Tourism Mobile and Recommendation Systems - A State of the Art

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Abstract - *Recommendation systems have been growing in number for the last fifteen years. To evolve and adapt to the demands of the actual society, many paradigms emerged giving birth to even more paradigms and hybrid approaches. Mobile devices have also been under an incredible growth rate in every business area, and there are already lots of mobile based systems to assist tourists. This explosive growth gave birth to different mobile applications, each having their own advantages and disadvantages. Since recommendation and mobile systems might as well be integrated, this work intends to present the current state of the art in tourism mobile and recommendation systems, as well as to state their advantages and disadvantages.*

Keywords: Decision Support Systems, e-Tourism, Recommendation Systems, Mobile Systems, Knowledge Management

1 Introduction

Where to go and what to do, in the limited amount of time available, are common problems encountered by tourists when visiting a city for the first time. In effect, cities are large information spaces, and in order to navigate these spaces visitors often require numerous guide books and maps that provide large amounts of information. Häubl and Dellaert [1] state that this can be both a blessing and a curse. Although the amount of information allows tourists to select more appropriate points of interest, it also turns the process so complex that the tourist might not be able to assimilate all this information adequately. A recommendation system helps the tourist narrow the universe of choice, giving results according to the tourist preferences. Also, the system is able to process much more information and points of interest than the tourist could possibly do.

The recommendation system interaction with the tourist is also of utmost importance. When the tourist interacts with the system, every taken action has meaning and can be used to complete the tourist profile. Nowadays, most systems build the tourist profile implicitly and/or use forms to request feedback. This is mostly possible through the use of mobile devices that travel along with the tourist, providing context-aware and location-aware information.

2 Concepts and Evolution

2.1 Mobile Systems

Mobile devices are pocket-sized computing devices which popularity is growing day by day. Since they are small, simple and becoming relatively cheap, it's easy to carry them around and use them in all kinds of environments. These devices have wireless network capability that allows the device to connect to the internet, even with the low speed connections that networks on the go usually permit. Power consumption is also an issue, because batteries still don't provide the desired amounts of energy without the need to constantly recharge. Because of its portability, mobile devices are ideal to create an integrated system to assist the tourist in effectively planning a trip to an unknown city, and also to help the tourist when he or she arrives to the desired destination (country, city or region).

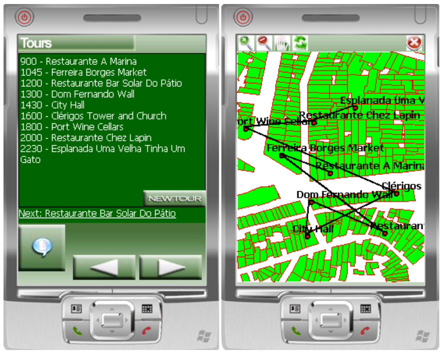

Figure 1. A mobile tourist guide application.

Tourists certainly appreciate to have a quite simple tool to assist them in planning their staying, according to their objectives, preferences, knowledge, budget and staying period, instead of having to look for guide prospects/bulletins which sometimes can be quite confusing [2]. This happens since the number of tourism-related services in the Web grows every day, offering hotels, flights, tickets and information of all sorts.

Some major issues in offering mobile services to nomadic users are the limited display size, resolution and networking capacity of mobile devices. This last issue heavily affects the way the mobile application communicates with a central service.

In a tourism information system, it might be necessary to plan routes and to show information about sights. With a good networking capacity, the system could perform the intelligent integration of information from different data sources and services. This includes geographical information systems, multi-media databases, and interactive internet data sources such as reservation systems.

Thus, the question if people would like to use computers as a replacement to the traditional books, maps and tourist guides splits the tourists into two groups: traditionalists, who want to stick with classical paperwork, and experimentalists, who like to try out new technologies.

