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Bachelor Thesis

The Taxonomy of Local Services: A Systematic Literature Review

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Abstract

This bachelor thesis explores a specialized form of Location-Based Services called "Local Services." In contrast to general Location-Based Services like Google Maps, which can be accessed from anywhere, Local Services are only available at a specific, physical location. Once the user leaves the location, they can no longer access the service in its entirety. Due to the close interconnection between service and location, Local Services can offer particularly personalized and context-aware services. Despite their widespread use in various industries, the concept of Local Services has not been adequately studied in scientific literature.

Local Services are often used in mobile commerce, where stores send exclusive offers via push-notifications to customers passing nearby. As the notification is only available to consumers at the physical location of the store, the service can be qualified as a Local Service. Another popular use case consists of applications for museums or tourist sites. These applications provide exhibit information via Bluetooth beacons and QR-Codes and are thus only accessible to users at the location.

All in all, numerous real-world examples of Local Services exist, but they are not adequately studied in scientific literature. Neither does the literature provide a consistent definition for them, nor do authors acknowledge their particular characteristics when vaguely describing them as general Location-Based Services.

This work is a first attempt to close this research gap by systematically studying and classifying Local Services. As methodology, we use the Systematic Literature Review which is considered particularly adequate for doing fundamental research on a topic. Moreover, the results are then classified into a taxonomy.

Thereby, this work contributes a first definition, Systematic Literature Research and taxonomy of Local Services. The results indicate that Local Services are a subcategory of Location-Based Services and that service providers should acknowledge the importance of the location itself and how it is embedded into the service, to make the most of the advantages of Local Services. In sum, this study significantly advances the understanding of Local Services by providing a comprehensive framework that can guide future research and practical applications.

Kurzfassung

In dieser Arbeit wird das Phänomen der 'Local Services' untersucht, eine spezielle Form der Location-Based Services. Während traditionelle Location-Based Services wie Google Maps von überall aus genutzt und angefordert werden können, sind Local Services nur an bestimmen Standorten verfügbar. Sobald der Nutzer die 'Location' verlässt, kann er auch den Dienst nicht mehr wie vorgesehen nutzen. Durch die enge Verknüpfung von Service und Standort bieten Local Services besonders personalisierte, ort- und situationsabhängige Dienstleitungen. Trotz ihrer interessanten Eigenschaften und Popularität in der Praxis werden Local Services kaum in der wissenschaftlichen Literatur behandelt.

Local Services werden oft im Bereich Mobile Commerce eingesetzt, etwa um exklusive Angebote via Push-Notification an Passanten in der Nähe des Geschäfts zu senden. Da die Angebote also nur für Nutzer am physischen Sandort verfügbar sind, handelt es sich bei dieser Art von Dienstleistung um einen Local Service. Ein weiteres beliebtes Beispiel für Local Services sind Apps für Museen oder touristische Sehenswürdigkeiten. Bei solchen Apps werden Ausstellungsinformationen über Bluetooth-Beacons und QR-Codes zur Verfügung gestellt und sind damit nur am Standort selbst zugänglich.

Auch wenn es viele reale Beispiele für Local Services gibt, wurde das Thema in der wissenschaftlichen Literature noch nicht dementsprechend untersucht. Zum Beispiel fehlt weitgehend eine konsistente Definition von Local Services. Stattdessen beschreibt die Mehrheit der Forscher Local Services vage als allgemeine Location-Based Services, was den Eigenheiten dieser Services und ihren Unterschieden zu traditionellen Location-Based Services nicht gerecht wird.

Diese Arbeit ist ein erster Versuch Local Services systematisch zu untersuchen und zu klassifizieren, mit dem Ziel die eben beschriebene Forschungslücke zu schließen. Wir verwenden eine Systematische Literaturübersicht, weil sich solch ein Verfahren besonders für Grundlagenforschung eignet. Außerdem ordnen wir die Ergebnisse in eine Taxonomie ein und bieten anderen Forschern damit ein Framework für zukünftige Arbeiten über Local Services.

Diese Arbeit liefert eine erste Definition, Systematische Literaturübersicht und Taxonomie zum Thema der Local Services. Wir zeigen, dass es sich bei Local Services um eine Unterkategorie von Location-Based Services handelt und Service Anbieter die Wichtigkeit der 'Location' anerkennen sollten, um von den Vorteilen dieser Serviceart zu profitieren. Ziel der Arbeit ist es, das Phänomen der Local Services umfassend zu beleuchten.

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Acronyms

AI Artificial Intelligence. 17

CELL-ID Cell Identifier. 20

ECID Enhanced Cell Identifier. 74

GPS Global Positioning System. 20

GSM Global System for Mobile Communications. 74

LBS Location-Based Services. 15

QR-Code Quick Response Code. 16

RFID Radio Frequency Identification. 20

SLR Systematic Literature Review. 18

TDOA Time Difference of Arrival. 74

TTP Trusted Third Party. 82

WiFi Wireless Fidelity. 20

WLAN Wireless Local Area Network. 20

1 Introduction

> "Order a Whopper for $0.01.
> Only on the Burger King App.
> Offer is unlocked within 600 feet of most
> McDonald's restaurants.
> See you soon."
>
> *Burger King Whopper Detour Campaign [Kin24]*

Numerous real-world examples of Local Services exist, but they are not adequately studied in the scientific literature. This work is a first attempt to study and classify them systematically.

1.1 Problem Description

Most people cannot imagine life without Google Maps, as it offers a full range of functionalities at every possible location. That service follows us around wherever we go. No matter which city, country, or place, it is always available to guide us in the right direction. Under the condition of a stable Internet connection, it can be used at every location and in any context.

Google Maps is among the most popular Location-Based Services (LBS) [sta24a]. It is called location-based because it uses the location data and provides a location-dependent service [AKE04]. It is called a service because it can be expressed through a Web page or an application [OB08].

Analogously to the popularity of Google Maps for consumers, general Location-Based Services are extensively studied in scientific literature. But there is a new kind of service that is likely to change the perception of Location-Based Services and the locations where they are offered. The talk is about Local Services. For this work, we define Local Services as services that are only available at specific locations. Meaning that if the customer leaves the location to which the service belongs, they might no longer be able to access it. In contrast to the Google Maps service from the introductory words, Local Services cannot be used at any location. Their accessibility is restricted to the location where they are offered. Due to the close interconnection between the service and the location, Local Services can offer particularly personalized and context-aware services.

A famous use case for Local Services is mobile commerce. Commercial stores send push notifications with current offers to persons that walk sufficiently close to the store [Gro24]. As the offer can only be accessed by customers physically close enough to the store and not from everywhere else, it classifies as Local Services.

In literature, there exists no consistent definition or description of this phenomenon. What we describe as Local Services is often vaguely defined as Location-Based Service. Indeed, many Location-Based Services can even be considered as Local Services, like the commercial marketing push notifications we just mentioned. Nevertheless, Local Service is a phenomenon apart and many general Location-Based Services cannot be classified as Local Service, like the Google Maps services we mentioned in the introductory words.

We can conclude that Local Services are available as real-world services but have not been adequately studied in the scientific research literature. This work aims to close the research gap with the help of a Systematic Literature Review on Local Services and a taxonomy with its results.

Topic Relevance

The topic of Local Services is highly relevant because these services are already a significant economic reality. Yet, they still need to be more adequately studied in the scientific literature. This research gap emphasizes the importance of further research on Local Services.

Moreover, we illustrate the topic's relevance with some real Local Services. Local services with push-marketing notifications are very popular in mobile commerce. Burger Kings had a successful campaign using Local Services. It was named the "Whopper Detour Campaign" and used geofencing at 14.000 locations across the US [Com18][Kin24]. The promotion offered Whopper hamburgers for just $0.01, but only to users that entered a 600-foot radius around a McDonald's [Kin24]. Once within this geofenced area, they could activate the offer in the Burger King app and collect their discounted Whopper from the nearest Burger King [Com18]. Thus, the service was exclusively available within the specified radius around McDonald's locations and can be considered a Local Service. This use of Local Services was very successful for Burger King, as "the app was downloaded more than 2 million times in 48 hours and 150,000 one-cent Whoppers have been redeemed. The campaign has also resulted in one of the highest levels of footfall in Burger King restaurant history" [Com18].

Another example is Sephoras Mini Makeover. Sephora app users receive a push notification when they enter a specific radius around a nearby store, offering them a free mini makeover. The notification reads: "Got 15 mins? Stop in store (you're so close!) for a FREE Mini-Makeover" [Tap24]. Since this offer is available only to users near a Sephora store, it qualifies as a Local Service.

Besides mobile commerce, Local Services are often used as Information Services, for example, in museum apps. These apps guide visitors through exhibitions and provide complete functionality only when at the museum, utilizing Bluetooth beacons that work within a limited range. Beacons send specific information to visitors' devices or prompt the app to play audio content [Mus24]. Additionally, scanning Quick Response Code (QR-Code) at the museum directs users to detailed information about exhibits [Mus24]. These features enhance the museum experience by making exhibited objects more interactive and engaging [Mus24].

Overall, there are many use cases for Local Services. Each time a service is only offered at a specific location, one can create a Local Service for it. For example, a Local Service could also be offered at a parking garage, showing car drivers available parking lots. As parking is only possible in that specific garage, one can create a Local Service that complements the use of the location. In sum, the number of use cases for Local Services is at least as high as the number of locations that offer a specific service. Consequently, a Local Service can complement each location that offers a specific (analogous) service.

Main Goal

The goal of this work is to fill the research gap on Local Services with a Systematic Literature Review for a first time. That research gap exists because current studies focus largely on general Location-Based Services.

In addition to a Systematic Literature Review, we aim for a first extensive and comprehensive taxonomy of Local Services.

Thematic Demarcation

A thematic demarcation between Local Services and general Location-Based Services is necessary because although Location-Based Services and Local Services are often discussed as the same phenomenon in literature, they address different aspects of how services interact with geographical information.

Loosely speaking, Location-Based Services are services that use a user's geographic location to provide functionality to them [Wil12]. Navigation applications and real-time traffic updates are among the most popular LBS. Generally, the service can be called from everywhere and is not tied to a specific location.

Local Services, on the other hand, are only available at a particular, often physical, location. They require the user to access the service within a defined geographic area, making the Local Service tied to a specific site. This connection between a service and its specific venue, allow to integrate features designed to enhance the experience within that location.

The unique features of Local Services are highlighted and presented as a taxonomy in this work.

Original contribution

In short, the original contribution can be summarized in three points. First, this work is among the first to acknowledge the gap between the widespread phenomenon of Local Services in the real world and the need for proper definitions and studies in scientific literature. By recognizing the need for research, we can contribute a first definition on this topic.

The second unique contribution is to conduct an extensive Systematic Literature Research on Local Services in the databases ACM, IEEE, Elsevier, SpringerLink, and Elicit. Since Local Services are rarely referred to by that specific term, this literature review operates within the broader domain of Location-Based Services. We extract and analyze all relevant information from the results that applies to, or is specifically related to, Local Services. Moreover, the significance of the findings in the first four databases is even evaluated by a second search in the Elicit Artificial Intelligence

(AI)-database. We thereby want to evaluate whether our search string and search strategy for the first search is sufficiently high in quality to actually find all relevant papers on Local Services. Against this background, we can contribute a broad understanding of this little-studied topic.

The third contribution consists of a first-time taxonomy on Local Services. The input for the taxonomy is extracted from the Systematic Literature Review results. Again, this structured and thoroughly explained taxonomy on Local Services is particularly appropriate for summarising the current knowledge of this “niche”-topic.

Overall, this work contributes a definition, a first-time Systematic Literature Research and a fully explained, forty-pages filling taxonomy of Local Services.

The research question guiding this work is as follows: What could be a taxonomy for Local Services?

1.2 Methodology

The method for this work is the Systematic Literature Review. Systematic Literature Review (SLR)s are considered particularly interesting for studying a phenomenon that has never been studied extensively because an SLR aims to summarize all existing information about the research topic [KC07]. As Local Services are currently a “niche”-phenomenon in scientific literature, the approach of a Literature Review is an important contribution to producing a complete understanding of this topic.

After these first introductory words, chapter 2 enlightens the most essential definitions in the field of Local Services. In addition, it explains the methodology for conducting a Systematic Literature Review in detail. Chapter 3 realizes the Systematic Literature Review, and chapter 4 classifies the SLR findings into a taxonomy. Chapter 5 presents a discussion and interpretation of the SLR findings. It is followed by chapter 6 that finishes the work with an overview and outlook on the research topic.

2 Related Work

We analyze Local Services from a scientific literature point of view, starting with the most important definitions and followed by the methodology for Systematic Literature Researches. The theory behind SLR is critical for chapter 3, which puts the SLR into practice.

2.1 Important Definitions

Scientific literature about Local Services is based on some central concepts and definitions explained in the following pages.

Service

For the purpose of this work, we define a service as anything that can be expressed through a Web page or application [OB08].

Location-Based Services (LBS)

Location-Based Services are a subset of Web services that provide location-dependent content to mobile users [Wil12][BPAH13]. Location-dependent content means, that the "LBS utilize the (...) users' locations (...) to provide services" [AKE04]. The service application tracks real-time location data that indicates where the mobile device is currently located [Tec24].

Examples of Location-Based Services are:

- Navigation: Google Maps application navigates users to the nearest features of interest like an ATM or a restaurant [KL03][AKE04].
- Productivity: the "Uber" application is used for hailing car rides starting from the user's current location.
- Discovering new places: "Yelp" application helps to discover the local area or deciding where to go for dinner [Tec24].
- Games: "Pokémon Go" lets users play in public places with unknown people [XX16].

Positioning in Location-Based Services is realized with technologies like Satellite Networks (Global Positioning System (GPS)), Mobile Networks (Cell Identifier (CELL-ID)) or Wireless Local Area Network (WLAN) [MH07]. Besides Wireless Fidelity (WiFi), several technologies have been proposed to make navigation inside of buildings possible, like "Radio Frequency Identification (RFID) or Bluetooth like Apple's iBeacon" [Hua22].

Literature classifies LBS in two categories: pull and push [AKE04]. In a pull-based approach, the user starts the application by opening it and entering a request for location information [AKE04]. Whereas in the push-based approach, the service provider sends content to users based on an event (for example, them entering a predefined zone) without them requesting it [BBRB15] [AKE04]. Nevertheless, the service provider needs the customer's permission before sending them notifications [AA21].

Even though general Location-Based Services consider the user's location, they generally do not oblige the user to access the service only at a specific location. In sum, accessing the service at an arbitrary location or in a limited area is the distinctive feature between LBS and Local Services.

Local Services

For this work, we define Local Services as services only available at specific locations. If the customer leaves the location to which the service belongs, they might no longer be able to access it.

Examples of such Local Services are:

- Mobile Commerce: commercial store sending push notifications with current offers to persons that walk sufficiently close to the store [Gro24].
- Information Service: museums app that requires Bluetooth to be turned on to help visitors navigate the gallery and find content about the surrounding artwork [SIG24].
- Social Services: "friend-finder-application" that sends notifications when friends using the same service are sufficiently close [Met24] [LD09].
- Social Service: service for local communities that can only be accessed by people living in that physical neighbourhood like the platform "nebenan.de" [neb24].
- Games: games like"Pokémon Go" can be played at specific places where actions take place in the real world (e.g. inspecting artefacts) and at the same time in virtual space (e.g. interacting with avatars) [XX16].

Local Services use the same positioning technologies as location-based services. In short, those are: GPS, Mobile Network Service, WLANs, RFID or Bluetooth [MH07] [Hua22]. Moreover, they can also be categorized into the push-type and pull-type [AKE04] [BBRB15]. As mentioned, the pull type obliges user to activate the service by themselves [AKE04]. There are different options to activate a Local Service application besides just opening it. It is popular to check in at the location with the help of a QR-Code that activates the application on the mobile device [YH16].

The scientific literature does not mention a consistent name or definition for what we describe as “Local Services.” Nevertheless, the concept of Local Services is numerously hinted in literature, even though not under the name of “Local Service” or any other new name, but somewhat under the name of general “Location-Based Services” [JMRD03][WHH14][HRR+08][Wil12].

Against this background, we present some definitions from the scientific literature that all appear under the name of Location-Based Services but rather follow our understanding of a Local Service.

José et al. define a Location-Based Service as a service, “that is semantically associated with physical space“ [JMRD03]. According to the author, this association comes, for example, from the fact that the service delivers information about the geographic area or allows it to interact with the environment [JMRD03].

“Conceptual bookmarks” by Henze et al. follow the logic of Local Services, too. It is about a service that maps a snapshot of a physical object to a Web page and, thereby, to a service. The snapshot includes the user’s context (user location, user preferences) for a specific point in time. The user’s context then decides whether the snapshot is mapped to a digital service or not [HRR+08]. The snapshot is mapped to a service after checking the location information, what is very similar to the idea of Local Services in which users at a location can, for example, scan a QR-Code to be forwarded to the service [YH16].

Moreover, the “hyperlocal computing” research field describes exactly what we consider as Local Services. The author discusses Location-Based Services that “target very specific local geographical areas (e.g. neighbourhoods)” [WHC+14].

Ostermaier et al. emphasize that the idea behind Local Services is well-known [OB08]. The author says: “the idea to associate services with a specific location, (. . .) is well-known and many systems have been built around this idea” [OB08].

Position, Space, Place and Local Context

Location, place, space and position are often used synonymous. The following paragraph emphasizes that they express different things.

Location as Position In general Location-Based Services like, for example, Google Maps, location is initially understood to mean position [Edw09]. Location as position is defined as an exact point in the geospatial space. [OB08]

In this understanding of location, the “human is still being abstracted to a position” [Edw09]. For example, in GPS, the position of people and objects is represented as “geometric coordinates, captured by positioning sensors” [HS08].

Location as Space Even though space also treats “locations and objects as points (. . .) within a reference coordinate system,” it is different to the position concept above [Leo98]. Position refers to a point within an area, whereas space refers to an area as a whole [OB08]. In short, space focuses more “on how the world looks than what it means,” making it invaluable when a service provider needs to present static and descriptive information about geospatial phenomena [Edw09]. Those mathematical representations are completely independent of the particular user situation.

Location as Place In contrast to position and space, the place stands for the subjective experience of a location [Edw09]. It reflects how people perceive, understand and make sense of the location. Making sense of a location is naming it and thereby giving it a meaning [Edw09]. In consequence, “place is a human-readable labelling for positions” [Hig03].
The consciousness and experiences transforming a space into a place can be based on very “direct sensations, such as how somewhere looks and feels, by more emotional or cultural ties, such as growing up somewhere or through dependencies people have to a place related to its particular affordances, for example, being the only source of water in a desert“ [Edw09].
A place is a semantic location. Semantic location means not a position as such, but every location where people can make sense out of it [Edw09]. The concept is explained later on in detail. In this semantic context, “being with Bob” is also a location. Apps like Facebook’s “Nearby Friends” feature work with this semantic and more emotional understanding of location. The app gets activated if two people who are using the app and are connected as friends on Facebook pass nearby in a public area [Met24] [LD09]. The application gets activated, because it interprets “being with my friend” as a semantic location.

Local Context Placing the user in a contextual world instead of a grid of coordinates is an essential approach for Local Services [FŠD13]. The concept of place acknowledges that locations are always embedded in their local context [SBG99]. Nevertheless, context goes far beyond location; it is a concept. Or as Schmidt et al. say, context is “far more than location” [SBG99].

A “context is any information that can be used to characterize the situation of an entity” [Dey00]. Entity is a person, place or object that is “considered relevant to the interaction between a user and an application, including the user and application themselves” [Dey00].

For this work, we follow the definition according to which the context is an interplay of the location and “the identity of nearby people and objects” [ST94].

Context plays a central role in classifying Local Services. If a Local Service can discover and take advantage of contextual information, it is classified as context-aware [WW06].

Taxonomy

The word taxonomy describes both a process and the result of this process. Oxford Learners Dictionary defines taxonomy as “the scientific process of classifying things (= arranging them into groups)” [Pre24]. We follow the definition from the Cambridge Dictionary that describes taxonomy as a system for organizing things into groups that share similar qualities [Ass24]. The taxonomy in this work is a system for organizing characteristics and features of Local Services.

Systematic Literature Research

The term Systematic Literature Review (SLR) refers to organizing the literature review in a certain way, with the aim to present the state-of-the-art, as well as gaps and challenges of a field [COLL22]. The literature review process includes “to collect, identify and critically analyze the available research studies” [PL18]. Furthermore, it is a two-stage process with a planning and conducting phase [KC07]. In the planning phase, researchers write down the review protocol that documents strategic decisions like the research question, the search string or the study selection criteria. The conducting phase then implements this review protocol [KC07]. In computer science, SLR are considered as "qualitative (i.e. descriptive) in nature," what makes them so interesting for this work, as we aim for a comprehensive description of the available knowledge on Local Services [KC07][COLL22].

2.2 Theoretical Framework for the Systematic Literature Review

Systematic Literature Reviews include two phases: The planning phase and the conducting phase [KC07]. In the planning phase, researchers write a review protocol describing the need for the research, the search strategy and the data extraction form. The conducting phase is, above all, executing this review protocol. Therefore, this chapter is mainly about writing the review protocol in the planning phase and less about the conducting phase, which represents just the researcher's concrete implementation of the review protocol.

The organization of this SLR is based to a large extent on the recommendations from the author Kitchenham, with some minor changes. Kitchenham expects the SLR to be done in a group of researchers, which is impossible for this work. Consequently, some of the instructions cannot be followed. Those instructions not considered for this work are: "Commissioning a Review," "Project Timetable," "Evaluate a Review Protocol" [KC07].

