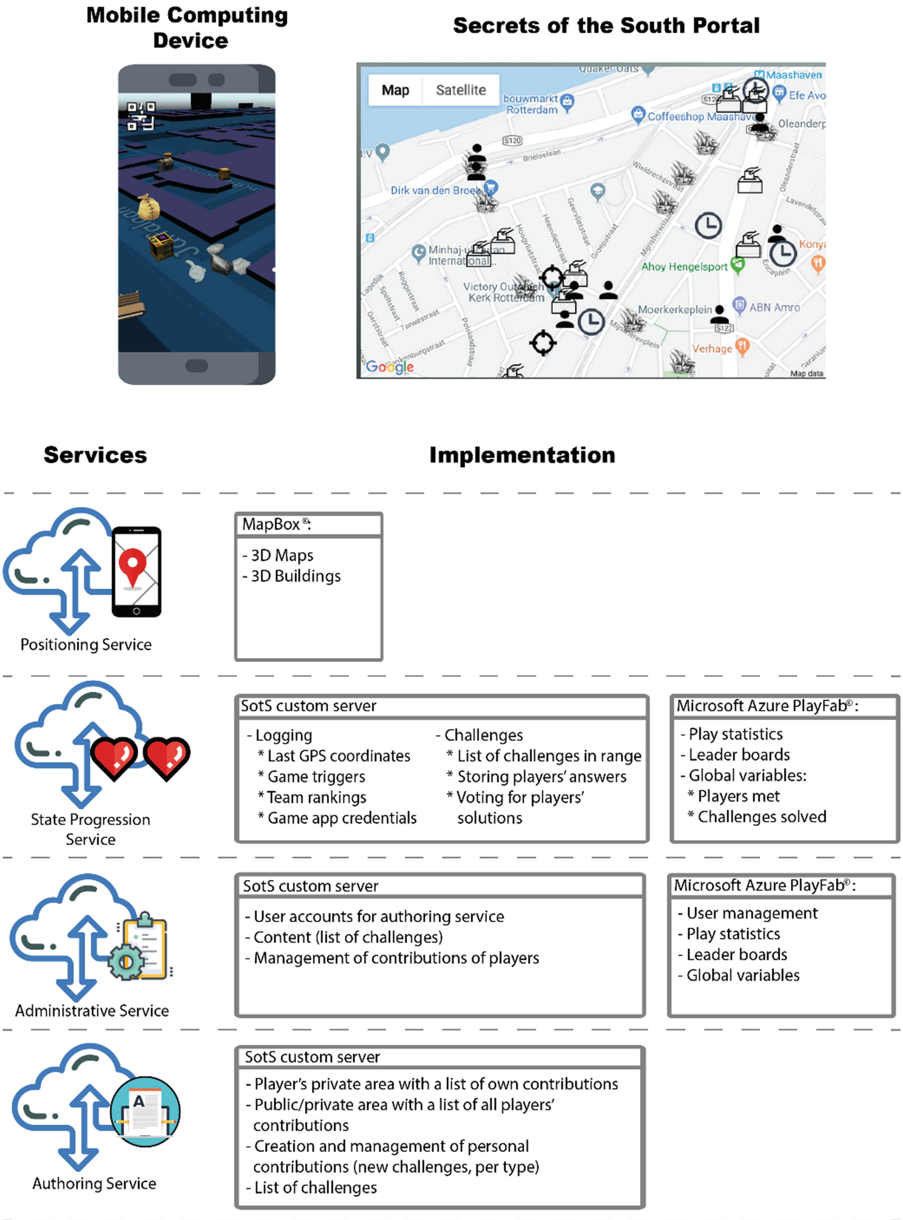


Fig. 3. Implementation of the software architecture in the game (Mapbox (https://www.mapbox.com/); Azure Playfab (https://playfab.com/); and the SotS custom server (https://github.com/xavierfonsecaphd/SecretsOfTheSouth)).

rights can not only create content but also manage other users' challenges and accounts. In 2), an administrator can operate leader boards and statistics. In 3), and during play, administrators can either elevate or demote the credentials of players by scanning their QR ID. This changes the options offered in the menus of the game, to support different dynamics of play while playing.