A question remains. Why does the second group still not use mobile devices? The answer is simple: there are not, yet, the right IT systems available. Personal Digital Assistants (PDAs) only now are becoming powerful enough, and Laptops are not practical since wireless networks are too slow in some regions. Only now, PDAs come with an integrated GPS that is very useful to retrieve contextual information and provide location-aware services.

A tourist that uses a system like this expects location-aware information about the destination domain, including history, culture, folk, art, economics, environment and nature. Advanced tourists also expect individualized information and services, taking into account their own interests and their history of activities and information [3].

A tourist with his mobile device (or with a specific tourism guide mobile system) can retrieve information via SMS, MMS or WAP/Web. Over the last years, these technologies have become more and more advanced, and the data transfer rates are rapidly increasing. GPRS (General Packet Radio Services), for instance, was the first to appear and has a low data transfer rate (of approximately 40 Kbps). In the year of 2000, UMTS (Universal Mobile Telecommunications System) appears with a data rate of approximately 220 Kbps, finally providing good enough speed to support a system like this and to confirm its potential.

After UMTS, the HSDPA (High-Speed Downlink Packet Access) appears with a typical performance of 750 kbps. Although the data transfer rates are higher, the coverage area is smaller. Although these technologies are used in a global scope, there are also indoor specific technologies (e.g. Wi-Fi and Bluetooth) that usually outperform them. While they have better performance, they cannot usually be implemented outdoors and limit the application context to indoor specific sights. Also, places with rules not allowing the use of mobile devices to avoid noise, can render the application obsolete.

2.2 Recommendation systems

As the World Wide Web evolved into an incredible huge mass of distributed information, recommendation systems emerged as an option to minimize the time consuming task of searching the Web. Although the concept is not new, the classical pure techniques have been subject to great research efforts and evolved into different hybrid techniques.

The way the recommendation systems interact with the user is very important. Retrieving feedback from the user is time consuming, thus leading the user to avoid submitting feedback forms. Transparency might also be important to some users, as they want to know why they are receiving certain recommendations. The right transparency helps the recommendation system getting higher trust levels from its users.

The initial amount of data when the recommendation system first runs is also a big issue. Since recommendations are usually based on already existing data (e.g. user profiles and choice history), systems need to tackle this issue so they don't suffer from the cold start problem. Latest implementations begin to use ontologies, thus empowering the recommendation system with rich semantics.

Although many derived approaches are emerging, recommendation systems are mostly based in three different paradigms: content-based, collaborative and knowledge-based. The content-based paradigm applies to systems that rely on item information to retrieve recommendations. This means that item attributes and ratings are used to see what best fits the user needs. On the other hand, collaborative systems compare similar users to provide recommendations. The knowledge-based paradigm tends to tackle the content-based and collaborative systems weaknesses and problems. Through the use of ontologies (or case-based rules) a reasoning process is performed, allowing the user to incrementally specify her or his needs, thus improving the recommendation results. Since pure recommendation systems contain multiple weaknesses that can usually be tackled by merging different paradigms, hybrid systems have become the current popular choice that shines especially when the system needs to deal with highly heterogeneous information. A hybrid approach can involve all three recommendation paradigms.

Some systems implement profile learning techniques that halt the system to run the learning process. However, most techniques use a lazy learning approach through which the system can update the model while making recommendations, thus having no offline period. Information filtering methods often include content-based, collaborative, demographic or knowledge-based filtering. The following table contains the main characteristics of the information filtering methods previously described.

Table 1. Information filtering methods characteristics.

Content Based	**Collaborative Filtering**	**Demographic Filtering**	**Knowledge Based**
Similarity	Similarity	Stereotypes using	Rely on an

between items characteristics and user preferences.	between users.	demographic information.	explicit representation of knowledge (e.g. *ontologies*).
Suffers from *cold start* and *over specialization*.	Suffers from the *cold start* and the *gray sheep* problems.	Useful when combined with other filtering methods.	Can benefit from machine learning and semantics.