In sum, the methodology for our SLR is listed below and based on Kitchenham with minor modifications for this thesis [KC07]:

Methodology of Systematic Literature Reviews

- Step 1: Confirm the need for a Systematic Literature Review
- Step 2: Define the Research Question
- Step 3: Develop the Review Protocol
  - Rationale for the Review
  - Research Question
  - Search Strategy
  - Study Selection Criteria
  - Study Selection Process
  - Study Quality Assessment Checklist
  - Data Extraction
  - Data Synthesis

Step 1: The need for a Systematic Literature Review

Kitchenham provides three reasons for conducting an SLR. First, SLR allows summarizing "the existing evidence concerning a treatment or technology". Second, it allows to " identify any gaps in current research to suggest areas for further investigation" and last, to "provide a framework/background to appropriately position new research activities" [KC07]. Consequently, the review is necessary if researchers want to "summarize all existing information about some phenomenon in a thorough and unbiased manner" [KC07]. Summarizing existing knowledge with the help of an SLR is particularly important if the research topic is not well-studied yet. Before starting the Review, Kitchenham recommends determining if an SLR has already been done about the topic. If so, those results should be analyzed regarding quality and informative value. All in all, the existing research might help to conduct the next review [KC07].

Step 2: The Research Question

Researchers must identify the research question(s) as soon as the need for a review is confirmed. The definition of a research question is the "most important part of any systematic review" because that research question guides the study selection and data synthesis later in the review [KC07]. An unspecific or unprecise research question might lead to erroneous study selections. Consequently, researchers must pay attention when formulating the research question. The "PICOC"-approach helps to formulate a significant research question which contains all essential keywords on a topic.

PICOC stands for Population, Intervention, Comparison, Outcome, and Context, representing five different perspectives on a phenomenon. Analyzing the research topic through those points of view might make it easier to formulate a specific and focused research question [COLL22]. The "PICOC"-approach originates in the medical field, but Kitchenham explains how to use it in the computer sciences [KC07]. Some authors developed the alternative "SPIDER"-approach which is doing the same thing as the PICOC-approach and will therefore not be further discussed here [CSB12].

The "P" in PICOC stands for "Population (Who?)" and means the group of interest for a study [KC07][CSB12]. That can be a specific role, an application area, an industry domain, IT systems, or an industry group such as Telecommunication companies or Small IT companies [COLL22][KC07].

Next, "I" stands for "Intervention (What or how?)" and can be interpreted as "software methodology/tool/technology/procedure that addresses a specific issue" [KC07][COLL22] [CSB12]. Those tools could be technologies for performing specific tasks.

Third, the "C" for "Comparison (Compared to what?)" is mentioned [KC07][CSB12]. Here is described, if the technology or approach is compared against another [KC07]. Nevertheless, this is an optional step, as not all SLRs include a comparison [COLL22].

The fourth step for defining the research question is the "O" to clarify the desired "Outcome (What are you trying to accomplish/improve?)" of the SLR [KC07][CSB12]. In other words, What should be generated by the SLR? Should it explore the reliability of a technology? Or gather knowledge that helps to reduce costs? [KC07]

The "C" stands for "Context (In what kind of organization/circumstances?)" [KC07][CSB12]. This perspective on the research topic describes the thematic context of the research problem and the situational context of the review [KC07][COLL22][CSB12].

The keywords brought forth during the PICOC approach are then combined into a research question [KC07]. In consequence, the research question is significant because it includes central perspectives and keywords around the research topic.

Step 3: Develop a Review Protocol

Writing a review protocol ensures that "other researchers can replicate the process and understand how the analysis was performed" [COLL22]. By making the planning phase transparent through a review protocol, researchers reduce the "possibility of researcher bias" [KC07].

The review protocol includes the following elements:

- Rationale for the Review
- Research Question
- Search Strategy
- Study Selection Criteria
- Study Selection Process
- Study Quality Assessment Checklist
- Data Extraction
- Data Synthesis

Step 3.1: Rationale for the survey The review protocol starts with some background information, confirming the need for an SLR on the topic [KC07]

Step 3.2: Research Questions The review protocol then mentions the research question for a second time.

In addition, the protocol documents how the search string for the digital libraries is built. The search string combines keywords and concepts around the search topic in a meaningful manner with the help of boolean ANDs and ORs [KC07]. Researchers should try variants of the search string on different databases before choosing the final string.

Those preliminary and trial searches are necessary to determine if "various combinations of search terms derived from the research question" can find potentially relevant studies in a reasonable amount [KC07].

The conducting phase of the review applies the here-developed search string to different digital libraries. One has to emphasize that the search string is not static but can change after each iteration through a digital library. Nevertheless, the researchers must document whether, when, and how the search string changes.

Step 3.3: Search Strategy Step three of the review protocol presents the search strategy, which includes enumerating the potential sources that are combed through during the process. The potential sources include journals, databases, digital libraries, research registers or the Internet. Moreover, this step mentions the start and end date of the search period [KC07][KC07]. One has to emphasize that the selection of digital library sources is crucial, as the quality of the SLR depends on the quality of the databases. Against this background, the author recommends libraries like ACM Digital Library or IEEE Digital Library because they cover areas like computing, information technology, engineering, and technology [KC07]. Nevertheless, international and multidisciplinary databases like the Web of Science might also be helpful [COLL22].

Step 3.4: Study Selection Step four of the review protocol describes how to to identify the relevant articles among the numerous results. This step includes two tasks:

- Select articles that contain the research keywords in the title, abstract, and conclusion [BKB+07]
- Among the now remaining articles, select those that match the inclusion and exclusion criteria [BKB+07]

Brereton et al. notes in his article that selecting articles based on only the title and abstract is insufficient. The author underlines that the "standard of IT and software engineering abstracts is too poor to rely on when selecting primary studies. You should also review the conclusion" [BKB+07]. Selecting articles based on title, abstract, and conclusion means analyzing these elements about the occurrence of the search string keywords. Suppose the keywords do not appear in the title, abstract or conclusion; likely, the article is irrelevant for our Systematic Literature Review [BKB+07].

After selecting articles based on title, abstract and conclusion, the second study selection starts: select the remaining studies based on predefined inclusion and exclusion criteria. Again, those transparent criteria aim to reduce the likelihood of bias [BKB+07][COLL22]. Inclusion and exclusion criteria usually rely on things like time period, the journal, type of literature, the language, accessibility, the subjects or the date of publication [KC07].

More precisely:

- Time Period: researchers can include articles upon a particular year and exclude articles before this year.
- Language: include only literature in a specific language, for example, English.
- Type of literature: decision about whether to include or not to include grey literature. Grey literature means information that is "produced outside of traditional publishing and distribution channels" [Uni23].
- Type of source: the type of origin might determine if literature is included. For example, articles from journals could be included, whereas articles from books could be excluded.
- Impact Source: in this category, the journal impact score (JIS) of an author determines whether an article is included or excluded from the review.
- Accessibility: literature can be excluded based on the fact that it is not available in specific literature databases.

- Relevance to the research question: literature can be excluded from the review if it is not relevant to a particular research question or a number of research questions [COLL22].

After excluding some papers based on the exclusion criteria, Kitchenham urges the researchers to perform a quality assessment on the remaining papers [KC07].

Step 3.6: Study Quality Assessment After selecting the studies and before extracting the data, the studies are assessed for their quality. The quality assessment helps to standardize the quality of the SLR findings [KC07].

The quality assessment should be done with the help of a checklist. Elements for this checklist are mentioned by the author Zhou et al. The author enumerates reporting, rigour, credibility and relevance as criteria for Quality Assessment during an SLR [ZZH+15]. More precisely, all selected articles must meet these demands:

- Reporting: "represents the minimum quality threshold of a review and is used to exclude non-empirical research papers" [ZZH+15].
- Rigor: "focuses on whether the research method used is thorough and appropriate" [ZZH+15].
- Credibility: "is related to whether the findings are well-presented and meaningful" [ZZH+15].
- Relevance: "is the usefulness of findings to the software industry and research community." [ZZH+15]

Studies that do not match those quality criteria are then excluded from the next steps.

Step 3.7: Data Extraction The data extraction is now conducted on the remaining papers to summarize the general knowledge about the studied phenomenon [COLL22].

The review protocol describes a data extraction form, that enumerates the kind of data which should be extracted from all the papers (e.g. author, tile, answer to the research question) [KC07] [COLL22]. The form is predefined in the protocol to make the data extraction transparent and reduce the likelihood of bias because, each researcher perform on each paper the same steps [KC07][COLL22].

According to Kitchenham and Carrera et al., the data extraction form should include at least the following points [KC07]:

Points for the Data Extraction Form

- Name of the Reviewer [KC07]
- Date of Data Extraction [KC07]
- Title, Authors, Journal, Publication Details [KC07][COLL22]
- Main Focus of the Paper [COLL22]
- Identified Problem [COLL22]
- Proposed Solution [COLL22]

- Space for additional Notes [KC07]

Even though the data extraction form guarantees some transparency, Kitchenham says that "whenever feasible, data extraction should be performed independently by two or more researchers" [KC07].

Step 3.8: Data Synthesis In this last step, the review protocol describes how to summarize and synthesize the extracted data. Kitchenham recommends summarizing the data in a tabular form for reasons of clarity [KC07]. No matter the form, the synthesis should give an overview of the phenomenon or close the existing gaps in current literature [KC07].

After extensively preparing the Systematic Literature Research, chapter 3 is now about conducting the research following the here presented methodology.

3 Systematic Literature Review

We now implement a Systematic Literature Review with the goal to aggregate the existing, scientific knowledge about Local Services.

Moreover, we describe the realization of the SLR in detail, so the methodology of this work is transparent and reproducible. The review is split in two phases: First, the literature review is planned. Second, it is implemented in the conducting phase, based on the preceding planning. To follow this structure, we start the SLR by describing the planning phase.

3.1 Planning Phase

The review protocol is the centre of the SLR and is written during the planning phase. Such a protocol documents all strategic decisions around the SLR, like the search string, the research strategy or the data extraction strategy, before starting the search itself. The conducting phase is then realized based on the review protocol mentioned above. Thereby, researchers guarantee that the Systematic Literature Review takes place transparently and reproducible [KC07].

For the sake of this paper, we follow the arguments from Kitchenham and structure the Systematic Literature Review in this thesis as follows:

- Step 1: Confirm the need for a Systematic Literature Review
- Step 2: Define the Research Question
- Step 3: Develop the Review Protocol
  - Rationale for the Review
  - Research Question
  - Search Strategy
  - Study Selection Criteria
  - Study Quality Assessment Checklist
  - Data Extraction
  - Data Synthesis

Step 1: Confirm the need for an SLR

We can confirm the need for a Systematic Literature Review in the field of Local Services for two reasons. In literature, those services are not consistently defined and often vaguely described as LBS but not as phenomena apart. Therefore, it is necessary to aggregate the existing scientific knowledge and consolidate the existing research.

Second, there is an imbalance between white and grey literature on Local Services. Local Services have been repeatedly observed as an empirical phenomenon and discussed in blogs and newspaper articles, but they have never received a corresponding interest in the scientific field. Consequently, it is necessary to contribute new knowledge to white literature by synthesizing existing knowledge in a taxonomy.

Step 2: Define the research question

Step two is about defining the research question with the help of the "PICOC"-approach [KC07].

Table 3.1: Evaluation of PICOC-approach for Local Services

Perspective on Local Services	**Description**
Population	The SLR addresses the phenomenon of Local Services within the field of Location-Based Services.
Intervention	We define Local Services as services that are only available at specific locations. In literature, they are often vaguely described as general Location-Based Services.
Comparison	The SLR does not include a comparison.
Outcome	The outcome of the review is a taxonomy of Local Services
Context	We conduct this research in a context where Local Services get much attention as commercial phenomena in blogs and newspaper articles, but scientific articles about them are missing. A research gap exists on that topic.

In consequence, the research question for this Systematic Literature Review is: "what could be a taxonomy for Local Services?" This research question includes the keywords used in the "PICOC"-approach, such as taxonomy and Local Services.

Step 3: Develop a review protocol

Now that the need for research is confirmed and the research question has been formulated, we will continue writing down the review protocol.

3.2 Conducting Phase

Technically, writing the review protocol still belongs to the planning phase. However, the conducting phase is de facto, the concrete implementation of the protocol, so we write down the realization of the review protocol in this conducting section.

Step 3.1: Rationale

The rationale is supposed to give background information about the research topic and explain the need for a review. As we mentioned background information and the topic relevance of Local Services in chapter 1 and 2, we will only summarize the key points here. In short, Local Services are services only available at specific locations, such as push notifications with exclusive offers that can only be accessed by users close to a physical store. The need for a Systematic Literature Review is already confirmed in step 1, saying that an SLR is necessary because numerous real-world examples of Local Services exist, but they are rarely studied in scientific literature. Consequently, this existing research gap confirms the need for an SLR.

Step 3.2: Research Question

The research question guiding each step and decision during this SLR is as follows: “what could be a taxonomy for services only offered at specific locations?”

In addition to the research question, we must define a search string that can be applied to digital libraries. Based on the keywords and synonyms from the research question and the “PICOC”-approach, we create the following search string: (“services in specific location” OR “location based Services” OR “location based applications” OR “location based systems” OR “location aware services” OR “location specific services” OR “location specific applications” OR “taxonomy of location based services”).

This search string is significant because, on the one hand, it mentions the keywords from the research question like “taxonomy”; on the other hand, it takes into consideration that the phenomenon of Local Services is closely linked to Location-Based Services and has no proper name, yet. Therefore, the search string includes the concept of “Location-Based Services” and descriptions for Local Services like “services in specific locations,” and “location specific services.”

Step 3.3: Search Strategy

Our search strategy includes the search period from December 2023 to June 2024 and the digital library resources:

- ACM Digital Library
- IEEE Xplore Digital Library
- SpringerLink
- Elsevier

- Elicit

Step 3.4: Study Selection

Study selection criteria help researchers to identify relevant papers among the numerous results in each database. We identify papers as relevant if the search string keywords appear in an article's title, abstract and conclusion. By including the conclusions of each potential relevant paper to our analysis, we follow the recommendation from Brereton et al., who say that selecting articles only based on the title and abstract is not sufficient in computer science [BKB+07]. Sometimes, we even include the introduction of a paper if its title, abstract, and conclusion are poorly written and do not hint aspects of Local Services. Consequently, we deviate from Kitchenham, according to whom only the title and abstract analysis are necessary [KC07]. We value this deviation because our impression of these papers is, that the aspects relevant to our research question are often not mentioned in the title or abstract but somewhere in the introduction or conclusion. After this first selection based on title, abstract and conclusion, we apply the inclusion and exclusion criteria listed in tables 3.2 and 3.3. Paper that do not match the inclusion or exclusion criteria are then removed from further steps. The content of our inclusion and exclusion criteria follows the recommendations from Kitchenham [KC07]. We chose to include grey literature in the inclusion criteria because many blogs and newspaper articles discuss the phenomenon of Local Services and real-world examples.

Table 3.2: Inclusion Criteria

Inclusion Criteria	Description
Time period	Articles of all years are included in the SLR.
Language	All articles in the English language are included in the review.
Type of literature	White and grey literature are included in this SLR. Including grey literature in the review is important, as commercial examples for those Local Services are often discussed in blogs and newspaper articles. Even papers not subject to peer review are included if they are interesting.
Accessibility	All articles we have access to, are included in the given SLR.
Relevance to research question	All articles relevant to the research question are included in the SLR
Impact Source	All articles, independent from their CiteScore, are included in the SLR

Step 3.5: Study Quality Assessment

The checklist for the quality assessment in table 3.4 is based on the recommendation from Zhou et al. from chapter 2 [ZZH+15].

Table 3.3: Exclusion Criteria

Exclusion Criteria	**Description**
Language	All articles not in the English language are excluded from the SLR
Accessibility	All articles that we are not able to access are excluded from the SLR
Relevance	Articles not relevant to the research question are excluded from the SLR

Table 3.4: Quality Assessment Criterion

Quality Assessment Criterion	**Description**
Q1	Does it represent the minimum quality threshold of a review?
Q2	Is the research method appropriate?
Q3	Are the findings meaningful?
Q4	Are the findings useful?

Step 3.6: Data Extraction

Data extraction forms indicate the type of information that must be extracted from each relevant paper [KC07]. The categories for our data extraction form are presented in table 3.5. Again, they are based on the recommendations from Kitchenham and Carrera et al. [KC07][COLL22].

The concrete realization of the data extraction form in our SLR is available on request.

Step 3.7: Data Synthesis

In the data synthesis step, we go through all the papers listed in the data extraction form, read them carefully and extract pertinent knowledge into a Word document. This process ensures we gather relevant insights on Local Services from each selected paper. The findings are then summarized and synthesized into the taxonomy that can be seen in chapter 4.

Table 3.5: Data Extraction Form

Data Extraction Field	**Description**
ID	Gives each article a unique identifier
Author	All authors of the article
Title	Title of the article
Year	Year of publication
Link	URL to article
Published in	Journal in which the article is published
Topic Area	Topic that is covered by the article
Identified problem	Identified research problem
Proposed solution	Solution offered by the paper
Title relevant	Yes or No
Abstract relevant	Yes or No
Conclusion relevant	Yes or No
Relevant based on Inclusion/Exclusion Criteria	Yes or No
General Relevance of article	Yes or No
Q1	Yes or No
Q2	Yes or No
Q3	Yes or No
Q4	Yes or No

4 Results

The following pages present the SLR findings and synthesize them into a taxonomy. A taxonomy is particularly adequate for presenting the results because it is easy to read and visualizes that the scientific literature has multiple and manifold perspectives on Local Services.

4.1 Systematic Literature Review

We describe and analyze the characteristics of our conducting phase.

Databases and Search String It can be seen that the SLR produces a vast number of results in terms of relevant papers. The search includes the databases ACM, IEEE Xplore, Elsevier, Springerlink, and Elicit, and it is conducted from December 2023 to July 2024. The SLR is undertaken in the just-mentioned order.

The final search string for this Systematic Literature Review is: ("services in a specific location" OR "location based services" OR "location based applications" OR "location based systems" OR "location aware services" OR "location specific services" OR "location specific applications" OR "taxonomy of location based services" OR "hyperlocal computing" OR "location sensitive charging" OR "place-based-computing" OR "virtual Location-Based Services").

The terms "hyperlocal computing," "location sensitive charging," and "place-based computing" are added to the search string after the data extraction in the ACM results. The term "virtual location-based Services" is added to the search string after conducting the search in the IEEE Xplore database. The search string stays the same for the databases Elsevier, SpringerLink. Instead of a search string, the Elicit database requires a research question. We apply the following, adapted research question to the database: "what could be a taxonomy for classifying Location-Based Services that are only available at a specific location?".

Quantity of results In each database, the advanced search option is used whenever possible, and sometimes, the search is restricted to only a subset of a digital library. For example, in the case of the ACM digital library, the search is restricted to the "ACM Guide for Computer Literature." Otherwise, the number of results is too huge.

In ACM, the search string is applied to the fields title, abstract, author keyword, and full text. Applying the search string to the general search field would give too many results.

In the IEEE Explore database, the search string is applied to the fields document title, abstract, author keywords, and full text only. The fields must be connected with AND.

In Elsevier, the search string has to be entered in the advanced search fields “find articles with these terms”, “title, abstract or author-specified keywords,” and in the field “title”. Elsevier does allow a maximum of eight boolean connectors per field. Therefore, we had to shorten the search string for this database to (“services in specific location” OR “location based services” OR “location based applications” OR “location based systems” OR “location aware services” OR “location specific services” OR “location specific applications” OR “taxonomy of location based services” OR “hyperlocal computing”).

In the SpringerLink database, the search string is applied to the field “where the title contains.” In the Elicit database, we enter the adapted research question (“what could be a taxonomy for classifying Location-Based Services that are only available at a specific location?”) in the general search field.

In sum, the search string gatherers a total number of 609 papers:

Table 4.1: Total Number SLR Results

Digital Library	Amount of Results
ACM Guide for Computer Literature	135
IEEE Xplore Database	167
Springerlink Database	135
Elsevier Database	122
Elicit Database	50

Unlike the other databases, Elicit does not indicate the total number of results for an research question. For the sake of this work, we choose to review only the first 50 results.

Quality of results The number of relevant papers varies by database, as one can see in the following:

Table 4.2: Total Number Relevant SLR Results

Digital Library	Amount of Relevant Results
ACM Guide for Computer Literature	100
IEEE Xplore Database	45
Springerlink Database	31
Elsevier Database	27
Elicit Database	18

Even though 18 out of 50 results are relevant in the Elicit Database, several of these also appear in other databases.

In addition, many papers in Elicit are not accessible and are therefore excluded from the next steps in the review.

Literature Selection and Data Extraction All in all, reviewing the results and extracting data is extremely time-consuming. Nevertheless, data extraction is easier in some databases than in others. As databases are designed differently, information like the number of citations or the type of document for the data extraction form are easier to detect in some databases than in others.

For example, filling out the data extraction form with ACM and IEEE is easier than with Elsevier because the first two databases mention the “total number of citations” on the page with all results. In Elsevier, one has to click on the next page with the relevant paper only to see the number of citations related to it.

After the data extraction, the Systematic Literature Research results are synthesized in a taxonomy.

4.2 Taxonomy

We now present an extensive taxonomy of Local Services, based on our Systematic Literature Review. Figure 4.1 provides an overview of the taxonomy, which includes the four main categories: "Business Model," "Location," "Infrastructure," and "Privacy." The following pages offer a complete presentation of Local Services that is backed by scientific literature.

