International Cartographic Association
Association Cartographique Internationale

Taxonomy of Trust in Location-Based-Services (LBS) – Providing trustworthy information with better maps and data

Jukka M. Krisp [a,*]

[a] *Jukka M. Krisp, jukka.krisp@geo.uni-augsburg.de*
* Corresponding author

Keywords: Location Based Services, LBS, Spatial Data Quality, Trust, Cartography

Abstract:

The availability of fast mobile broadband is growing in many countries, enhancing access to the internet via both mobile and fixed connections. Mobile broadband enables users to access maps and services on their devices, thanks to the integration of Global Navigation Satellite System (GNSS) receivers. These receivers allow to display the user's current position, while mobile broadband facilitates the use of Location-Based Services (LBS) such as navigation and local information. This connectivity empowers users to access spatial information at any time and from any location. Combined with advancements in information and communications technology (ICT), this trend has spurred the development of numerous innovative applications. Nevertheless, using Location Based Services (LBS) can be a frustrating experience. Why is that? A concept that might be closely connected the usefulness of Location-Based-Services is *trust*. Trust is defined by the belief or confidence in the reliability, integrity, ability, or character of someone or something. It is the expectation that they will act in a consistent, fair, and honest manner, fostering a sense of security in interactions or decisions. How does this relate to maps used in Location-Based-Services?

In the realm of Location-Based Services, tailored maps play a crucial role. Maps are often used as background visuals or tools for specific services, such as routing and wayfinding. Frequently, these maps are implemented using standard map interface APIs, with Google Maps being one of the most popular options. The distinctive layout of Google Maps has gained such widespread acceptance that it has become a "quasi-standard" for map displays on smartphones and tablets. However, many app developers, such as those behind mobile games like "Pokémon GO" or "Ingress" and routing applications, tend to focus on their app's functionalities while paying less attention to map design. Consequently, there is a growing need to enhance Location-Based Services by creating trustworthy maps tailored to the specific application and context of use. This includes following established guidelines for designing maps for mobile devices, which take into account small screen sizes, limited interaction capabilities, technical constraints, and user contexts.

Best practices in cartographic communication on small screens have been the focus of extensive research. One significant concern is preventing information overload, which can occur when excessive details lead to overlapping symbols and labels, rendering the map unreadable. Addressing these challenges is essential for ensuring effective and user-friendly map displays on compact devices. Emerging technologies, such as smartwatches, are increasingly being used to visualize maps. As a result, we anticipate a growing variety of technical systems, including diverse data formats, alongside an expanding range of devices like wearables (e.g., smartwatches and glasses). When it comes to cartographic content presentation, this could lead to the development of platform-specific systems specialized for particular devices, as well as more universal or web-based systems that cater to multiple media types. Different devices process content and interactivity uniquely, necessitating adaptable solutions, such as maps that scale information appropriately.

Do we trust the information for a specific location displayed on the device? Accurate and truthful communication of location-based service information presents another challenge. Many services rely on data streams, as seen for example with weather information provided on smartphones and smartwatches. However, discrepancies between the user's actual location and the location data processed from the stream can result in inaccurate information being displayed on these "smart" devices.

As one example, figure 1a shows an example of weather information indicating "unhealthy air quality". This information is completely arbitrary, as the index showing (an odd) "42" is not explained. There is no information on the spatial extent of this information. This picture is taken on a normal day in the city of Düsseldorf with no unusual official reading on particularly unhealthy air quality. Additionally, an example of the Withings scale (Figure 1b), measuring your weight, and apart from that providing information about the local air quality. The position is acquired via the rough

Abstracts of the International Cartographic Association, 10, 157, 2025
32nd International Cartographic Conference (ICC 2025), 17–22 August 2025, Vancouver, Canada.
https://doi.org/10.5194/ica-abs-10-157-2025

estimation of the IP address, still the information is very vague and inaccurate. This seems to be a good example of a “superfluous LBS services”.

a. Smartwatch (Apple, 2019) including an LBS service, indicating "unhealthy" air quality in Düsseldorf, Germany; measured with a number of “42 (unhealthy)”, which meaning remains unclear.

b. Example of a scale (Withings 2025) including an LBS service, indicating low air quality on a perfectly healthy winter day, with apparently very good air quality.

Figure 1. – Examples of arbitrary (unnecessary) LBS services

Inaccurate information on location-based services can create navigation challenges, disrupt emergency responses, and affect business visibility. It undermines the concept of *trust* in these services. It may lead to inefficiencies in operations, delivery delays, and increased fuel use. Users might experience inconvenience, missed opportunities, or stress. Regular updates, user feedback, and improved verification methods help maintain the accuracy and reliability of these services.

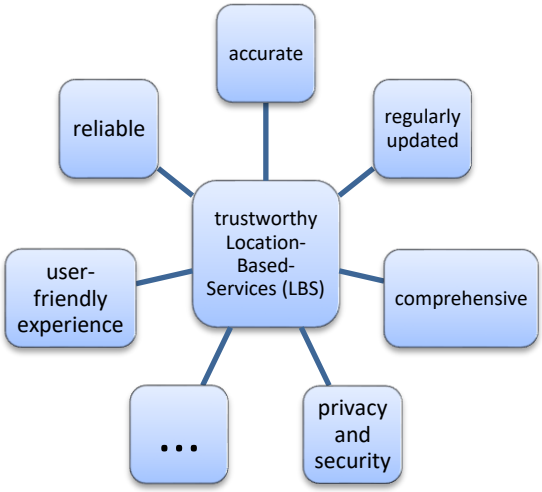

Figure 2. Taxonomy of concepts leading to more trustworthy Location-Based-Services (LBS)

Trust in Location-Based Services (LBS) refers to user confidence in the accuracy, reliability, and security of the maps (and data) provided. Delivering better maps and information builds this trust by ensuring data is accurate, regularly updated, comprehensive, and responsive to user feedback. Prioritizing privacy and security further enhances trust, creating a reliable and user-friendly experience. Figure 2 illustrates the idea of this taxonomy leading to more trustworthy location-bases services needs to be extended and verified. Challenges to this approach might come from the increasing use of artificially generated data. Large language models (LLMs) or other artificial intelligence (AI) system may provide geographic information. In many cases such systems are “black boxes”, meaning they provide irreproducible data. This might pose a challenge towards the concept of trust. Will we increasingly rely and place our *trust* in location-based-services that provide their services based on information from a “black box”?

Abstracts of the International Cartographic Association, 10, 157, 2025
32nd International Cartographic Conference (ICC 2025), 17–22 August 2025, Vancouver, Canada.
https://doi.org/10.5194/ica-abs-10-157-2025