According to Berka and Plößnig [4], travel recommender systems can be quite difficult to develop since they need to deal with a great range of rich and heterogeneous information. As each one of the information filtering methods deals with different kinds of information, hybrid approaches are very well suited to tourism recommendation systems.

3 State of the art

A tourist companion, or mobile device application, provides important services to guide the tourist along its travel. On the other hand, recommendation systems allow the tourist to plan and select an appropriate route and set of points of interest. Although these systems can be (and should be) integrated, very little approaches integrate both systems.

TIP [5] and Heracles [6] provide recommendation services through mobile devices for tourism. These services implement hybrid algorithms to calculate tourist preferences, using the defined tourist profile and location data (location-aware).

Proximo [7] is a location-aware mobile and recommendation system that fits the pure paradigm approach. It guides users through tours within buildings using Java and Bluetooth technologies. The mobile device also tracks the user location and builds a context, providing the system with important information. The user position is taken by “sniffing out” the fixed Bluetooth devices or low-cost beacons deployed in the area of use. This room-level accuracy means improved precision and is accurate enough for a certain class of trail-based applications such as a tour guide. The mapping service on the mobile displays a map of the intended area of use which can be manipulated in a variety of ways. Also, the application constantly monitors the user location and displays the active areas of the building (the area the user is in) accordingly. Since this is an indoor application, Quigley and Parle conducted tests under a gallery context at the University College Dublin School of Computer Science and Informatics building, where the system was able to guide users through a gallery, and provide recommendations using ratings to paintings from similar users. The Proximo pure collaborative recommendation system relies on its user’s item ratings to provide recommendations. As long as an item doesn’t have its first rating, it cannot be recommended. Also, user profiles are built using interaction data from the user’s mobile device. This data is processed through a weighted nearest neighbors algorithm, leading to the construction of the user profile.

The TLTIS [8] (Travel, Leisure and Tourism Information Service), intends to provide adaptive tourist maps and 3D visualization of buildings and sights. Using location-aware information, the system is able to adapt the presented 3D map and object representation according to the tourist culture and weather condition. Also, the tourist special needs and physiological limitations are evaluated using a tourist profile.

One of the issues that the TLTIS system tackled regarding adaptation is the cultural aspect. Since different cultures, make different interpretations of symbols and colors, maps need to be rendered according to those interpretations. These kinds of systems highly rely on user interaction, thus needing cultural and social research.

Although TLTIS is not a mobile information system and does not contain explicit recommendation capabilities, its features and characteristics can be exploited by both tourism mobile and recommendation systems.

3.1 Mobile systems

More and more people combine several purposes with travelling, such as business, leisure, entertainment, and education. Such people may not have time to pre-plan a travel schedule in detail. They need location-aware information about the destination domain and expect individualized information and services.

There are systems that only display information about sights, like MultiMundus. MultiMundus [9] primary goal is to provide multimedia information (texts, images, cards, audio and video sequences) of a sight to the tourist on his personal mobile device. With this content it can provide moderated audio guides for travel groups, automatic detection of the tourist physical position on the map, and presentation of the sight closest to him.

The GeoNotes [10] system tries to blur the boundary between physical and digital space (ubiquitous computing and augmented reality). At the same time, it strives to socially enhance digital space (collaborative filtering, social navigation, etc.) by allowing users to participate in the creation of the information space. GeoNotes is a location-based information system that allows the user to access information in relation to the user’s position in geographical space. With this mobile application, tourists can retrieve notes regarding their current location. These notes are introduced by other tourists that visit the same place, thus leaving their own geo-referenced notes.

MacauMap [11] is a tourism-oriented mobile GIS application for the city of Macau that features map navigation displaying the user current location. It also provides information about the public bus network and bus guides for calculating optimal bus routes. MacauMap also provides sightseeing guides with information about museums, churches, temples, hotels, restaurants and other places of interest, along with their location on the map.

etPlanner [12] is a mobile planning assistant, that allows the creation of personalized tourism stays. Using a mobile device (e.g. a PDA or mobile phone) the costumer's stay is intelligently planned. This way the user can be assisted before, during and after his journey. The system is not only able to react in real-time to special destination offers, but also to relevant occurrences like flight delays or weather adversities.