Companies use Local Services for example for targeted advertisement, which is already an economic and societal reality. This is reflected in the "Business Model" category.

Unlike general Location-Based Services, Local Services are closely linked to the physical location where they are offered. That interconnection of Local Service and its location is treated in the "Location" category.

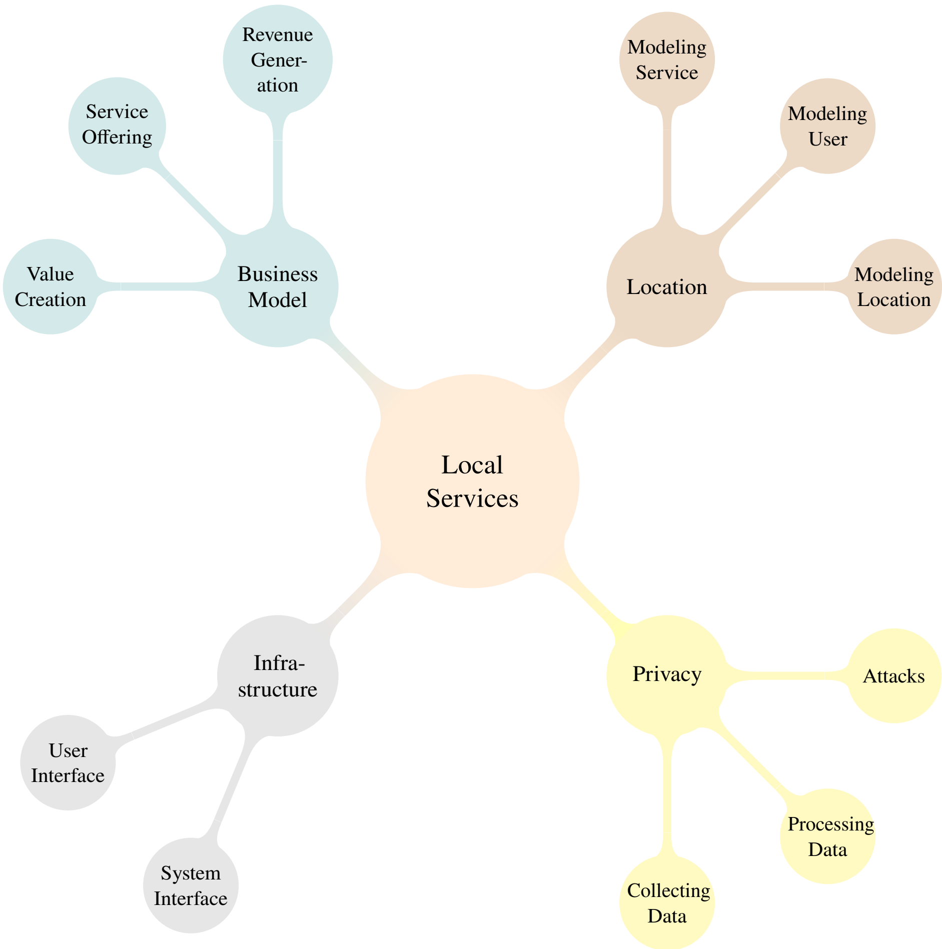

Figure 4.1: Taxonomy Overview

The location must dispose of a technological infrastructure to offer the service on-site. The category "Infrastructure" explores positioning technologies and user interface configurations for Local Services.

Many users are hesitant when it comes to releasing personal data, such as location information. Privacy risk beliefs may even cause a user to renounce a Location-Based Service. Therefore, the “Privacy” category is fundamental to our taxonomy.

Business Model

Local services are used in different business fields, such as mobile commerce, gaming, and knowledge transformation. As Local Services differ in their application area, they vary in generating revenue or delivering a benefit to the user, too. To better understand the available business models around Local Services, we present current "business"-perspectives from the literature on Local Services.

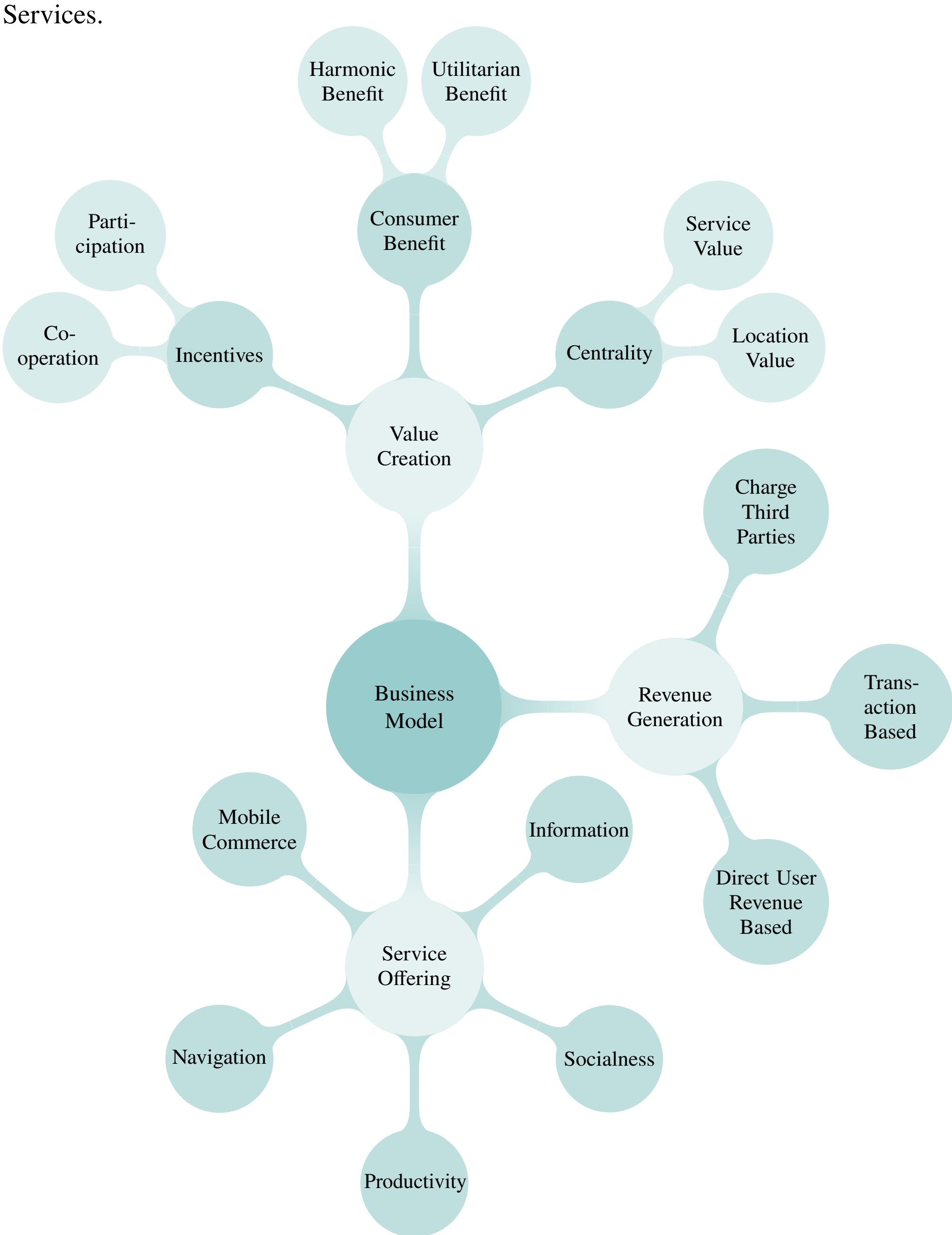

Figure 4.2: Business Model Taxonomy

Value Creation

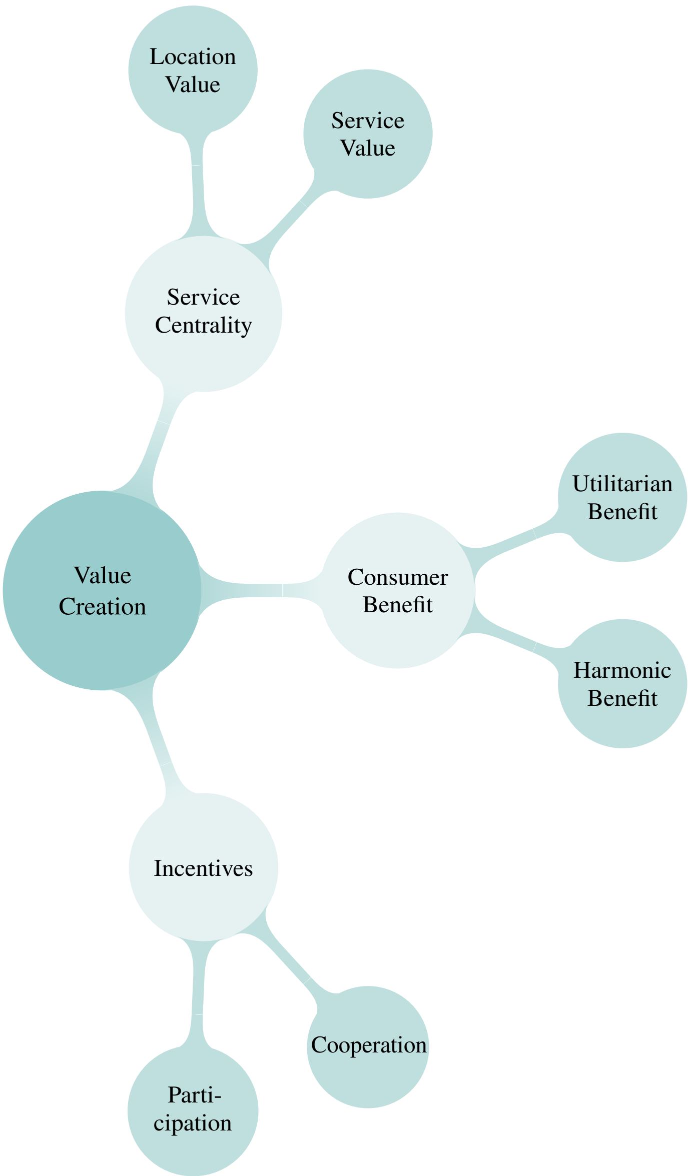

Figure 4.3: Business Model - Value Creation

Service Centrality This section presents the value proposition that a Local Service can offer to its customers. First, we take a look at the centrality of the value proposition. It describes whether the value for the customer is either generated through the interplay between the service and its location (**location service**) or through only the service itself (**service value**) [PW11].
If the Local Service proposes a service value, the customer is primarily attracted to the service itself, with its location being a secondary factor. In other words, the "service value proposition is based on the expectation that customers will be drawn to a Location-Based Service that is customized to their geographical location" [PW11].
Unlike service value, which focuses on the appeal of the service itself, location value refers to the additional benefit gained by making a service aware of and responsive to its location [PW11].
All in all, service centrality explains whether the focus of the service lies in the service itself or more in the location where it is available. In both cases, the service offers a customer benefit that can be either functional or emotional, which is explained in the next paragraph.

Consumer Benefit Loosely speaking, a service can create two types of benefit for its consumers: **utilitarian benefit** and **hedonic benefit** [AA21].
Utilitarian benefit is an economic concept that describes the "main benefit that can be obtained from the product" [AA21]. A service with a utilitarian benefit offers a specific functionality to a consumer, such as selling a product, delivering information about a location, or sending push notifications with coupons to people in front of a store.

In contrast to the economic nature of a utilitarian benefit, the hedonic benefit is a “behavioural concept associated with personal experiences” [AA21]. More in detail, the hedonic benefit is the pleasure of using a product or service. The user does not receive any material gain from the service, but rather an emotional value and positive experience[AA21]. An example of such hedonic value could be the positive feelings of meeting new people in a certain geographic area through a Local Service.

Whether utilitarian, hedonic or both, the existence of those benefits within a service ensures that users are “satisfied with their application utility, the level of benefit they receive, and the quality of the application” [AA21]. Utilitarian and hedonic benefits are an essential contribution to the taxonomy of Local Services because they allow us to classify services in how they recognize “that consumers use mobile applications for both hedonic and utilitarian reasons” or not [AA21]. Consequently, service providers must consider those consumer benefits for their service offering [AA21].

Even though consumer benefits bind current customers to the service [AA21], service providers must consider using incentives to acquire new ones, too. The taxonomy presents incentives for new users to participate and cooperate in the service.

Incentives Han et al. distinguish two types of incentives: **incentives for participation** and **incentives for cooperation** [HYLY22]. Incentives for participation encourage new users to participate in the system or service. Incentives for cooperation train existing users to act according to the service’s rules and avoid selfish or malicious behaviours [HYLY22]. Of course, incentives for cooperation are more relevant to some services than others because not all services allow the same range of freedom and selfish behaviour of the user. For example, “Pokémon Go” is a Local Service and social game that highly depends on user cooperation.

Analogous to consumer benefits, incentives may either follow a more economic or behavioural approach. **Economic incentives** are linked to the functionality of a service, like its “perceived usefulness and ease of use” [ZM13]. In other words, the usefulness of a service encourages people to participate in its use, whereas the application design makes it easy to use the service in a cooperative way. By this, the service provider makes selfish behaviour difficult and disadvantageous, for example, through a rating system that gives users with harmful behaviour a negative score [ZM13].

Conditional values can be classified as economic incentives because they make the service useful and easy to use. Zhang et al. describe it as the context “that prompts the use of LBS (e.g. using the services because someone did not plan a trip)” [ZM13]. As the context prompts the use of the service, for example, with a push notification, the service is likely to be useful for the specific moment and location. Through the push notification, it is easily accessible, just as requested for an economic incentive.

Behavioural incentives on the other hand, are linked to the pleasure and experience of using a service. **Emotional values** are part of the behavioural incentives. They are described as “consumers’ arousal feelings, affect, or mood (e.g., the joy of finding information through phone apps)” [ZM13]. In addition, privacy risk beliefs play a crucial role for users when they decide to participate in a Local Service [RW13]. In consequence, incentives must give the user a feeling of privacy control to motivate him to use the service.

Another very popular behavioural incentive is **social values**. Those are “defined as perceived utility acquired from a product or service’s association with unique social groups” [ZM13]. Users experience social values and, therefore, behavioural incentives when using an application that allows them to communicate with other users with the same interests in the same area. Social values are not just about communication with others; self-representation and the consumer’s reputation might also incentives participation and cooperation in the service [Ril12].

Epistemic values belong to behavioural incentives, too. Epistemic values in a service fulfil “consumers’ needs for novelty and curiosity for knowledge (e.g., use of LBS is viewed as an innovative way of searching for information)” [ZM13].

Constantiou et al. present a less obvious incentive. They say people are more likely to switch to a Location-Based Service if a well-established analogue service exists in this field [CLH14]. They use the example of “traffic-monitoring services, where people used to listen to the radio for traffic information, whereas they currently switch to LBS” [CLH14]. In sum, many situations have a “reference service”, which makes it easy for the user to switch to the location-based version of it once it exists [CLH14]. In short, existing but outdated “reference-services” incentives Location-Based Services. Many papers underline the importance of incentives and consumer benefits for the success of Location-Based Services. Therefore, service providers must consider these elements when analyzing and designing a Local Service [LCWC09].

Service Offering

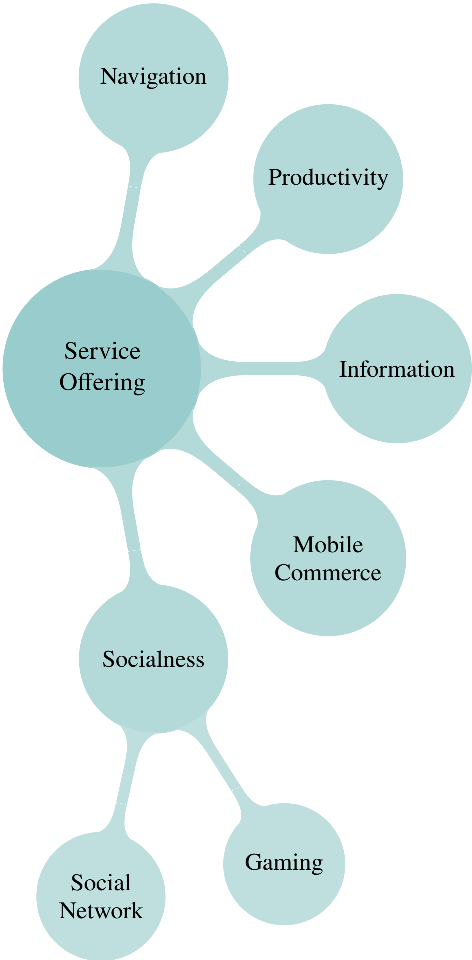

Figure 4.4: Business Model - Service Offering

Application fields for Local Services are manifold. We present the most popular categorizations for them.

Mobile Commerce Local Services in the field of Mobile Commerce often use location-based push advertising [KL09][SRRF23]. In this use case, customers nearby a store receive a push notification informing them about current offers [PW11]. A real-world example of such a service comes from the beauty retailer Sephora. The brand has a campaign inviting customers to a free mini makeover when they are close enough to a store [Tap24].

Information Besides notifications for marketing reasons, Local Services are often used as **Information Services** [KL09][Sui10][PW11]. A widespread use case is museum apps, allowing users to access exhibit information via the app and Bluetooth beacon technology [BPAH13][KPAK05].

Socialness Local Social Services aims to connect (unknown) users with the same interests and location with another. Such "Dynamic Social Networking supporting LBS" or "location-based social networks" [LD09] [AA21] combine Location-Based Services with social networking, to allow its customers to "communicate with various unknown persons that share common interests (. . .) within a certain geographical range" [LD09]. Examples of such social networking services are "location-aware social networking, friend finder applications, social search applications, or proximity alerts based on users' profiles" [Sui10]. Besides communicating with unknown persons or friends in a specific geographic area, Local Social Services allow to "check-in" at physical locations [AA21]. These functionalities increase the awareness and experience at locations and allow random encounters [AA21].

Gaming is another application field of Local Services [SRRF23][KPAK05]. For example, "Pokémon Go Plus" uses Bluetooth "that activates game mechanics whenever the user approaches in the real world special marked locations on the game's map" [XX16]. The game encourages people to discover a location and meet up with other (unknown) service users.

Navigation Navigation is a very popular application field for LBS in scientific literature, which is due to the already sizeable market of this service category in today's world [KL09] [PW11] [KL09]. In traditional LBS, navigation services "determine the fastest route between two positions at the moment, estimate the total travel time, or provide alternative routes for the remaining travel" [KPAK05], but Local Services allow, for example also to "taking into account the current location of subscribers to inform the subscribers driving around" [KPAK05]. A real-world example of a Local Service with navigation elements is mentioned in the paper by Mitchel et al. They present a navigation application only offered at the religious place of Makkah. The service aims for crowd management with RFID tags. The pilgrims at the religious place are then tracked, and the service provider offers them services around the religious practice on-site [MRDA13]. Among those services are "sending emergency requests, finding friends and points of interest on the map and receiving alerts" [MRDA13].

Productivity Productivity applications help people to organize their lives more efficiently. A real world example are e-scooters, currently offered in many German cities by the service providers " Lime," "Bolt," or "Voi" [sta24b]. As users can only access the service with the adequate app and in the correct physical distance to the scooter, such e-scooter services can be considered as Local Services. A popular example for productivity applications in business context, is for example fleet management at the location of a company [KL09] [Sui10] [PW11].

One must emphasize that each application field can be found in a commercial or private context [PW11]. Location-based push marketing is an example of a commercial Local Service, whereas the popular geocaching game would rather be an example of a private Local Service. Moreover, the consumer is not always a private person (B2C) but can be a business (B2B), too [AAAA15].

Revenue Generation

We can categorize services according to how they generate revenue for the service provider.
Breuer et al. has a paper on potential revenue models around LBS [BBRB15]. The author distinguishes three types of revenue generation [BBRB15]:

- Charge Third Parties or monetize the access to the customer base
- Transaction based
- Direct User Revenue Based

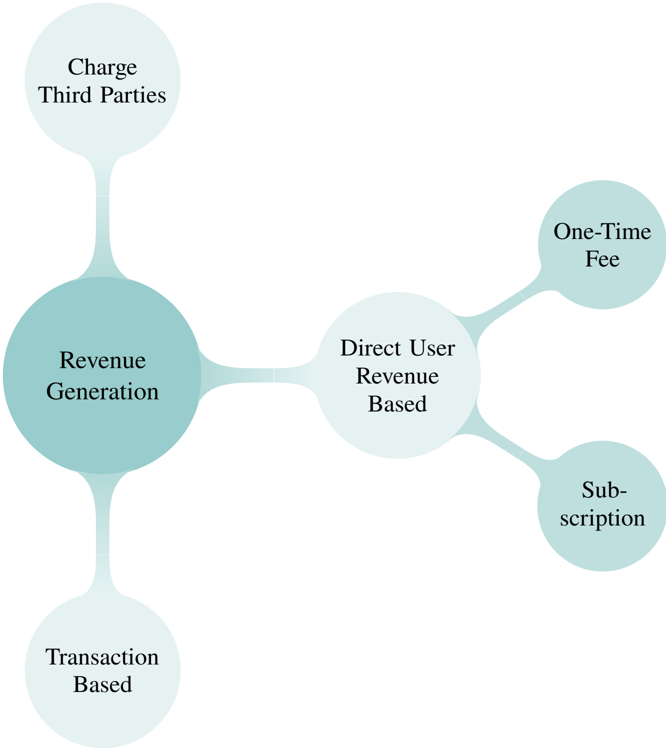

Figure 4.5: Business Model - Revenue Generation

Charge third parties In this very popular approach, "third parties pay for being visible on the virtual map and promoting their information, deals or offers" [BBRB15]. Thereby, other businesses "pay a fee to be included in location-based business directories" [WS05]. Charging third parties is particularly interesting for applications that are free for their users. [BBRB15].