The implementation of the SotS mobile application communicates directly with the *Positioning, State Progression,* and *Administrative* services to render the map and position a player according to the location of the device and the information provided by the *Positioning Service* (**Navigation** and **Augmentation** key components). It also enables the game to provide a gameplay experience aiming at interaction with the game environment and people (**Interaction**) that is supported by the *State Progression Service* (**State Progression**). Finally, some administrative tasks can be performed by players with specific permissions due to the link with the *Administrative Service* (**Administration**), e.g., player management, but all other administrative tasks are done in the SotS game portal. The *Administrative Service* also makes it possible for players to submit their own challenges, via the *Authoring Servi*ce (**Participation**).

Note that all services are essential to gameplay. Without the *Positioning Service*, the game would not be able to represent the environment of the player; the absence of *Administrative Service* would make the game incapable of adapting to the dynamic behaviour of players, rendering it inconsistent and useless; not having an *Authoring Service* would make players incapable of adapting the content offered by the game to the different types of social interaction they desire; and not having *State Progression Service* would mean not having a functional game. The game design, game application, and custom server of SotS are further detailed in the supplement material of this article [24], with greater detail on the design choices and implementations made.

6.2 Limitations

The proposed architecture aims at providing technical guidance to building LBGs for social interaction and is based on the 6 key components that were identified in the performed cross-game analysis. Even though it aims at supporting the state-of-the-art design and development processes, it does so at a top-level only. This is to warrant freedom of implementation to game developers and artists and by not setting "in stone" the inner workings of such technological artefacts. Even though the software architecture is detailed in what should be implemented, this sets itself as a limitation, by not providing further details of exactly how the key modules should communicate across each other. Still, this limitation does not undermine the guidance contribution that the proposed software architecture offers to the field.

Another limitation is that these games were created for entertainment, and probably with a particular target population in mind. This paper argues that the sampling of game titles that the followed methodology produced is appropriate to gather high-level characteristics of very successful LBGs leading to social interaction. Due to the high diversity of the game selection used, any potential bias in the conclusions based on a small sample of games is arguably not relevant. Yet, a different sample of games could produce or introduce other key components than those found with the used sample, particularly if the (unknown) premises used to build such games focus on different purposes or target groups. This poses itself as an opportunity for further research.

7 Conclusion

Addressing the lack of guidance from a system's perspective that designers and developers face when creating a LBG, this paper identified the architectural components that are key for LBGs designed to foster social interaction in public space. It enhances the understanding of software architectures for LBGs of this type at system level that is essential for game design and development. Commonalities in essential functionality provided by 7 such LBGs have been presented, i.e., functionality without which these games would not be capable of delivering the designed game play. Six key components were identified: *Augmentation*, *Navigation*, *Interaction*, *State Progression*, *Participation*, and *Administration.* These components are key because without them: an LBG would not be able to represent the environment of the player (*Augmentation*) or assist him/her in the location-based game play that is central to this genre (*Navigation*); multimodal interaction with other players and the environment would not be possible (*Interaction*); tracking of the interaction with physical/digital objects, the game play, and every game-like progression would not exist (*State Progression*); contribution and involvement of players both at the level of content and maintenance of game play would not be possible, rendering long-term game play of an LBG designed for social interaction obsolete (*Participation*); and the centralized orchestration and management of the game, required for the consistency of the game, would render the game unplayable (*Administration*). Based on these key components, a modular software architecture was proposed. This software architecture guarantees that not only designers and developers know which components to include, but also that they benefit from an approach that grants freedom of implementation. This aids designers and developers without constraining either their creativity (through a too detailed method) nor their freedom of choice (of how to implement each component). The applicability of the software architecture was shown with a proof of concept based on the LBG *Secrets of the South* (SotS). SotS incorporates the proposed architecture, which enables the game to provide opportunities for players to interact with other people [5, 18].

The proposed software architecture provides guidance on how to create a system for an LBG that fosters social interaction in public space. It supports the identified six components and can be extended to include further components for other types of functionalities as needed. This architecture provides future game designers and developers of LBGs support for less complex game design and development processes, while leaving room for creativity and implementations.

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