The personal mobile assistant mobiDENK [13] has been developed for a tour to the Herrenhausen Gardens in Hanover and includes points of interest on which historical information and images of the most significant features are presented on a PDA. It focuses on drawing the user’s attention to historic sites and provides location-based multimedia information at different sightseeing spots while displaying the person’s current location on a map.

AccessSights [14] is a subproject of mobiDENK, and is intended to provide tourist information to both normally sighted users and visually impaired people traveling in the Gardens. Normally sighted users will make use of both senses to obtain information and may simply follow a guide map, while blind people listen to information. The system uses loudness in order to point out the distance between the user’s current location and point of interests, by simply making the voice signal get louder as the user comes closer to the point. A mobile chase and location-aware game is included, which challenges its players to find a set of geo-referenced checkpoints by solving associated hypermedia riddles. The checkpoints are proximity-aware, exploiting the player’s location. After the riddle is solved, the player physically moves on to another checkpoint indicated on the map. The paper chase game has also been enhanced by auditory support, to provide the players with weakly intrusive navigation and orientation support.

Tourist Guide [15] is a location based tourist guide application for the outdoor environment and it was developed for visitors to the Mawson Lakes campus (of the University of South Australia) and the North Terrace precinct in the Adelaide city center. The user interacts with the system using a PDA that displays his current position along with detailed information about specific nearby points of interest (a self guided tour of a specific area) like buildings, attractions and nearby utilities such as public telephones and toilets. This system can be operated in three different modes: Map mode, which shows the user's current position on the map and the nearby attractions; Guide mode, which supplies the user with a map showing a tour of related attractions; and Attraction mode, which provides textual and multimedia information about a sight.

Mobile recommender systems based on profiles have the potential to substantially enrich tourist experiences. As their handling marks a big challenge for ordinary users, its acceptance can only be evaluated when utilized by the intended user group itself - real tourists. One of them was the m-ToGuide [16] project. This project is targeted for the European tourism market and offers location-specific multimedia information about major monuments and points of interest. A portable, handheld terminal is used to exchange information between the m-ToGuide system and the tourist. All information and services delivered to the tourist will be relevant to his/her specific location (location-based) and tailored to that end-user's personal profile. To evaluate m-ToGuides potential, a trial project was implemented and tested with an on-the-go ticketing facility that allows tourists to make bookings and reservations directly from the terminal via GPRS. The m-ToGuide experience can be personalized to give tourists direct access to the information and services they prefer. The trial results indicated that the system was useful but the charged prices were not well accepted by users.

The TIP (Tourist Information Provider) system [5] was created to provide sight related information to the users. This system provides not only sight information but also gives recommendations regarding nearby sights, which match the user preferences. The whole system has a database which contains user profiles, user context, sights context, travel history as well as user feedback given to visited sighs. The user interacts with the system through a handheld device (e.g. PDA or mobile phone), defining his profile (like the type of sights he’s interested in) and giving his current location. Subsequently, the system recommends the sights to visit.

The GUIDE [17] project has been developed to provide the Lancaster, U.K., city visitors up-to-dated and context-aware hypermedia information while they explore the city. Visitors view this information through a Fujitsu TeamPad 7600 hand-held device. This unit is equipped with an 802.11 wireless networking card. To back up the device, several 802.11 base stations have been installed all over the place. In GUIDE, the adaptive hypermedia presented to visitors is tailored to both environmental context (the major attractions in the city) and the visitor’s personal context, where he can produce a customized tour of the city so he can explore it in his own way. Examples of the personal context used to drive the adaptation process include the visitor’s current location, the visitor’s profile (that is, the visitor’s interests), and the set of attractions already visited. Other features include the possibility of making reservations for dinner in a restaurant and sending messages to other users, or to the staff of the tourist information center.