Transaction Based If the revenue is based on transactions, customers have to pay a fee for each transaction they take inside the application [BBRB15].

Direct User Revenue Based When the revenue comes directly from the user, we can distinguish between a subscription model and a one-time fee approach [BBRB15]. Often "the consumers choose which version they are going to use based on their willingness-to-pay" [BBRB15]. This is even more relevant when a combination of different revenue models exists, and they are offered "the choice between the advertiser and non-advertiser supported services, with the former provided at no cost and the latter, provided for a fee" [WS05].

- **Subscription Fees**: the customer pays on subscription basis for a bundle of services or for a specific service [DB03] [IPMF10].
- **One-Time Fees**: the customer only pays one fee. Different types of one-time fees exists [DB03]:
  - Connection and airtime fees,

- fees for content,
- micro-payment,
- transaction fees or margins on the price of products ordered
- free of charge

Free-of-charge services are often combined with the Charge Third Parties approach. By doing so, the customer can use the service for free, but the service still generates revenue, for example, with advertising that the third parties are paying for [IPMF10] [DB03].

Micro-payments are well suited for Local Services because they allow “the payment of small amounts of money and the user pays only for the consumed data” [IPMF10].

Scientific literature not only says something about revenue models around LBS but also about the organization of charging and billing for those services. We give a short explanation about that. The billing for an LBS can either be organized by third parties or not [KPAK05]. More precisely, “the Charging, Accounting and Billing (CAB) service can be either under the administrative domain of one of the involved parties (i.e. mobile operator, value-added service provider, Location-Based Service provider, etc.), or it belongs to an independent third trusted party (e.g. charging/payment provider) that has the responsibility and authorization for the overall charging procedure” [KPAK05].

Location

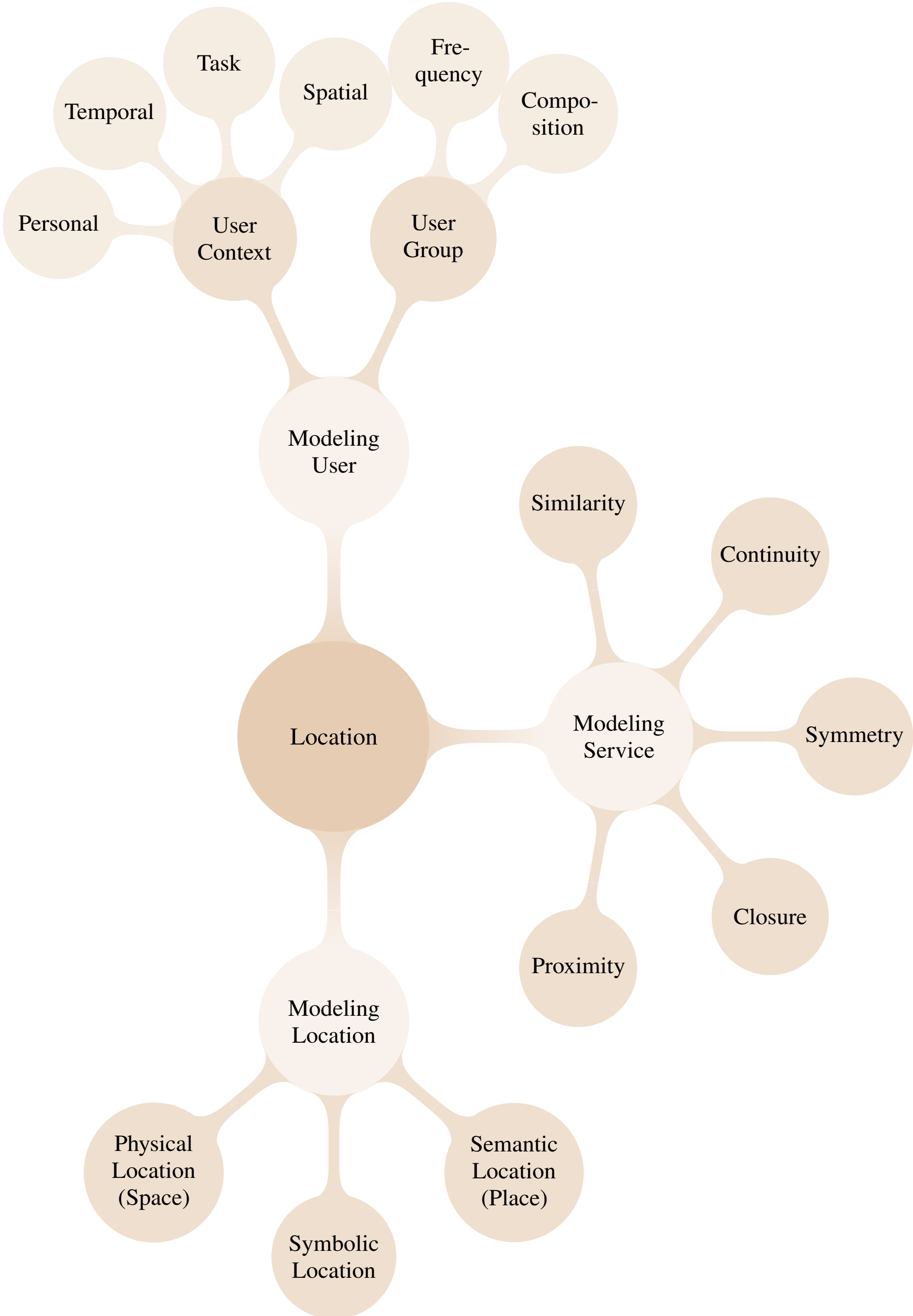

Figure 4.6: Location Taxonomy

Unlike general Location-Based Services, Local Services are closely linked to the physical location where they are offered. This unique connection to the location can even be described as symbiosis because, on the one hand, the location's artefacts are reflected within the service, and on the other hand, the service extends the location itself. The following section emphasizes the role and importance of the location for the service.

Modeling User - User Group

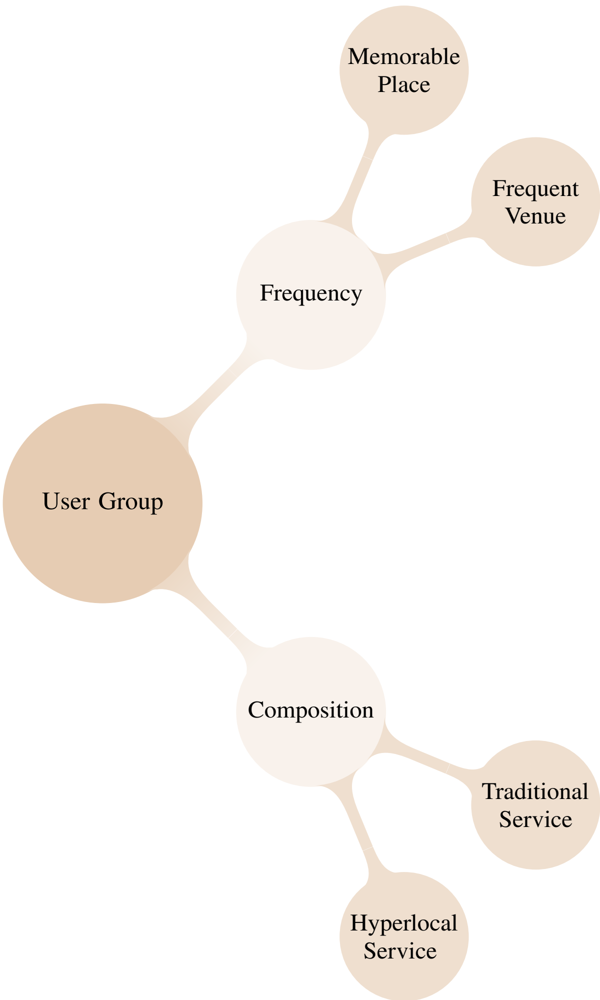

Figure 4.7: Location - Modeling the User Group

As Local Services are only available at specific locations, we must investigate which kind of user group frequents that location. A better understanding of the location and its visitors leads to a more detailed characterization of the Local Service and its consumers.

Composition First, we take a look at the personnel composition at the location. Wasinger classifies LBS as **hyperlocal services** when their user group stay the same over a long period. This differs from **traditional services** where the user group changes typically frequently [WHC+14].
The author explains that users of hyperlocal services are familiar with the geographical surroundings, with people at the place, they usually spend much time there, and they are strongly bound to the area [WHC+14]. Those locations are often things like the home or the work, where people spend much time regularly.
The familiarity with the location allows higher levels of personalizing within the service and "the ability to reach people in a much more targeted manner than most traditional LBSs, by delivering content that is relevant not just to the individual but to the individual in the specific geographical area where he/she resides" [WHC+14].
In short, traditional services target a frequently changing and unsteady user group, whereas hyper Local Services address a user group that is stable over a long period.

Frequency After defining the turnover in the user group at the location, we now examine the frequency in which the location is visited. Bently et al. finds out that some locations can be considered as **frequent venues of daily life**, whereas others as **memorable places**. A home is a frequent and memorable place. A park or concert area is be a memorable place that is no frequent venue of daily life [BCM15].

The findings reveal that “different Location-Based Services are used in different place types (. . .) and not every service needs to address the same spots” [BCM15]. Some services belong to locations that are frequent venues of daily life, others fit better to memorable places or a combination of these. [BCM15].

Analyzing Local Services about the visit frequency is important because “differences in service or interaction design create differences in the places and times where a system will be used” [BCM15]. Therefore, the location, its visitors, and their visit frequency are direct consequences of the service characteristics, which help to analyze these.

Modeling User - User Context

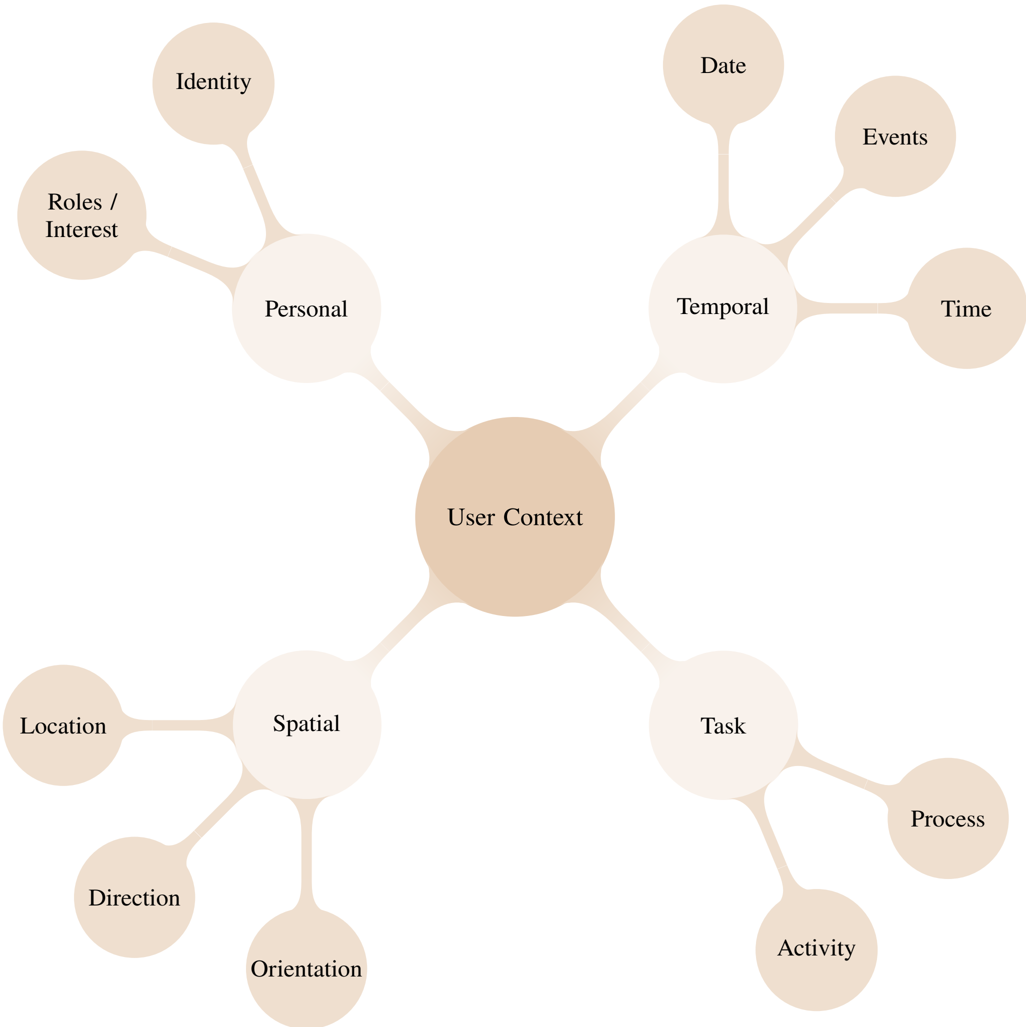

Figure 4.8: Location - Modeling User Context

According to many authors, the physical environment of the service, as well as the individual context of consumers, impact their perception of the service [PK07][Con09]. That individual context of the consumers is often called **local context** of the user.

Constantiou defines the local context as: "the immediate context of use, such as the situation in which the choice is made, and may or may not include other available options (e.g. presence of substitute products/services)" [Con09]. As the local context might impact whether a customer chooses a Local Service or not, we must analyze our SLR results for reflections on those local contexts.

Hossain describes something similar to local contexts. The author uses the term "context identifiers" to describe the situation surrounding the consumer when they are (likely) to consume a service [HAS08]. Those identifiers can be different aspects of the user's reality, such as their interests, the time when they are at the location, or the task that they want to do at the location. "We represent each contextual situation by using a context identifier" [HAS08].

Context identifiers, according to Hossain et al., answer different questions [HAS08]:

- Where? Is the user at an indoor or outdoor location? If it is indoors, is the user at home or in the office?
- When? Does the user frequent the location on a weekend morning, weekend noon, weekday morning, or weekday noon?
- With whom? Is the user alone at the location or with family or friends?
- What activity? Is the user working or relaxing at the location?
- What Mood? What is the mood of the user at the location? Happy, sad, or stressed?

In addition to the context identifiers mentioned by Hossain, Rahman et al. give a detailed overview of "user context" dimensions. User context has four dimensions: spatial context, temporal context, task-based context and personal context [RHS14]:

Spatial Context [RHS14]

- **Location**
  - Low-Level: lat., long., alt., temperature, noise level, light level ...
  - High-Level: meeting room, indoor, outdoor
- **Direction**
- **Orientation**

Task [RHS14]

- **Activity**: Sensor-based (conversation, running, sleeping)
- **Process**: Service-based (online meeting, see a doctor)

Temporal [RHS14]

- **Time**: Sensor-based (conversation, running, sleeping)
  - Absolute (10:00 AM)
  - High-Level (Morning)
- **Events**: Service-based (online meeting, see a doctor)
  - Deduced: weather, traffic, cooking
  - Scheduled: calendar, appointment, party
- **Date**:
  - Absolute (5th October)
  - High-Level (birthday, meeting, doctor appointment)

Personal [RHS14]

- **Identity**
  - Atomic (E-Mail)
  - Composite (User Profile)
- **Roles / Interest**
  - professional
  - social
  - family

In accordance with the authors mentioned before, Wu et al describe those factors as "attributes of a location" that might impact the behaviours of a user at that location [WS05]. They emphasize that the place type, or the number of people inside a certain indoor or outdoor area, might influence whether the user wants to use the service or not [WS05].

Given that location context characteristics are discussed by many different authors, we can conclude that the location and its local context play an important role in Local Services. In consequence, the service provider should consider the user context of a service and its users.

Modeling Service

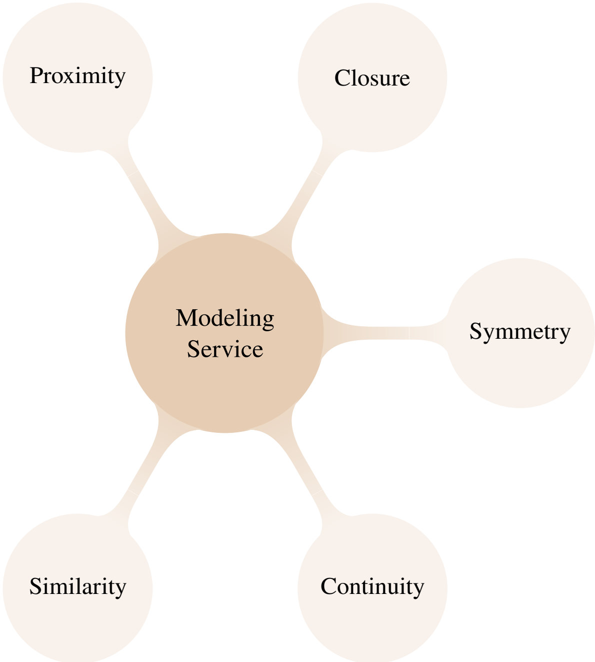

Figure 4.9: Location - Modeling the Service

The following section shows how a service can be embedded into its location and how location elements might be integrated into the service itself.
Paay et al. use the Gestalt Theory approach to explain the interconnection between location and service. Gestalt Theory serves as an analytical framework that helps to explain "the interplay between people, mobile devices, and context of use through principles of perceptual organization" [PK07].
The author reminds us not to underestimate the role of the physical environment for users of Location-Based Services. According to the author, people do not blank out the environment of the Local Service; quite the contrary is happening.
The context of service impacts the user experience because "things are affected by where they are and by what surrounds them" [PK07]. Meaning that the perceptions of the location might influence the perception of the user interface on the screen. Thereby, using a Local Service at a location does not mean to experience either the service or the location, but rather both of them simultaneously [PK07]. They describe this interplay as an "cognitively perceived ensemble of technology and context" [PK07].
After those introductory words on the relevance of the environment for the service, Paay et al. introduces the five Gestalt Theory principles: Proximity, Closure, Symmetry, Similarity and Continuity. All those principles help to classify the interaction between the location and the service.

Proximity The principle describes to which extent "content of the user interface can be grouped with objects in the environment" [PK07]. The principle is fulfilled if the user recognizes elements from the user interface that seem to belong to their current physical location [PK07]. Thereby, the "system acts as an annotation of its physical location" [PK07].

Closure The closure principle describes to what extent "the pieces of information in the user interface and the surroundings can be combined to create a meaningful larger whole" [PK07]. The closure is about how well the interface and the location complement each other, creating a new experience than they would do on their own. This principle only works if the user can make sense of fragmented information or add missing bits between the user interface and the location [PK07]. On the one hand, the system includes those clues that are not already available in the environment. On the other hand, the user interface removes the redundant information that is already in the environment [PK07].

Symmetry Symmetry-principle questions whether “the system aligns information representations in the user interface with the user’s surroundings” [PK07]. This principle is based on the fact that people have a preference for “symmetry between system and surroundings” [PK07]. That information representation in the user interface can take different forms based on the service. Paay gives the example of a service that allows one to control the temperature of a room. In that case, the service not only allows the user to interact with its location but also simultaneously provides the electronic counterpart for the room’s temperature. There is a symmetry between the temperature feature in the interface and the real temperature in the room [PK07].

Continuity In contrast to the already mentioned principles, continuity adds a “temporal dimension” to the service [PK07]. It questions: “ does the content of the system accumulate over time based on people’s use of it?” [PK07]. If a service fulfills the principle of continuity, service and location form a continuous story rather than a series of disjoint events. A Local Service for experiences over a longer period rather than for sets of disjoint interactions can be classified as continuous [PK07].

Similarity Similarity-principle concerns iconic and symbolic representations that appear in the location and in the user interface on the screen. The principle question: “does the user interface match elements in the surroundings, such as prominent signage, landmarks, and visual style of a place or area?” [PK07]. Thereby, the user is asked to group “content and representations in the system with elements in their physical surroundings based on iconic and symbolic similarity” [PK07]. Again, this principle is about similarities between interface elements on the screen and in the physical surroundings, but this time based on symbolic representations. A good example of such symbolic representation could be a map that is the abstract representation of a real geographic area [JMRD03].
Gestalt Theory helps classify Local Services according to the extent to which they have realized a meaningful interconnection between them and their location.

Modeling Location

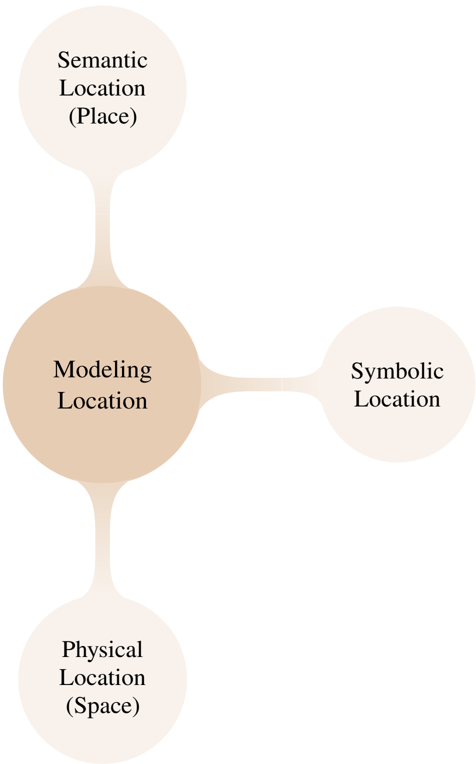

Figure 4.10: Location - Modeling the Location

The last section emphasized that the physical environment affects how users perceive the Local Service on-site. Moreover, the intertwining of location and service goes so far that even elements from the physical surroundings might appear on the user interface. This interplay is unique to Local Services when compared to general Location-Based Services. As location is a core concept of Local Services, the following section presents the SLR findings on location representation in Location-Based Services.
Multiple perspectives on locations exist, and different kinds of Local Services might need a different definition.
The definitions vary so much that authors do not even agree on how many perspectives on locations exist. Zhao et al. state that two perspectives exist: "physical location and geographic location."[ZLZ07], whereas Wu et al. describe locations in three ways with: "geospatial coordinates, civil addresses, and location attributes" [WS05]. Moreover, Leonhardt argues for the two models "geometric and symbolic models" [Leo98] and Hightower mentions "absolute location" and "relative location" [HB01]. We agree with the definition from Edwardes in how it presents a classification with physical, symbolic and semantic location [Edw09].
Each location category gives a new perspective on the location and how the service can be embedded. In other words: "location as a "thing," geometrically bounded, is a very different concept to location as a context for social interaction or location as a setting for different activities" [Edw09]. In consequence, "LBS (..) need to mix different geographic perspectives in presenting useful services and information" [Edw09].
Consequently, the following pages present SLR findings about the three Physical, Symbolic and Semantic Locations.

Physical Location Physical Locations, or sometimes "Geometrical Location," refers to a mathematical understanding of the location [ZLZ07]. It is expressed in "points, areas and volumes within a reference coordinate system" [Leo98]. Consequently, the physical location "represents the position of people and objects as geometric coordinates, captured by positioning sensors" like GPS [HS08]. Physical locations and **space** describe the same geographic phenomenon. The focus of "space is more on how the world looks than what it means" [Edw09].

Moreover, a physical location is not restricted to 2D. Several authors mention that a physical location can take place in 2D or 3D [GPZK19][PN10][Edw09]. Authors expect the 3D location to increase in the future of LBS. They say "geofences will not only represent flat regions but also arbitrary 3-dimensional spaces such as no-fly zones for drones" [GPZK19]. "Another example for 3D services are the different levels of a shopping mall" [GPZK19].

In the SLR findings, some authors have argued that the concept of a physical location is not sufficient [Edw09]. Leonhardt reminds the difficulties that consumers have with the mathematical representation of a location because the general public is "more used to linguistic expressions of spatial features, locations, and spatial relations" [Leo98]. And Hoareau even says that "raw coordinate-based information is meaningless in human interactions" [HS08] [USK13]. In short, authors argue that geometric primitives fail to account for "the geography sensed by the user" [Edw09].

In consequence, a location that is sensed by the user but cannot be measured by positioning technologies are excluded from Location-Based Services. Edwardes argues that "a large amount of geographic information is either not available or not relevant as points, for example, addresses and postcodes, buildings and their functional parts, distributions of wildlife etc." [Edw09].

Even if geographic information is theoretically available as a point, this does not mean a Local Service can practically use the location, because "different positioning techniques have differing levels of precision and accuracy." In consequence, this again "constrains the types of services the technique can be used for" [MR01].

The definition of physical location contributes to the understanding of how location is used in Local Services, even though it is limited [Edw09]. The following pages show supplementary perspectives on location, such as symbolic and semantic locations.

Symbolic Location Symbolic location often takes the shape of addresses. In an outdoor environment, this could be a postal zone or the address of a building in a city. In an indoor environment, an address can refer to a specific room number [Edw09] [WS05].

Hightower reminds us that more complex Location-Based Services like "context-aware service" cannot be achieved by just the physical interpretation of a location. The author says: „most context-aware services require higher-level information captured by a symbolic location model" [HB01]. Wu et al. remind us that civil addresses are easier to understand by end users but are less accurate for computers [WS05].

Semantic Location Semantic Location Models reflect the meaning of an area rather than its geographical coordinates or address [PN10]. More precisely, it is about the meaning that users give this location so users make sense of that physical environment [Edw09][PN10].

When frequenting such locations, consumers are adding personal and emotional connections to it. The location is instead a geographical experience [Edw09]. "Semantic locations can also be defined by social relations e.g. the people who you are near. In this sense, a location might be "With Bob"" [Edw09].

A location that fulfils that semantic model is called **place** [Agn87]. In contrast to a space (physical location), the personal and individual connections of the user with the area are paramount [Agn87]. The consciousness and experiences transforming a space into a place can be based on "how somewhere looks and feels, (. . .) or through dependencies people have to a place related to its particular affordances, for example, being the only source of water in a desert." [Edw09].

Place is an important concept for Local Services, as it introduces a "human dimension to location and helps blur the boundary between direct and indirect experience" [Edw09]. Semantic Location is a "human-readable labelling of positions," like the name for a place [HB01]. The author suggests working with location models that do not focus on spatial representation but use "description and narrative to characterize locations and guide users between them."[Edw09].

In contrast to position and space, there is no easy way to represent people's perceptions of a location. Therefore, the spatial presentation is dominant in LBS. "Place" is also probably "the most neglected aspect of location in current LBS" according to the author [Edw09].

The importance is that the spatial representation should not dominate the other ones. "Hence, care needs to be taken to ensure the spatial operates in the background, underpinning the alternative perspectives rather than subsuming them" [Edw09].

Uzun et al. remind us that location information is much more than pure data; it is "knowledge about the topology of that location in terms of dynamic meaningful information, such as points of interest, events occurring in the vicinity as well as its relation to other neighbouring locations" [USK13]. And even though geographic coordinates are a popular tool for defining a location in LBS, valuable semantic information is generally more interesting for LBS "rather than spatial data" [USK13].

Semantic information enables more complex, context-aware and personalized services. For example, the semantic location model allows the provision of such personalized services, "where two users submitting the same request at the same location and time are expected to receive different notifications according to their user profile" [USK13]. A service based on physical location would receive the same GPS coordinates from both users and, therefore, deliver the same notification. In contrast, semantic information about the location allows differentiated services.

Infrastructure

Local Services are strongly connected to their location, so one should look at the on-site technological infrastructure. Against this background, we present scientific literature on positioning technologies, push notification settings, and user interface configurations closely linking Local Services to a specific physical location.

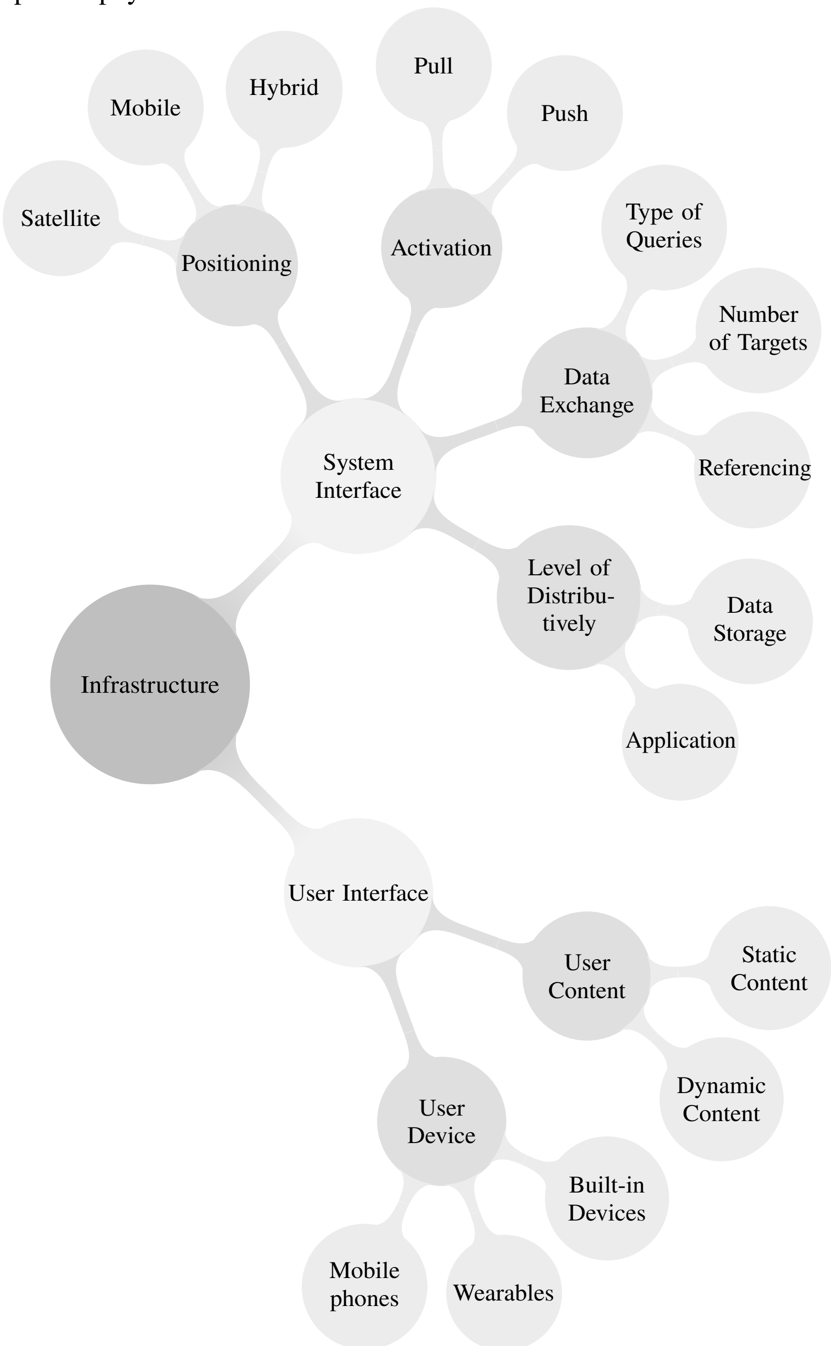

Figure 4.11: Infrastructure Taxonomy

User Interface

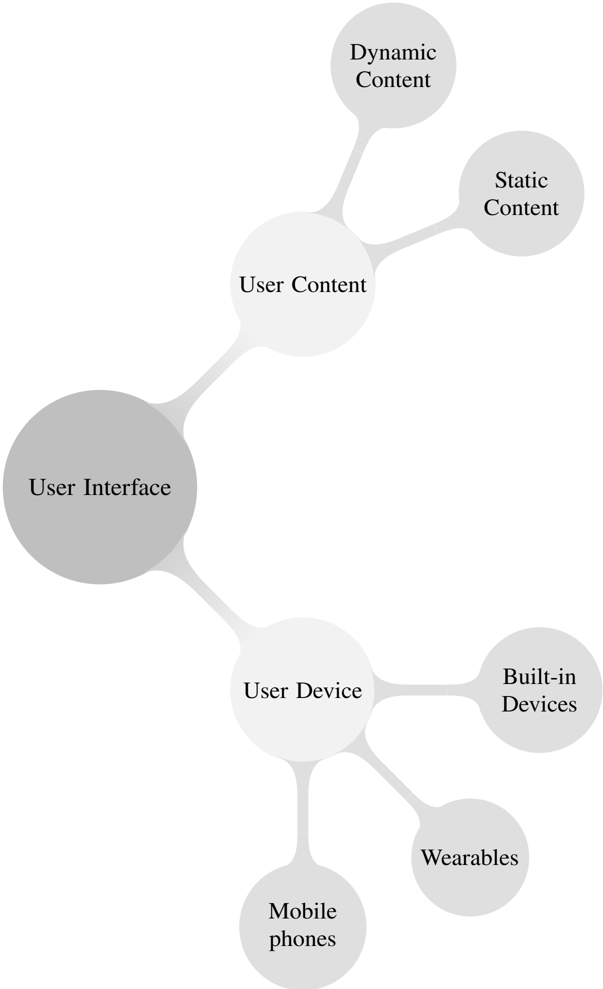

Figure 4.12: Infrastructure - User Interface

User Device Consumers of Local Services access the service through a user interface. That interface can be described through the user device on which it is displayed and the user content that it displays.
First, we start with characterizing the user device of a Local Service. One can distinguish between three categories: **mobile phones**, **wearable devices**, and **built-in devices** [Hua22]. Mobile phones include basic phones, feature phones, and smartphones. Wearable devices mean smart watches, and digital glasses. Built-in devices are for example car-navigation systems [Hua22]. Nevertheless, smartphones are still the most common mobile client for LBS [Hua22].
Different types of mobile devices often have their own characteristics, e.g., screen sizes, computational power, and sensors embedded; interaction modalities, e.g., touch, voice, gesture, gaze based, and technical constraints. Therefore, it is important that the LBS applications can adapt to these devices"[Hua22].
The choice of a target device is even more crucial as it influences the possible user interface. It is well-known that user interfaces "can take several forms including graphical, text-based and auditory" [Li06]. Recent literature often mentions alternatives to the traditional graphical interface and calls it "multimodal conversational agents" [GM16] [NTK08]. Those interfaces that allow voice entries and outputs, too, are especially interesting when targeting an older audience [GM16] [NTK08]. Nepper et al. even mention a Local Service use case for interfaces with voice input. The author talks about: a "novel user experience will be provided, for example, by a tourist guide that speaks to the LBS user as soon as she enters a new city district. The tourist guide can for example tell the LBS user about the name of the district and its landmarks and provide an optional introductory text" [NTK08].

User Content A Local Service is characterized by the user device that allows access to the service but mainly by the user content the service delivers to its consumers. Therefore, the following paragraph deals with different kinds of user content. We can distinguish between dynamic and static user content.

Dynamic content is characterized by the fact that not all users are provided with the same content. Services that offer this kind of dynamic content are also named “Knowledgeable Services” [YS10].

Their content adapts to the user and its context, allowing them to “provide up-to-date answers in heterogeneous and dynamic environments” [YMII14].

Those services can change their content based on the dynamic and changing environment, so they rely on explicit context knowledge. Its content does not come from a centralized repository but is obtained by communication with other devices [YBM20].

User content is classified as **static content**, if the content is the same for each user [YS10] [YKH+06]. Services that offer this type of content are also named “Not-Knowledgeable Service” [YS10].

Two main reasons explain why service provider choose static content. First is the traditional data management technique, which current Location-Based Services rely on. In this case, all data the service uses is integrated into a single centralized repository that provides all the users with the same services [YS10].

In addition, Location-Based Services are mostly designed for specific scenarios and goals with implicit knowledge about the application context” [YMII14]. Implicit knowledge means the “data for the user is hard-coded in the application” [YBM20]. In this case of static content and knowledge, the services are “tailored to specific scenarios, where both services and data are completely attached to predefined and non-evolving schema” [YMII14].

One must emphasize that services can integrate both dynamic and static content into their applications. In this case, the ratio between static and dynamic content depends on the development phase of the service they are in. Petrova et al. present such a classification on LBS based on the nature of content that the service delivers [PW11]:

- LBS “possible”: the content is static and only a few services are available. “Services are based on static location information, and there is a lack of dynamic content” [PW11].
- LBS “feasible”: the content is a mix of mostly static and some dynamic content, and a range of services is available. [PW11].
- LBS “viable”: in this phase, the service range is expanding, and the content is static and dynamic as required. [PW11].
- LBS: LBS type and content is broad, and there are many incentives for continuing investment [PW11].

Tyfona et al. give another approach for classifying the content of Location-Based Services. The authors characterization distinguishes [TP05]:

- Domain Data: including spatial and temporal concepts, namely, position, location, movement and time,
- Content Data: describing the LBS-specific content,
- Application Data: consisting of the user profile and the services provided by LBS.

System Interface

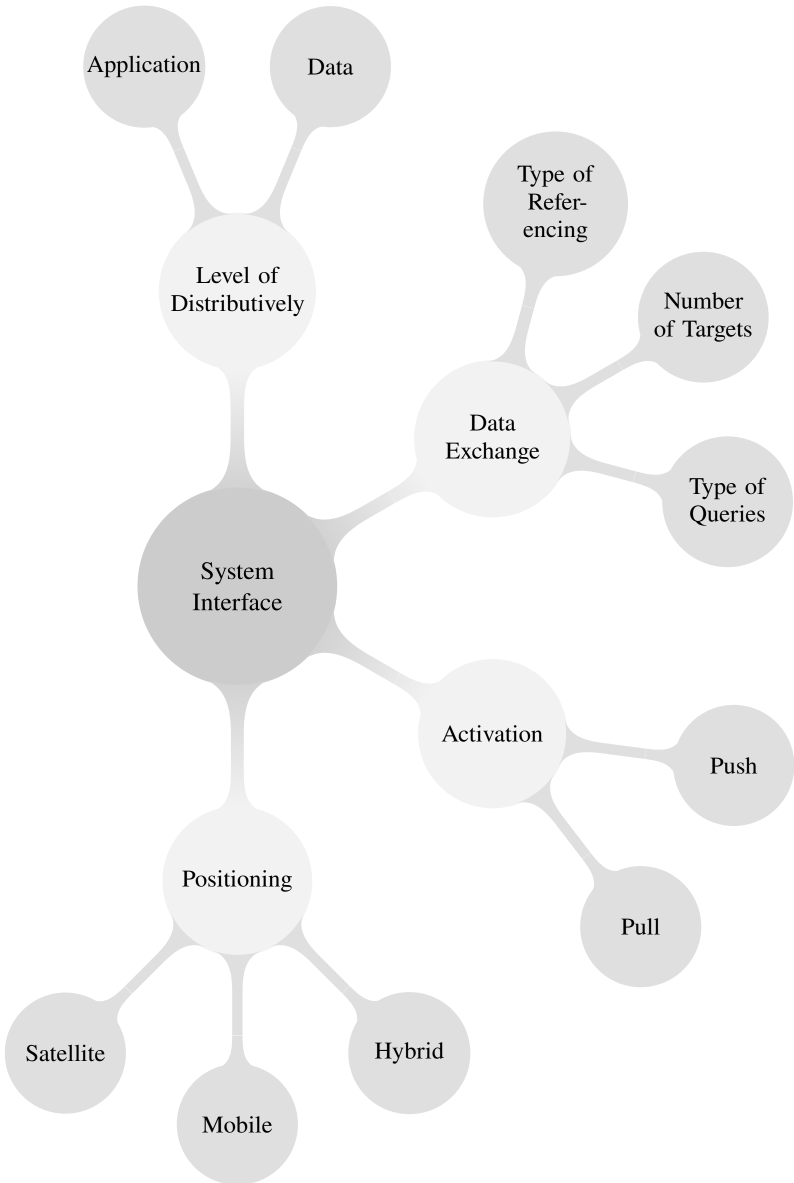

Figure 4.13: Infrastructure - System Interface

All those mentioned aspects like user context, location characteristics and service offerings are then translated into technology with the help of the system interface. The following section allows to classify services based on which technologies they use to implement the Local Service. The overview starts with SLR findings about application architectures.

Level of Distributively

The literature presents different ways to organize **applications** about levels of distributively.

The application can be organized in a centralized or distributed manner. Centralized architectures "need to maintain a geographical map (. . .) in its central server, which can cause low scalability and traffic congestion" [JJK14]. General Location-Based Services mostly follow this centralized approach. But the disadvantage with them is that "the central server is a single point of failure due to its centralized search mechanism, and traffic congestion can occur when numerous lookup are concurrently requested from several different points" [JJK14].

In contrast to those centralized solutions, distributed network infrastructures exist. Those "self-organizing and fully distributed indoor LBS system, (. . .) dynamically adapt to changes in the indoor infrastructure. In particular, the indoor LBS system includes many resources that have more dynamic and frequent mobility, as well as many people in a confined space" [JJK14].

Moreover, there is a classification of device-centric systems and infrastructure-centric systems. “For device-centric systems, location data of mobile devices are calculated by the device itself. For an infrastructure-centric system, the location of mobile devices is calculated in the location infrastructure” [PN10].

Finally, there is also a categorization of the location-based system into Network-based technologies and Client-based technologies[WCKJ14]. “Network-based one utilizes service provider’s network infrastructure to identify the location of the mobile device” [WCKJ14]. “Client-based ones requires the installation of the client application on the mobile devices to determine the user’s location” [WCKJ14].

Each of these categorizations highlights different aspects of how Location-Based Services can be implemented. Service providers can then decide based on aspects like cost and scalability.
Regarding the distributivity level for **Data Storage**, two approaches exist in current literature: the cloud approach and the traditional approach [ZLWL23].

The traditional approach includes not outsourcing the data but rather putting the user’s data usually on the “Location-Based Service Provider-controlled or trusted platform for processing” [ZLWL23].

In contrast to that traditional approach, location data outsourcing has become increasingly popular due to “the rapid development of cloud computing” [ZLWL23]. The author explains that with cloud computing, “Location-Based Service Provider uploads a large amount of LBS data onto the cloud to process user’s queries with its powerful computing power, which effectively reduces Location-Based Service Provider costs” [ZLWL23]. Nevertheless, one should not ignore that this approach brings privacy concerns with it [ZLWL23] [CZS+15].

Data Exchange Several data exchange modalities among service and query objects exists. First, we look at the type of referencing that can be used between the service and query objects.

There is always a direction of mapping between two objects, described as **type of referencing** in the literature.
“It’s important to distinguish between the user, who requests and consumes an LBS, and a target, whose location is requested for LBS provisioning. Self-referencing LBSs are services in which the user and target coincide, while cross-referencing LBSs exploit the target location for service-provisioning of another user, thus requiring stronger privacy protection. In particular, targets should be able to restrict access to their location data to a limited and well-defined group of users.” [BKH08].

Two types of referencing exist. First, self-referencing means “LBS user and target are the same entity” [Küp05]. Ryschka et al. describe the same phenomenon with the words if the “service provision is centred on the user’s actual position, its focus is on targets at location (also called self-referencing)” [RMB16].

Second, cross-referencing means "the LBS user and the target(s) are separate entities." [Küp05]. Again, Ryschka offers an alternative definition: "the service can, also be built on the location of a target, which means that one or several targets are related to each other (also called cross-referencing)" [RMB16].

We have already mentioned that query and service objects exchange information. Thereby, the **number of targets** varies. "Single-target LBSs relate the position of a single target to geographic content like in the restaurant finder service. Multi-target LBSs take into consideration the positions of multiple targets, thus allowing for new kinds of services such as community services" [Küp05].

"In single-target LBSs, the major focus is on tracking one target's position, which is usually displayed on a map or about nearby points of interest. In multitarget LBSs, the focus is more on interrelating the positions of several targets among each other. Nowadays, LBSs detect the proximity of multiple targets" [BKH08].

Data Exchange: Type of Queries Now, we take a look at the **types of queries** that are issued by mobile and stationary objects [MAHP03]. Mokbel mentions different kinds of queries like traditional queries, spatial queries and spatio-temporal queries [MAHP03]. Nevertheless, the author explains above all the characteristics of spatio-temporal queries, which are "queries where both the objects and the query region may change their locations and/or shapes over time" [MAHP03]. In addition, Mokbel classifies two subcategories of spatio-temporal queries, which are snapshot and continuous queries [MAHP03].

Snapshot queries "can be answered using data that is already collected, either in one of the fixed regional servers or in a large repository server" [MAHP03]. The use of snapshot queries gives access to single-moment Location-Based Services [HZS+21]. In practice, "single-moment LBSs require users to provide their current location to service providers at a certain moment to obtain the required service information (e.g., querying the current surrounding gas stations)" [HZS+21].

In contrast, "continuous queries are queries whose responses depend on data progressively accumulating into the servers. A continuous query may either report accumulated results at regular intervals of time or may be triggered to report a result when a certain event happens" [MAHP03]. He et al. say that continuous Location-Based Services need the implementation of continuous queries [HZS+21]. They describe continuous LBS as requiring users "to periodically provide their location to service providers to obtain services" [HZS+21].

The choice of the query type is important for Local Services. Different query types offer different services and functionalities; Local Services can be differentiated according to the type of query they allow between the service and query object. Mokbel explains this by saying that in a "location-aware environment, where objects are continuously moving, any delay in query response results in an invalid and an obsolete answer" [MAHP03]. The choice of type of query must be made with precaution.

Further differentiation on spatio-temporal queries exists. Those can be classified based on the time of the query or the mutability of both objects and queries [MAHP03].

Historical spatiotemporal queries ask about “the past data (data that is stored at the repository servers), NOW queries are interested only in the current location of moving objects,” and “future queries are interested in predicting the locations of moving objects” [MAHP03]. All three are spatio-temporal queries based on the time of the query.

Stationary Queries on Moving Objects, Moving Queries on Stationary Objects and Moving Queries on Moving Objects all belong to spatio-temporal queries based on the mutability of both objects and queries [MAHP03].

First, when using Stationary Queries on Moving Objects, “the query regions are stationary, while objects are moving” [MAHP03]. These queries include: “how many trucks are within the city boundary?” One can see that in these queries, “the query regions (city boundary) are fixed, while the objects of interest (trucks) are moving” [MAHP03].

Second, in the case of Moving Queries on Stationary Objects, “query regions are moving, while objects are stationary” [MAHP03]. An example of this category is ”as I am moving in a certain trajectory, show me all gas stations within 3 miles of my location” [MAHP03].

Third, Moving Queries on Moving Objects are defined as “both query regions and objects are moving” [MAHP03]. An example of such queries is ”as I (the sheriff) am moving in the space, make sure that the number of police cars within 3 miles of my location is more than a certain threshold” [MAHP03].

As Local Services appear in different combinations of moving or stationary objects, the need to classify the mobility of those entities within Location-Based Services becomes clear.
Gratsias et al. offer an often quoted classification of Location-Based Services based on a query process point of view [GFDT05]. They say: “the novelty of the proposed classification stands on the fact that database query processing is the driving wheel behind our approach” [GFDT05]. This classification is necessary, as each query processing category offers its algorithm, and different service functionalities can only be realized with specific algorithms [GFDT05].

Gratsias defines the user of the service as a query object and the service provider and its entities as the data object [GFDT05]

Case 1: Query Object and Data Object are both stationary In this use case, the algorithms “what-is-around,” “routing,” and “find-the-nearest” can be applied [GFDT05]. “what-is-around” returns points of interest within a certain radius. Moreover, “routing” “find the optimal route between a departure point P and a destination point Q” [GFDT05]. The “find-the-nearest” approach “helps to find the k nearest points of interest for example find the two nearest bakeries” [GFDT05].

Case 2: Query Object is mobile and Data Object is stationary The “guide-me algorithms” belong to this category, where “here, the query object (person requiring the service) is moving, while the data object (the destination where the query object wants to go) is stable” [GFDT05].

Case 3: Query Object is stationary and Data Object is mobile The “find-me” algorithm does that “the query object (person requiring the service) remains stationary, while the data object is mobile and their location is automatically recorded as they approach the user” [GFDT05].

Case 4: Query Object and Data Object are both mobile The “get-together” approach is “a moving user invites other users, also moving into the the same area, to converge at a meeting point not known in advance” [GFDT05].

By classifying a service’s queries as stationary or moving, we get an idea about the functionalities that the service can offer. Overall, these different types of queries allow service providers to design services that can handle different levels of location and movement complexity.

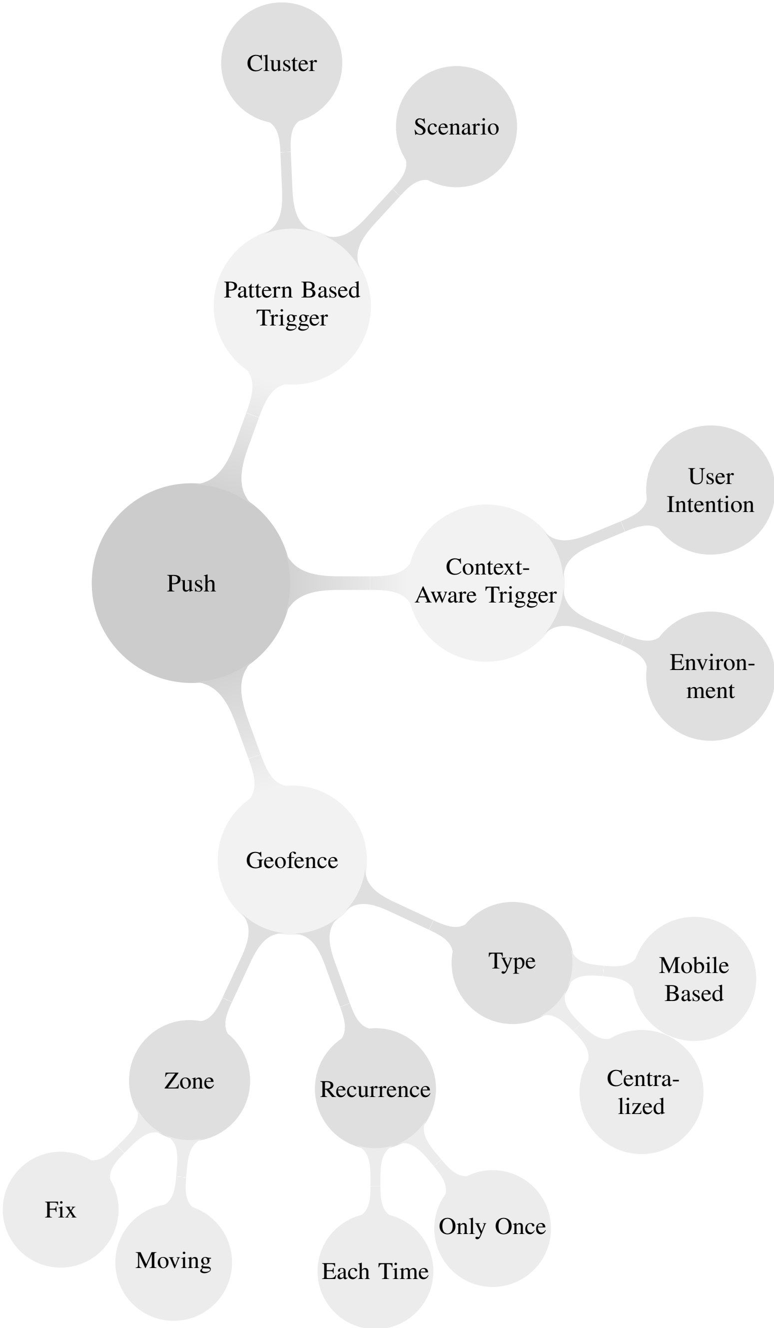

Figure 4.14: Infrastructure - System Interface and Geofences in Detail

Service Activation We have already clarified that Local Services are linked to a physical area. If they want to, people passing by this area can access that service. However, we have not discussed how those services are activated until now. In other words, we need to explain how sessions with the Local Services are initiated.
The unique characteristics of Local Service make activation a thing in itself. The following pages explain this fact.
SLR findings classify Local Services in two big categories based on their session initiation mechanisms: if the service only "responds (. . .) on demand," the LBS is called a "reactive" LBS [GZK13]. Other common names for this is pull-type [AKE04].
Breuer et al. emphasize that "the type of delivery mode - push or pull - is another significant factor for classification" [BBRB15]. While the former supplies location-sensitive content to users based on their location without them requesting it, the latter needs users to request the information or services [BBRB15].

On the other hand, if the service is constantly monitoring the user's location and then contacts them on their own without being asked for it by the customer, the service is called "proactive" LBS [GZK13]. An alternative notion for it is push-type [AKE04]. The push message is often triggered by a specific event, for example, when the user approaches a specific point within the location [GZK13].

As a reminder, pull- and push-type notifications help categorize Local Services because the choice of the notification type changes the functionalities and experiences a Local Service can offer. Therefore, those concepts are explained in detail on the following pages.

Option 1: Proactive Services (Push-Type) A service uses the push-type if the "request for service is not technically made by the customer but by the service provider" [AKE04]. More in detail, proactive LBSs are such that are "triggered by some kind of location event, e.g. a target entering or leaving a specified geographic area" [GZK13]. Those services send push notifications using their own logic.
Of course, the service provider needs the customer's permission before sending them content [AKE04]. Often, customers give those permissions more or less unconsciously when installing the application on their smartphone.
Geofencing is the technology that "allows tracking locations and sending push messages" [GDPM15].

Geofence Characteristics We take a look at some possible configurations for Geofences. First, the service provider can define the zone of the geofence, meaning the zone in which users can be monitored and push notifications can be sent. This dedicated zone is called geofence [GDPM15]. The **zone** of the geofence can be **fixed** or **moved** [GDPM15]. A geofence with a fixed zone could be, for example, a "certain checkpoint on a route within a freight management application" [GDPM15]. In that first case, push notifications are only received if the user gets closer to a specific point within the location. A geofence with a moving zone could be a "friend within an application for 'friend-close-by'-notifications"' [GDPM15]. In that second case, the relevant geofence is moving. The push notification could be theoretically triggered at any location where the friend with the "friend-close-by" application is moving.

Second, service providers influence how often a push notification is sent. In other words, one can manage the **recurrence** of the notification. Thereby, the service provider can choose between the "notification can be triggered **only once**," or the "notification is triggered **each time** one enters the zone" [GDPM15].

Third, a geofence system is either of the **type mobile-based** or **centralized** [GDPM15]. The mobile-based geofence operates on the user's mobile device. In contrast, the centralized geofence operates on the service provider systems [GDPM15]. In both cases, positioning and matching with geofences are computed, but only mobile-based geofences do this on the user's mobile device. That just described mobile-based approach is "by far the most popular type of Geofencing system in use" [GDPM15].

According to McKiou, push notifications are often sent by commercial or organizational entities. Consequently, those notifications are often about available products or services [MS11].

Context Aware Trigger Mechanisms Service providers are often not satisfied with simple trigger mechanisms that just send push messages each time a zone is entered, because those unconditional trigger mechanisms may "send notifications at inappropriate time without considering user's intention and changing environment"[ZWJH10].
In consequence, service providers make those trigger events more complex, to a point where context

information is integrated into the service trigger mechanism [ZWJH10]. By doing so, the service provider hopes to reach a "designated user rather than a group of users" [LD12]. The idea of context-aware trigger mechanisms is explained in the following paragraph.

According to Zhu et al., contextual information is beside the user's location, preference, plan, network connectivity, etc. [ZWJH10].
He classifies those context information for service triggering as follows:

- "**Environment context** (E.g. time, location, traffic condition, and weather)
- **User intention context** (3W: Where (location), When (time), Why (user intention/emotion))
- Another context (E.g. user behaviour, advanced context information which comes from the reasoning of history context information)."

Consequently, Location-Based Services should not be rigid and isolated from contextual information [ZWJH10].

Until now, the service gets activated at the moment a customer enters the location [KL03]. According to some authors, a geofence should even be able to predict the entry of the customer into a zone. In this context, prediction means that the geofence "predicts" "future locations (e.g. locations at later times)" that the user could pass later on in time [KL03]. This prediction is computed with the two parameters, L and t, where L is the location and t is the time. Then, "location prediction dynamically estimates the mobile user's future locations using the user's current location information, the historical mobility patterns and the auxiliary information" [KL03].

Karimi et al. then say that those predictions provide the service provider with extended resources, such as time, to improve the system's reliability. In return, this "increases the users' confidence and the demand for LBSs" [KL03].

Pattern Based Trigger Anagnostopoulos suggest using the fact that people often move in groups together (e.g. friends, families) [AKH13]. Instead of tracking and notifying each person at a location individually, which can be very costly in crowded places, the author suggests an alternative approach.

He suggests that the backend system forms a group of users in the system and then only monitors one person among this formed **cluster**. If the trigger gets activated for the monitored person, the formatted group around this person get the push notification, too [AKH13]. Consequently, moving patterns reduce the use of resources in the underlying network and the computation overhead in the backend system [AKH13]. The advantage of those moving patterns is, that if the number of users "increases and they continuously change their position, the system and network load for location-based content delivery becomes quite significant without the use of patterns" [YPPK08] [AHK15]. Group formatting within patterns is possible because "temporal changes of moving objects tend to possess a unique, regular pattern" [LPR04].

Users with similar moving patterns might also request similar content delivery (e.g., museum/city-tour guidance, traffic conditions). Moreover, users can be formed into (temporal) groups whose structure can vary over time (i.e., group merge/split, group membership). The larger the number of users is, the higher the overall back-end system load becomes" [BPAH13].

Another example of group formatting is when a service provider at a museum classifies the users into different groups, e.g., passionate, selective, and cursory, according to their viewing styles and interests[Hua22]. Group formatting allows to personalize the content, as “LBS designers can then determine what information should be provided to them and in which way” [Hua22]. The user information for group formation can either be requested explicitly by the user “when using the LBS application or automatically learning from their past behaviours or interactions with the application”[Hua22].

Another example of using patterns is geofence **scenarios**. Those patterns are based on the fact that if users pass by a sequence of specific targets, a push notification is likely relevant for them. The author explains that a “geofence scenario comprises a sequence of geofences which need to be passed by a potential target in a particular order so that a related geofence notification gets triggered at the mobile device” [GDPM15].

Option 2: Reactive Service (Pull-Type) A service is considered as “reactive” or “pull-type” if the service must be “triggered explicitly by an LBS user’s request” [GZK13]. In contrast to the push-types, the “request for service is made by the customer” [AKE04].
The user has several possibilities to explicitly “check-in” at the service:

- Barcode [ZH15][YH16][BCR+10]
- QR-Code [ZH15][YH16]
- Bluetooth [ZH15][BCR+10]
- RFID [ZH15][BCR+10]
- Type something in an app [ZH15]
- Speak something in an app [ZH15]
- Point the camera at something [ZH15]

All in all, “the push mode is less popular because the user has little to no control, fears of privacy invasion or related costs that might emerge” [BBRB15]

Positioning Positioning technologies allow the service provider to locate users at the location. The literature mostly distinguished three categories of positioning technology: Satellite Networks, Mobile Networks, and WLANs [MH07][YR15].

Satellite Network based techniques are the most prominent positioning technologies [MH07] [PW11] [ZGL02] [YR15]. They include GPS, defined as "the worldwide satellite-based radio navigation system" [MAHP03]. The satellite then transmits navigation messages, that the GPS receiver uses to determine its position [ZGL02].

One has to know that "satellite-based positioning does not operate properly in deep canyons and indoors where cellular coverage may be denser" [MH07] [GZK13] [MLGL16]. In other words, it only "works well in outdoor environments since GPS signals cannot easily penetrate and/or are greatly degraded inside of buildings" [FFCB14].

Due to this fact, GPS belongs to the outdoor wireless location systems [PN10]. Those are characterized by the fact that they provide extensive coverage but generally provide lower location accuracy [PN10].

Localization also exists in **Mobile Networks** [YR15]. The Mobile Network approach is also called "Mobile telecommunication," "terrestrial infrastructure-based techniques" [MH07], or "Mobile Networks (Global System for Mobile Communications (GSM))" [YR15].

Technologies like CELL-ID (Cell Identification), Angle of Arrival, Time Difference of Arrival (TDOA), and Enhanced Cell-ID (Enhanced Cell Identifier (ECID)) belong to this approach [MH07] [PW11].

More in detail, CELL-ID "relies on the fact that mobile networks can identify the approximate position of a mobile handset by knowing which cell site the device is using at a given time" [ZGL02].

Cellular positioning has some inconveniences. First, the accuracy of the technology depends on the cell size. Consequently, this technology is less accurate in rural environments but higher in densely covered areas (for example, urban places) [ZGL02]. In the rural areas, satellite visibility would be better [MH07]. Moreover, "cellular positioning can be influenced by deflections from buildings and other large objects" [GZK13].

WLAN technologies can be used for indoor and outdoor positioning. But they deliver better results in the indoor context. More in "detail, indoor wireless location systems generally provide smaller coverage areas, but higher location accuracy" [PN10].

Against this background, WLAN is today considered as "state-of-the-art" indoor positioning technology" [Hua22][YR15].

Several authors mention a **hybrid approach** that "make use of the collaboration between different wireless radio access technologies existing in the same geographical area" [YR15].

Fernandes et al. mention the example of a hybrid system for outdoor environments, in which "GPS is used as main information source and RFID (radio-frequency identification) for corrections and location error minimization" [FFCB14].

Graf mentions some more technologies used for data transfer of positioning information between a smartphone and a stationary device. "Currently, there are four major technologies that are used for data transfer: Universal Serial Bus (USB), Bluetooth, Near Field Communication (NFC) and standard IP over LAN/WLAN" [GZK13].

Besides WiFi, more technologies can be used for indoor positioning like "RFID (radio-frequency identification), Bluetooth like Apple's iBeacon, IMU (inertial measurement unit) sensors such as accelerometer and gyroscope, and even LED (light-emitting diode) lighting systems" [Hua22].

Moreover, Graf mentions problems if a device lacks GPS and WLAN for positioning. As a solution, they offer to use an Internet Protocol (IP) address for positioning that approximates their position only coarsely [GZK13].

Interconnection of positioning technology and Local Service After examining different positioning technologies and their characteristics, we need to discuss the interplay between them and their impact on Local Services. Authors in the findings of the SLR mentioned several times that GPS technologies are not well suited for indoor use.

Therefore, based on the positioning technology, we can classify Local Services into indoor and outdoor services. Outdoor Local Services use either GPS, mobile networks or Wi-Fi location systems; indoor Local Services can use mobile networks or Wi-Fi location systems [PN10].

Another classification of Local Services about positioning technologies is whether a Local Service needs high or medium accuracy positioning [ZGL02] [TN09]. Usman et al. mention the example of services in coffee shops or for sending advertisements that do not need exact proximity [UAA+18].

Nevertheless, "there are many scenarios wherein it becomes imperative for proximity devices to learn the exact distance between them" [UAA+18]. The author mentions the example of social games, where "some features are activated only when a player is within a certain physical distance from its counter player" [UAA+18]. It is clear that in such situations, the accurate distance must be determined with positioning technologies.

In short, the use of a specific positioning technology helps to classify local services. More precisely, some services can only be realized with a specific positioning technology, and therefore the used positioning technologies hint at the functionalities of the service.

Moreover, when releasing their location data, for example, with Wi-Fi, consumers know the privacy risks they encounter. In other words, location data release is always linked to the service user's privacy risk beliefs. Therefore, the next section deals with the privacy aspects surrounding the release of location data and Local Services.

Privacy

Users often hesitate to release their location data due to privacy risk beliefs. Zhou et al. underline that perceived risk influence usage intention because it negatively affects user willingness to use the service [Zho13]. In consequence, the success of a service is influenced by how the service provider handles sensible data. Against this background, this subcategory explains different approaches to the collection and processing of user data and attacks particular to Location-Based Services.

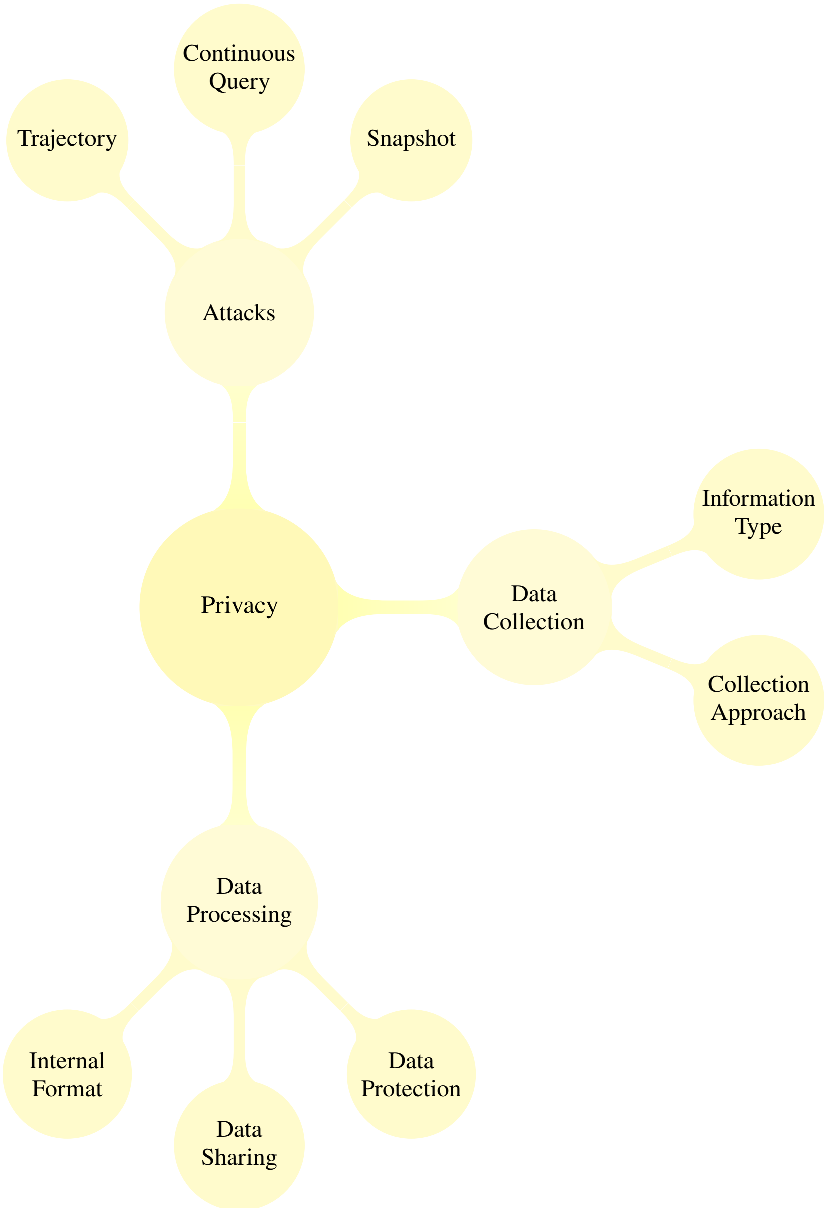

Figure 4.15: Privacy Taxonomy

Attacks

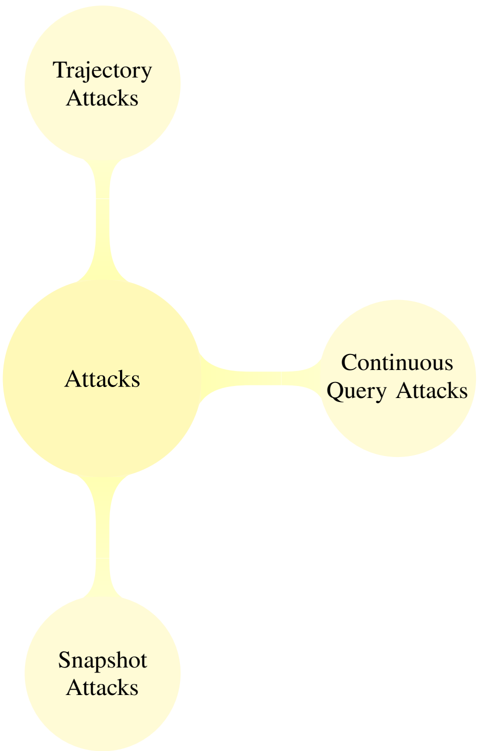

Figure 4.16: Privacy - Attacks

It is a well-known fact that consumers have privacy concerns when it comes to Location-Based Services. They "worry whether mobile service providers properly collect, store and use their location information" [Zho13]. Against this background, "Privacy" is a recurrent aspect in scientific literature about Location-Based Services.
The following pages explain how data in such services is collected, threatened and protected. We start with attack types that are especially considerable for Location-Based Services and location data.
Saravanan et al. distinguished three types of attacks based on whether the location data is tracked at a concrete moment or over a more extended period.

Snapshot query attacks Snapshot attacks are applied when the update frequency in the service is low and appear just in a sporadic way [SRRF23]. When using this attack, an attacker aims to "localize users at certain time instants" [SRRF23]. Such snapshot query attacks do not allow to continuously trace user data. According to Saravanan et al., snapshot queries are the most commonly used queries because the service provider only needs one "timestamp (when the query is initiated by the user)" [SRRF23].

Continuous Query Attacks Continuous queries linked to a high update frequency in the service because those queries are continuously issued by users, and series of timestamps is used to provide a service for the consumer [SRRF23]. Continuous query attacks allow the attacker to "track users over time and space" [SRRF23].

Both snapshot and continuous query attacks are "on-line attacks" in common, meaning that they " happen while processing of users' request" [SRRF23]. Consequently, the service provider must protect the user request processing sufficiently. A later section in the "Privacy" category is dedicated to the security measures for user data processing.

Trajectory Attacks Trajectory refers to the sequence of locations that a user visits. A trajectory attack uses a person's movement patterns to obtain its data [SRRF23]. In contrast to snapshot and continuous query attacks, trajectory attacks are "off-line attacks" that do not happen while processing the user request. Moreover, "the attackers use a series of location-contexts on the trajectory databases to reveal users' identity" [SRRF23].

Data Collection

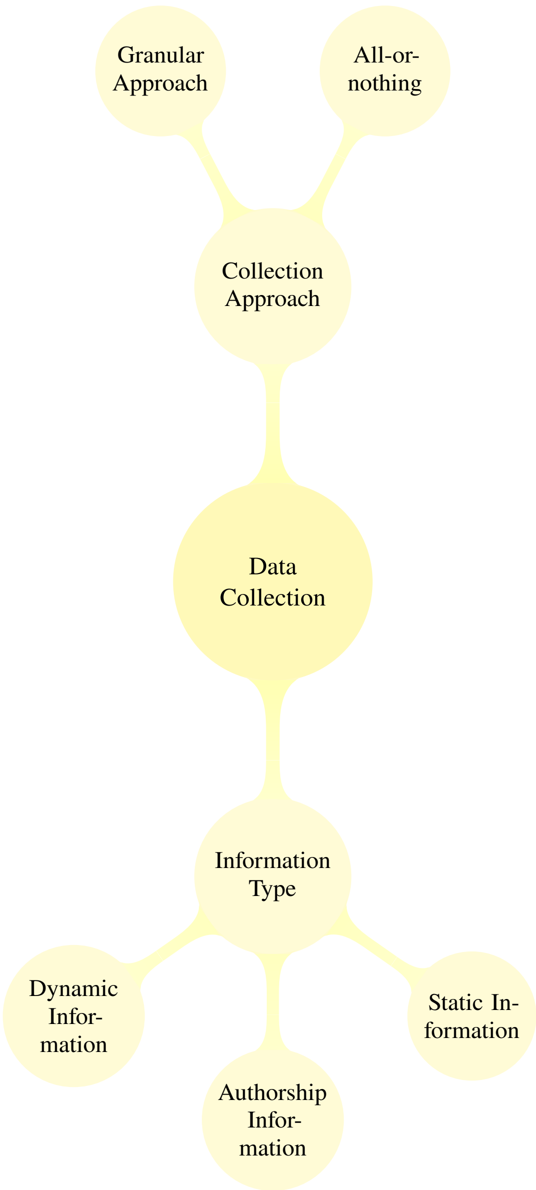

Figure 4.17: Privacy - Data Collection

We now present scientific literature about the data collection process for LBS. The chapter addresses the types of information collected for these services and the methods through which the service accesses the data.

Collection Approach The literature distinguishes two collection approaches: **all-or-nothing** and **granular Approach** [RW13]. Often, LBS have have a **'all-or-nothing basis'** [RW13] [MS05]. All-or-nothing refers to the fact that users lose control over their data when check-in to those services. They can not control the level to which they give the service provider access to their data. Roback et al. compare this to other services like social networks, where it is more common to have control over the level of granularity. The author says that, for example, Facebook allows the user "freedom of discretion as to the depth of the information they post online" [RW13]. In other words, Facebook allows people to have a user profile without ever posting something. LBS and Local Services are often designed differently. When opting for the service, users have "no control over this level of granularity; they simply decide whether to check in at a particular location, which itself is a fairly precise indicator of their physical location“ [RW13]. In this "all-or-nothing"-approach, using the service means giving the service providers (and potential attackers) access to all relevant data.
In contrast to the popular all-or-nothing basis, there exist LBS services with **Granular Approaches**. That privacy management allows users to control the amount of data they release [RW13]. In other words, in a granular data collection approach, it is up to the user to specify which kind of information they want to share with another group of subscribers and the service provider [MS05].
Besides the already mentioned "always-allow-to-everybody" approach, Mohapatra et al. recommend the following granular policies for LBS [MS05]:

- Allow with notification and acceptance
- Restricted allowed or never allow exception list

- Do not allow at all

Whereas it is common in the literature to guarantee the user's privacy and protect its location data, only one author mentions protecting the service provider data by obligating the user to prove that its collected location data is correct and they are really at a certain location.
Only the author Teufl classifies services according to whether the user has to prove to the service provider that its information is trustworthy [TZKL12]. The author says: "there is yet hardly any service, which requires the user to prove that she is at a specific location at a certain point in time" [TZKL12]. The absence of those services is due to the fact, that "none of the position and time information gained by nowadays smartphones is trustworthy," as the author recognizes by himself [TZKL12]. Nevertheless, this is an innovative approach to collecting data.

All in all, no matter what privacy policies are offered, service providers must consider that location data "represent a distinct class" that requires increased protection and special procedures" [RMB16]. Therefore, it has been ensured by the EU Directive on Privacy and Electronic Communications, "that location data can only be used with the permission of the user" [RMB16]. Thereby, the findings of the SLR show that data collection for those Local Services is strongly regulated and must be considered when deciding to offer an LBS.

In addition to how much data is collected and whether service users have a say in this, scientific literature often analyses the kind of information that is collected. The collected data can vary from simple location data to more private information like the day of birth. As different Local Services need different kinds of data, the following section presents information classification for Location-Based Services found in the SLR results.

Information Type The classification of user data into different information types is a recurrent topic in the SLR findings. One can distinguish Dynamic Information, Static Information [LBDM03] and Authorship Information [Kan97].

As the name suggests, **dynamic information** is related to frequently changing user information. It can be the user's location, activity, identity of nearby people, and the time associated with those things. This information is classified as "context information," too, as it gives notes about the current situation of the user [LBDM03].

In contrast to dynamic information, **static information** rarely changes over time. Such information includes the social security number, birth date, gender or profile information" [Kan97][LBDM03].

Kang et al. have an alternative name for those static information. The author describes them as **descriptive information**. In accordance with Lederer et al., we define static information as information that represents the "permanent or non-fleeting status of the individual, either biological or social" [Kan97].

If static information is used "for institutional identification, secured access, or provision of some service or good," they can be classified as **instrumental mapping information**. Social security numbers and passwords are representative examples of this category of information because they allow the user institutional identification for public services and secured access to Web services [Kan97].

Most authors follow this categorization in static and dynamic information. Kang et al adds another category to this with **authorship information**. Authorship Information includes information created to share with a third party. All information “created purposely to communicate to a third party” belongs to this category [Kan97]. Kang et al. mention telephone conversations, personal diaries, and e-mails as examples [Kan97]. Authorship Information is an important category for this work, as Local Services are often used for communicating with known or unknown persons in the same geographic area. The information released during these interactions falls precisely in that category of authorship information.

Data Processing

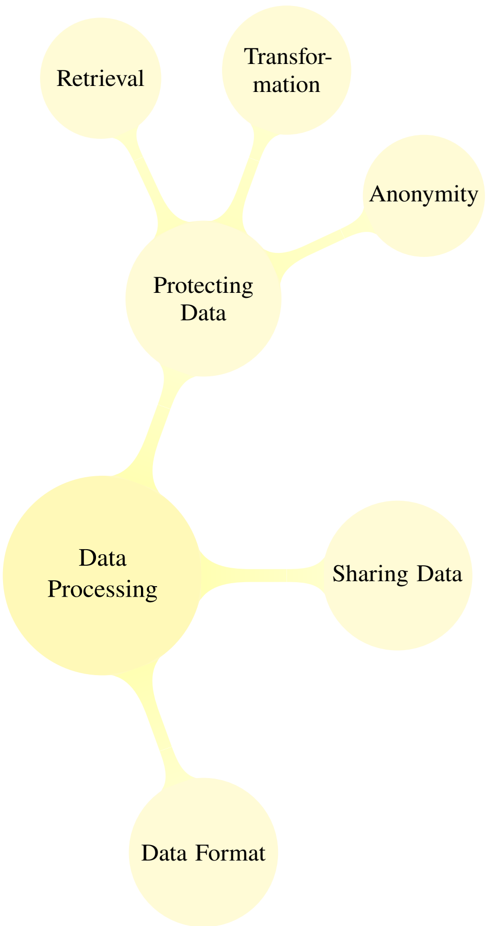

Figure 4.18: Privacy - Data Processing

Data Format Internal data processing is done in different ways based on the security types chosen for data representation. Literature findings distinguish the security types as anonymous, identified and pseudonym-based. **User is anonymous:** "The user can be fully anonymous because the service does not need any type of identification or pseudonym. An example could be a service of meteorological alerts for the city where the user is located" [IPMF10]. **User is identified:** Services in that category only work "if the user provides his true identity. An example could be an application to alert about a broken protective order by an assailant" [IPMF10]. **Pseudonym based:** "The user does not show his true identity, but he only shows a pseudonym. For example, a dating application, where it is not mandatory to show the real identity although other personal data could be shared, like age or sex" [IPMF10].

Protecting Data We already mentioned that attacks on LBS happen during data processing. Saravanan et al. describe this phenomenon as "on-line attacks" because the attacks " happen while processing (. . .) users' request" [SRRF23]. Privacy algorithms that secure the data processing and prevent those "on-line attacks" are crucial for understanding Local Services.
According to Khoshgozaran, three big groups of algorithms ensure privacy during data processing [KS10]:

- Anonymity / Cloaking
- Transformation
- Private Information Retrieval

The idea behind **Anonymity / Cloaking - Algorithms** is to hide the real position of a user behind several other users [SM08] [NZL+15]. Thereby, the user's exact location is blurred in a larger cloaked region that makes the individual user anonym among "the set of other (real or dummy) users located in the cloaked region" [KS10]. In the context of Local Services, data processing preventing those "on-line attacks" is crucial, as it increase the users willingness to use the service.

This Anonymity approach is inspired by the "k-anonymity approach," allowing the user to not be distinguished "from a set of k users because they share the same fake/masked location" [SM08].

The second category **Transformation - Algorithms** is “based on transforming the query to prevent the server from learning information about the user’s locations” [KS10]. Transforming the query allows the user to give one inaccurate position to the LBS provider instead of a set of locations as in the anonymity-approach. Even though Transformation-Algorithms are based on “the distortion of the real location” the location information should not be too inaccurate. Otherwise, the “provider cannot obtain any useful information, and the user cannot receive a proper answer” [SM08].

Both algorithms mentioned above suffer from a trade-off between privacy and the quality of the service [KS10]. On the one side, some transformation approaches allow perfect privacy but are very costly in query processing. On the other hand, some cloaking algorithms might even result in severe “privacy leaks under certain user, object or query distributions” [KS10].

According to Khoshgozaran et al., this trade-off between privacy and service quality can be resolved by **Private Information Retrieval Algorithms** [KS10]. They allow efficient “retrieval of a subset of the server’s database” [KS10]. Meaning, the user is allowed to retrieve data from a service while not being obliged to reveal what kind of data they requested. Among others, this can be realized with cryptographic approaches that use “homomorphic encryption, quadratic residues and other cryptographic properties” [KS10].

We discussed extensively that LBS users hesitate to share their location data due to privacy concerns. Those privacy risk beliefs are even reinforced by many service providers sharing user data with third parties. SLR findings suggest different ways to share user data with third parties. Depending on the application field of the service, those interactions with third parties might be necessary.

Sharing Data Some services allow users to share details with third parties, but others do not. Sharing data **vertically** means that the user’s location details are only visible to the service provider itself. Sharing user details and their location **horizontally** means that the data is shared with other service users” [RMB16]. When LBS allow users to share their location data independently with other users, Breuer et al. classify those services as **location-sharing** services [BBRB15].

Ryschka et al. additionally distinguishes between **location-tracking** and **location-aware** services. According to him, “location-tracking services supply entities other than the user (i.e. third parties) with the user’s information about his or her location. Location-aware services, in contrast, provide a user with personal location data” [RMB16].

Moreover, service providers might rely on Trusted Third Party (TTP) when implementing privacy-protection schemes. An example for the use of third parties is centralized cloaking where a “ TTP is responsible for location cloaking/anonymization, whereas in distributed spatial cloaking, location anonymization is done by mobile nodes (users) by collaborating with one another” [SRRF23].

Nisha distinguishes privacy protection schemes into two types: “TTP -free and TTP - based” [NNGX22]. In the case of TTP - based schemes, a fully trusted third party anonymizes the user’s location by acting as an intermediary between the user and the LBS provider. Thereby, the exact location is masked among other users. TTP-free schemes, on the other hand, do not rely on a third party and instead use techniques like adding noise to the location data [NNGX22].

After analyzing the privacy perspective on Local Services, we can conclude that this chapter is an important contribution to the research question, as it offers a multi-layered taxonomy and summarizes the existing knowledge about Local Services.

5 Discussion

The findings of the SLR are now discussed with regard to the research question. The discussion is structured in three parts. First, the SLR as such is discussed. Then, the global taxonomy is interpreted, followed by a section explaining the taxonomy subcategories.

5.1 Systematic Literature Review

We start our discussion with the general results of the Systematic Literature Review.

Distribution of Topics among Papers There is an imbalance between the most popular topics in the SLR results and aspects that we consider helpful for the taxonomy of Local Services.

In the SLR findings, the understanding of location is predominantly the location as a physical area. In contrast, only a few papers extensively treat semantic and symbolic locations, and criticize mathematical approaches of locations as necessary, but not sufficient [Edw09].

Table 5.1: Popularity of topics among papers

Topics mentioned by many papers	**Topics mentioned by few papers**
Physical location, Geometrical Location, Position	Symbolic Location, Semantic Location
Proactive and Reactive LBS (Push and Pull-Type)	Embedding of Service in Location (Gestalt Theory)
Positioning Technologies (GPS, CELL-ID, WiFi)	User Pattern and Group Formation
Service Types (Emergency, Tracking, ..)	Hyperlocal Service
Techniques for Check-In (QR-Code, Bluetooth, . . .)	Charging and Billing
(Economic) Benefits for using LBS	Location Value

Analogously, “mathematical” concepts like positioning technologies with GPS or techniques for check-in with QR-Code are studied in far more paper than the role of the user context and the embedding of the service. Table 5.1 illustrates this imbalance.

In addition, table 5.2 illustrates the appearance of papers among different taxonomy categories. The points symbolize the appearance of a paper within that category. We can see that the papers in our SLR cover noticeably often the category of “technical infrastructure.” Relatively few papers cover topics like the “business model” or the “location”. We interpret these findings in the sense that “traditional” LBS topics like positioning technologies, check-in techniques like QR-Code and technologies for Geofences are predominant in the SLR literature.

Table 5.2: Paper organized with regard to appearance in Taxonomy Category

Paper	Business	Location	Infrastructure	Privacy
[AA21]	•			
[AAAA15]	•			
[Agn87]		•		
[AHK15]			•	
[AKE04]			•	
[AKH13]			•	
[BBRB15]	•		•	•
[BCM15]		•		
[BCR+10]			•	
[BKH08]			•	
[BPAH13]	•		•	
[CLH14]	•			
[Con09]		•		
[CZS+15]			•	
[DB03]	•			
[Edw09]		•		
[FFCB14]			•	
[GDPM15]			•	
[GFDT05]			•	
[GM16]			•	
[GPZK19]		•		
[GZK13]			•	
[HAS08]		•		
[HB01]	•			
[HS08]		•		
[Hua22]			•	
[HYLY22]	•			
[HZS+21]			•	
[IPMF10]	•		•	
[JJK14]			•	
[JMRD03]		•		
[Kan97]				•

Continued on next page

Table 5.2 – continued from previous page

Paper	Business	Location	Infrastructure	Privacy
[KL03]			•	
[KL09]	•			
[KPAK05]	•			
[KS10]				•
[Küp05]			•	
[LBDM03]				•
[LD09]	•			
[LD12]			•	
[Leo98]	•			
[Li06]			•	
[LPR04]			•	
[MAHP03]			•	
[MH07]			•	
[MLGL16]			•	
[MR01]		•		
[MRDA13]	•			
[MS05]				•
[MS11]			•	
[NNGX22]				•
[NTK08]			•	
[NZL+15]				•
[PK07]		•		
[PN10]		•	•	
[PW11]	•		•	
[RHS14]		•		
[Ril12]	•			
[RMB16]			•	•
[RW13]	•			•
[SM08]				•
[SRRF23]	•		•	•
[Sui10]	•			
[TN09]			•	
[TP05]			•	
[TZKL12]				•
[UAA+18]			•	
[USK13]		•		
[WCKJ14]			•	
[WHC+14]		•		
[WS05]	•	•		

Continued on next page

Table 5.2 – continued from previous page

Paper	Business	Location	Infrastructure	Privacy
[XX16]	•			
[YMII14]			•	
[YH16]			•	
[YKH+06]			•	
[YMII14]			•	
[YPPK08]			•	
[YR15]			•	
[YS10]			•	
[ZGL02]			•	
[ZH15]			•	
[Zho13]				•
[ZLWL23]			•	

Explaining the absence of a uniform definition for Local Services The results tell us that until now, Location-Based Services with a physical understanding of location are predominant in literature. In this traditional perspective and in contrast to Local Services, the (semantic) location is not of importance for the service design.

As this traditional understanding of Location-Based Services is so predominant in the findings, we do not have to wonder that Local Services and semantic locations are not even named as such but just quietly somehow and sometimes namelessly mentioned in the large group of location services.

But more recent papers tell us that the understanding of location is changing. Authors now consider more dimensions of a location, namely the symbolic and semantic ones, too. Against this background, we can expect that Local Services rise as an alternative to general Location-Based Services and their "simple" understanding of location as position.

Comprehensiveness of the findings We can consider this SLR as extensive. All in all, the SLR is conducted throughout five recognized databases: ACM, IEEE, Elsevier, SpringerLink and Elicit. The SLR takes place from December 2023 to June 2024.
A total number of 609 papers is reviewed.

Table 5.3: Discussion: Total Number SLR Results

Digital Library	Amount of Results
ACM Guide for Computer Literature	135
IEEE Xplore Database	167
Springerlink Database	135
Elsevier Database	122
Elicit Database	50

Among those 609 results, 221 matches the study selection criteria and were then systematically analyzed using the data extraction form.

Table 5.4: Discussion: Total Number Relevant SLR Results

Digital Library	Amount of Relevant Results
ACM Guide for Computer Literature	100
IEEE Xplore Database	45
Springerlink Database	31
Elsevier Database	27
Elicit Database	18

The different databases cover a variety of taxonomy categories. We can see that some data bases offer more findings in some categories than in others. For example, papers in the IEEE database focus more on technical aspects. In contrast, papers in the ACM database cover a large field, from business aspects to technological aspects to reflections on semantic insights.

5.2 Evaluation

We enter the adapted research question in the Elicit database to double-check the significance of our results gathered in the ACM, IEEE, Elsevier and SpringerLink databases. Elicit is a free AI research assistant commonly used to speed up literature research. Our main idea is that the Elicit research assistant should find the most essential resources for a topic. If we have done this SLR right, the Elicit research assistant selects the same results as we do.

Table 5.5: Analysing Elicit Results

Criterion	Amount of Results
Resource available in ACM, IEEE, Elsevier, or SpringerLink database, too	8
Resource not accessible	21
Resource accessible, but no answer to the Research Question	9
Resource accessible and relevant for the Research Question	12

Unexpectedly, the results in the Elicit Database do not match our expectations. First, a significant amount of papers is relatively old. For example, 36 out of the 50 papers are published in 2010 or before. The publication date is fine per se, but that amount of “old” papers mostly does not appear in the other databases.

In addition, many old publications do not include a link to the digital version of the article. The absence of a link means, that there is no way to access the digital article of this resource. Moreover, the University of Stuttgart does not subscribe to all of the journals linked within the Elicit results.

Consequently, even though the link to a digital resource is available in the Elicit database, members of the University of Stuttgart are not allowed to access it.

Nevertheless, a significant number of the Elicit findings is relevant to our research question. But, all those relevant findings in Elicit are already covered by the papers we selected in the ACM, IEEE, Elsevier and SpringerLink databases. In addition, the findings of this first search seem to be more recent, more accessible, and more diverse. In other words, this evaluation step confirms that the Elicit database does not generate new content for our taxonomy. On the contrary, we can evaluate our SLR as a success because it covers all critical aspects and inputs necessary for the development of the taxonomy on its own.

5.3 Taxonomy

Chapter 4 classifies the SLR findings into a taxonomy. The taxonomy is a direct answer to the research problem that queries a taxonomy of Local Services based on a Systematic Literature Review.

After describing the results in chapter 4, this discussion chapter aims to interpret and explain the results by taxonomy categories. More in detail, in each category, we discuss the following points:

- Significance and importance of the findings for answering the research question.
- How the findings contribute to the existing knowledge in the field.

5.3.1 Overview

Chapter 4 starts with an overview taxonomy showing four categories: Business Model, Location, Infrastructure and Privacy. Analogously to that overview, we start this section with a general discussion of the results before becoming more detailed about the taxonomy subcategories in the subsequent sections.

Overall Findings A recurrent finding in all databases is that even though scientific literature does not mention a consistent name or definition for what we describe as “Local Services,” the concept behind Local Services is numerously described. The main idea of Local Services appears frequently under the name of traditional “Location-Based Services,” [JMRD03]. In contrast, numerous papers describe the logic of Local Services like “hyperlocal computing” or “conceptual bookmarks” but have yet to establish themselves [HRR+08] [WHC+14].

Even though Local Services have unique features, like the exclusive availability at a specific location, some common points with traditional LBS exist. For example, both types of services use push mechanisms, and even many services can be classified as Local Service as well as LBS, like the social Game “Pokémon Go” [XX16]. In sum, huge parts of this taxonomy can be applied to Location-Based Services. Still, our taxonomy does not qualify as taxonomy for general LBS, because it has a special focus on the interconnection of service and location, which is not adequately relevant for general LBS.

Applicability between LBS and Local Services Results can be interpreted in the sense that Local Services are a subset of Location-Based Services. Even though Local Services have some unique features that are not required for LBS in general, like the restricted geographical availability, they have a lot of points in common, too.
Traditional LBS take into account the user location as an input parameter for performing location-dependent content without special requirements as to where the service has been requested from. In Local Services, user location is still taken into account. But, the requirement is that the location has to be in a specific and limited geographic area; otherwise, the user cannot access the service.

Therefore, they both work with the user location data, but the LBS use them as simple parameters. In contrast, the Local Service use it primarily to evaluate if the user is in an eligible area to request the service. Loosely speaking, each Local Service is a Location-Based Service in some sense, but not each Location-Based Service can be classified as a Local Service.

Moreover, Local Services are a category apart because the service they offer is often (but only sometimes) a traditional Location-Based Service.

We illustrate the interpretation that Local Services are (location-based) services only offered at specific locations with the following examples:

- Mobile Commerce: push notifications for marketing are a Local Service because users can only access them when they are close enough to the physical store. In addition, the service is also classified as LBS because the service provider uses the user's location to provide services [AA21].
- Information Service: museums app to navigate users with Bluetooth through the gallery and provide them with information about the artwork is a Local Service. Because Bluetooth technology is used, the information service is only available if the user is in the venue; otherwise, the signal is not strong enough. The Museums app only available at the museum classifies as LBS too, because again, it uses the user's location as a parameter to provide services like explanations to a specific painting [AA21].
- Social Services: social games like Pokémon Go are qualified as Local Services because they offer specific game features only at particular locations in the public area. Moreover, where several players gather together can be classified as the semantic location "with other Pokémon Go players." Thereby, the service is only usable at the special locations where artefacts from the game can be found and where the semantic location exists for the moment. At the same time, we consider this as an LBS because the service takes into account the location of the user to provide the service of the game [AA21][XX16].

We illustrate the interpretation that not every LBS can be classified as Local Service with the following examples:

- Navigation: routing and navigation with Google Maps is considered as LBS, as it takes into account the location data from the user to provide them with location-dependent content, like the optimal path from his current location to his home. Nevertheless, it is not considered a Local Service because the service can be used everywhere and in any context.

- Productivity: analogously, the "Uber" application can be used from everywhere and is therefore per definition not a Local Service. But it is an LBS because it uses the physical location to provide a service.

These examples show that not every LBS can be classified as a Local Service, confirming that Local Services are a subset of LBS.

5.3.2 Subcategories

When interpreting the SLR findings, we pay special attention to data that answers the research question: What could be a taxonomy for Local Services?

Business

We now discuss business-related literature from the SLR.

Service Offering The standard classification of application areas is not optimal for answering the research question. More precisely, the literature mostly focuses on classifications with the traditional and most popular LBS application fields like "Navigation," "Tracking," or "Emergency Services" [ZGL02][Sui10][PW11]. Other categories, such as social or information services, are mentioned, but only sometimes. The problem is that services like emergency or navigation applications are rarely classified as Local Services, as navigation or emergency applications are not that useful if they can only be used at a very specific and limited location.

In consequence, "Emergency," "Safety," "Routing," and "Tracking" applications are no category on their own in our Service-Offering subcategory. Moreover, our taxonomy is less dominated by these tracking and safety applications but rather balanced between commerce, social and information services. According to the literature, Local Services seem more useful for leisure time and productivity than emergency cases.

Location Value and Service Value We want to highlight the importance of "location value," as it contributes a new idea to the current knowledge on Local Services [PW11]. Location value is the value that comes from the interplay of the location and the service.

Location value describes the unique value that emerges when service and location work together. As Local Services are often deliberately created for a certain location and, therefore, improve the experience on-site, they offer mainly a location value. In contrast, services like Google Maps, available from everywhere, often create more of a service value. That service value comes directly from the service's functionality but not from the interplay with a specific location.

Local Services often provide a location value in addition to the service value. The SLR findings describe the additional, unique value generated from the interplay of location and service, and whose generation is mainly reserved for Local Services.

Incentives for Participation In contrast to many Location-Based Services (e.g. Google Maps), a Local Service cannot be consumed from everywhere. The user must come to the location where the service is available. Consequently, the service provider must offer enough incentives to draw new clients to the location.

The literature presents different incentives for Location-Based Services, but we interpret especially two as relevant for Local Services. First, economic incentives offer financial benefits (e.g. coupons, rewards) and are therefore very easy to understand and popular among users and service providers [RW13].

Another very interesting incentive is the conditional one. In this case, the incentive comes from an exterior condition. Zhang et al. say that it is the context “that prompts the use of LBS (e.g. using the services because someone did not plan a trip)” [ZM13]. Conditional incentives teach us that the incentive for using a Local Service could come from the location itself. Conditional incentives are particularly interesting for our research problem, as many Local Services work with push mechanisms that only work at the location.

Finally, we want to refer to the approach von Constantiou et al. with “reference-services” that encourages people to switch from the analogous service to the location-based one. We can interpret their findings in the sense that service providers should consider developing Local Services that are more advanced than an analogue or LBS-based “reference service”, and thereby encouraging the user to switch to the new Local Service.
Those different kind of incentives are an essential contribution to our research question, because incentives describe how service provider can encourage potential users to use the service.

Location

The importance of Location for Local Services Location can be an essential feature of a Local Service, shown in the taxonomy by giving it its own category. The importance of the location for this SLR and taxonomy reflects the differences between Local Services and general Location-Based Services. Unlike Local Services, LBS are traditionally not so strongly tied to a specific location.

Semantic Location We must highlight the importance of SLR findings studying semantic locations. In contrast to a space (physical location), the personal and individual connections of the user with the area are paramount in this approach [Agn87]. In short, a simple position is turned into a place by offering a valuable/emotional service.

The semantic definition of a location is an essential contribution to the concept of Local Services. It allows us to see locations not just as fixed areas but also as dynamic environments and places experienced and interpreted by the user [Edw09]. This interpretation allows locations to be dynamic and varying, depending on how the user makes sense of the location. An example of this is the semantic location “being with Bob.” The idea is to relate a place to the encounters that take their place or to particular attendances. For example, being able to describe a location as “being the only source of water in a desert” is a unique feature of semantic locations [Edw09].

The contribution of the semantic location to the research problem consists in the reminder, that taxonomies about Local Services should consider alternative definitions of a location. Because when the service is closely linked to the location, the service provider should be aware of the personal and individual connections of the user with the area and integrate them into the service [Agn87].

In addition, the innovative approach of Gestalt Theory contributes to how one can systematically develop a strategy for integrating such user contexts into the service.

Gestalt Theory Approach Another important finding is the perspective of Gestalt Theory on Local Services. Gestalt Theory emphasizes the importance of the user context and how users perceive the interplay between the location and the service. Gestalt Theory offers service designers a strategy for systematically analyzing the connection between service and its location [PK07]. We must highlight this approach, as mentioned in only one paper. It still offers a perfect strategy that formalizes the reflections on user context and the semantic perspective on a location. All in all, we evaluate this approach as really innovative and powerful.

Infrastructure

Proactive and reactive services As a reminder, pull- and push-type help categorize Local Services because the notification type changes the functionalities and experiences a Local Service can offer. Based on the context in which a Local Service is provided, the provider should decide between a proactive or reactive type or a mix of both.
By interpreting the literature, proactive services are very useful when people are not sensible to small signs or alerts, such as concerts or crowded events. Local services that need to catch the user's attention quickly should employ proactive services.
In contrast, reactive services, where the user has to seek out the service actively, are better for situations where users want to control when and how they get information, like finding details at a museum or checking stock in a store.
Both types are an important contribution to the field of Local Services because they offer different ways to engage with users based on their needs and situations.

Positioning Technologies The SLR findings show an interconnection between positioning technologies and the characteristics of Local Services exists. The interconnection is because certain functionalities and service locations are better suited to specific positioning technologies than others. For example, GPS technologies are effective for outdoor services but not for indoor environments [PN10]. In contrast, indoor services mostly use mobile networks or WiFi for positioning [PN10]. Consequently, it is evident that Local Services should be classified into indoor and outdoor services. In addition, some services require very high-accuracy positioning, whereas others only need medium accuracy [ZGL02]. For example, GPS delivers accurate results in rural areas, whereas mobile network technologies are more accurate in urban environments [ZGL02].
All in all, the choice for or against a positioning technology not only classifies the type of Local Service but also hints at its functionalities.

Diverse User Interface We already interpreted the findings regarding proactive and reactive services as important because they allow us to get the user's attention differently, depending on the current situation at the location.

Literature even mentions how to adapt a service for different kinds of users. More precisely, they say it is important to design a user interface that can react to different user needs.
For example, using various types of interfaces, like voice commands, can help make services more accessible. Voice interfaces are especially useful for older users or when people are in situations where their hands are busy, such as when they are exploring a location.

Privacy

Attacks According to our interpretation of the findings, trajectory attacks are particularly dangerous for Local Services.
Trajectory refers to the sequence of locations that a user visits. A trajectory attack thereby uses a person's movement patterns to obtain its data [SRRF23]. As a consequence, those attacks use especially the semantic information from the location to retrieve personal data. As Local Services are closely linked to the semantic meaning of the location where they are available, this type of attack should be particularly considered when developing those services. Nevertheless, continuous and snapshot query attacks are also important contributions to this work because each of these approaches target the user's location.

Data Collection and Information Type A great deal has been written and said about privacy risks in the findings. Many papers discussed different types of attacks against Location-Based Services, but only one paper mentions the fact that "location data are considered to represent a distinct class that requires increased protection and special procedures" [RMB16]. Only Ryschka et al. emphasize the importance of the "Privacy" category not only from a cyber-risk perspective but also from a legal perspective, which is often neglected in computer scientific papers.

Moreover, only a few articles criticize the fact that users often need more control over data management. In other words, services often do not offer more granular approaches than the "all-or-nothing approach" [RW13]. Some authors criticize that users are not able to "block location tracking temporally for ongoing services" [RMB16].

Those findings are an important contribution to our taxonomy because they underline that privacy does not only mean protection against attacks but also how many rights the service provider gives the user to control its level of data disclosure.

Notably, among the results, there is a significant amount of papers about privacy risks in Location-Based Services. Due to time limitations, we only reviewed some of the papers in the privacy category. In consequence, the privacy aspect of Local Services could be an interesting topic for future research.

All in all, we can answer the research question about how to create a taxonomy for Local Services based on an SLR as follows:

- Several databases are needed for the SLR to provide a comprehensive picture of Local Services. For example, the ACM database provides reflections about semantic insights, SpringerLink offers information on location aspects, and IEEE contributes material on business and technological interfaces.
- Including diverse categories is important. As Local Services combine location and service aspects, the taxonomy should reflect that interdisciplinary reflection, which is even more important as this work is a first fundamental research on Local Services.
- The taxonomy has to take into account that Local Services can be considered as a subset of Location-Based Services.
- Although the idea behind Local Services appears in scientific literature, it has not been consistently defined or named before. This work is a first try, to provide a clear definition and taxonomy for this phenomenon and is, thereby, an essential and unique contribution to the field.
- While the mathematical approach to Location-Based Services is predominant in literature, the interest in Local Services and the meaning of locations for services is growing.

6 Conclusion and Outlook

This Systematic Literature Review on Local Services is important for several reasons. It covers key databases, examines about 600 studies, and extracts data from 200 papers. The extensive coverage ensures a broad understanding of the topic.

In conclusion, this research contributes significantly to the current literature by precisely defining Local Services and presenting its concept through a new taxonomy. In chapter 2 and 5, we define Local Services as a subset of Location-Based Services only offered at specific locations. Furthermore, we expect Local Services to become increasingly important as literature focuses more on local context and location semantics. Overall, our work directly addresses a research gap in literature and is, for this reason, an important contribution to the research field.

Second, this research is unique because it is among the first to apply a Systematic Literature Review of Local Services. Given that Local Services have not been extensively studied, using an SLR is particularly appropriate and valuable for summarizing and organizing the existing knowledge. The results of the SLR are presented in chapter 4.

Third, this work introduces a multi-layered taxonomy of Local Services, reflecting the various, existing perspectives in literature on Local Services. Again, this well-structured and easily understandable representation of Local Services in the shape of a taxonomy is particularly appropriate to sum up the current knowledge of this little-studied topic.

Overall, this research offers a clear and useful framework for understanding Local Services, making it a valuable contribution to the scientific field of Local Services. The value of our contribution is even confirmed with the evaluation step in chapter 5. Comparing the results from our first search to those in the Elicit database emphasizes that our SLR covers all important aspects of the taxonomy on its own, without the need for the input of the artificial intelligence database. In conclusion, our search string, study selection strategy and data extraction form led to a valuable Systematic Literature Review and an essential contribution to the scientific field of Local Services.

While this work is significant, it has some weaknesses that must be addressed.

6.1 Limitations

Due to the time requirements of this bachelor thesis, it is impossible to conduct the SLR and particularly the data extraction with two researchers, as requested by Kitchenham. Kitchenham says that if only some of the papers may be read by all the researchers, then at least all primary papers should be assessed by at least two researchers [KC07]. The fact that this SLR is conducted by only one researcher, can be considered as weakness.

In addition we have to point out that a significant amount of studies within the SLR results is not accessible. Consequently, this thesis might be influenced by the available literature and potentially overlook unpublished works. The fact that this work is neglecting less accessible research can be considered as another weakness.

These limitations hint at the fact that future research is required.

6.2 Outlook

Due to the general literature findings and limitations mentioned above, we can conclude some points for future research.

First, the SLR results are characterized by the frequent appearance of privacy risks and cyber-security issues. We conclude that privacy aspects of Local Services need more in-depth study in the future. In addition, many papers deal with user acceptance of Location-Based Services. They try to identify the factors that increase consumers' acceptance of the technology. As mentioned, privacy risk beliefs tend to reduce the user's willingness to continue using a service. Until now, all reviewed studies on user acceptance are studying general Location-Based Services. It would be interesting if the factors for increasing user acceptance for Local Services are the same as for LBS. Because Local Services are attached to a very specific location, people might have higher privacy risk beliefs. The higher privacy risk beliefs might come from the fact that when checking in at a location, users already share a "fairly precise indicator of their physical location" [RW13]. In other words, utilizing a Local Service always reveals to potential attackers the exact location and time the user was present. In contrast, with general Location-Based Services, it is difficult to pinpoint a group of users and a location where many individuals are using the same service simultaneously. Future studies could include experiments with test persons that evaluate different Local Services regarding the perceived ease of use, usefulness, and privacy risk beliefs.

Another hint for future research is the absence of real-world Local Services examples in scientific literature. Currently, only grey literature, such as blogs or informal sources, analyzes real-world examples of these services. Even though this SLR did not exclude grey literature, the latter did not appear in the databases. Therefore, by doing an SLR only on scientific databases, there is no possibility of extensively analyzing real-world examples. Nevertheless, it would be valuable to identify "best practice" examples of real-world Local Services and then analyze them concerning the here-developed taxonomy. This research gap between white and grey literature could be closed by an SLR that analyzes grey literature to the same extent that this work analyses scientific databases. In sum, this discrepancy between white and grey literature illustrates the research gap on Local Services, too.

In addition, future research should consider following Kitchenham's recommendations and conducting Systematic Literature Reviews with a group of researchers. Allocating several researchers to the next SLR on Local Services, allow analyzing even more databases and grey literature, leading to a better understanding of the empirical phenomenon of Local Services in scientific literature.
Despite its limits, this work emphasizes the importance of Local Services and presents a valuable framework for further scientific research on Local Services.

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All links were last followed on August 9, 2024.