CRUMPET [3] provides new information delivery services for a far more heterogeneous tourist population. The services proposed by CRUMPET take advantage of integrating four key emerging technology domains and applying them to the tourism domain: location-aware services, personalized user interaction, seamlessly accessible multi-media mobile communication, and smart component-based middleware or ‘smartware’ that uses Multi-Agent Technology. This system provides location-based and personalized information and services. The system learns more about the user’s preferences while he’s traveling and interacting with the system itself. If, for instance, the user has visited a certain number of parks, perhaps he’d also be interested in other parks.

Cyberguide [18] was developed at the Georgia Institute of Technology (GIT), Atlanta, USA. It is based on the ubiquitous computing concept and focuses on mobile context-aware tour guide. The system was designed to assist a visitor in a tour to the GIT, and helps the user obtaining information about the demos in display. Knowledge of the user’s current location, as well as a history of past locations are used to provide more of the kind of services that we come to expect from a real tour guide. The system is currently only being used indoors through infrared beacons, but in the future it is expected that the system will work outdoors using GPS. One of the downsides is that the system has very limited tourist information and recommendation capabilities.

CATIS [19] is a context-aware tourist information system with a Web service-based architecture. The context elements considered to this project are location, time of day, speed, direction of travel and personal preferences. This system will provide the user with relevant information according to his location and the current time. For example, if the user is traveling at noon, a simple integration of the time context, the location and respective user preferences for restaurants, will result on a list with restaurants to lunch.

Deep Map [20] realizes the vision of a future tourist guidance system that works as a mobile guide and as a web-based planning tool. Deep Map is a mobile system that aids tourists with navigating through the city of Heidelberg by generating personal guided tours. Such a tour shall consider personal interests and needs, social and cultural backgrounds (e.g. age, education and gender), type of transportation (e.g. car, foot, bike or wheelchair) and other circumstances from season, weather and traffic conditions, to time and financial resources. The core of Deep Map is a typical geographical information system (GIS).

The following table contains some comparison factors between the presented tourist mobile systems. Although they all have guiding capabilities, there are other factors that distinguish them well. This table is divided into seven functional requirements.

Table 2. User model component acquisition techniques.

	FR1	FR2	FR3	FR4	FR5	FR 6
MultiMundus	-	+	-	-	-	+
GeoNotes	-	+	+	-	+	+
DeepMap	+	+	+	-	-	-
Proximo	+	+	+	-	+	+/-
CATIS	+	+	+	-	+	+
MacauMap	-	+	+	-	-	-
etPlanner	+	+	-	+	-	+
mToGuide	+	+	+	+	-	+
TIP	+	+	+	-	+	+
Tourist Guide	-	+	-	-	-	-
Guide	+	+	+	+	+	-
CRUMPET	+	+	+	-	+	+
Cyberguide	+	+	-	-	+	+/-
mobiDENK	-	+	+	-	-	-

Tour recommendation (FR1) defines the system capabilities to recommend a personalized tour based on the tourist profile.

Sightseeing guide information (FR2) defines if the system is able to deliver location and context-aware information.

User profiles and information filtering (FR3) describes systems that support personalized information delivery. The user preferences have to be defined and stored, and the information provided to the users is to be filtered according to their profiles.

Booking (FR4) defines the capability to book a restaurant, a hotel and so on.

Personalized recommendations based on history (FR5) states if the system should recommend sights that match the user profile, travel history, current position or other similar users.

Domain of the system (FR6) describes if the system works anywhere (indoors and outdoors), and not only in a specific structured environment.

3.2 Recommendation systems

Recommendations can be given for multiple, vast concepts and different areas of knowledge. There are already a many implemented systems that provide highly content-based recommendations. While highly content-based systems might not need a profile learning process, tourism recommendation systems must have effective profile learning techniques implemented to be valuable through time.

Triplehop's TripMatcher and VacationCoach's Me-Print [21] are web-based recommendation systems that use the content-based approach, but also implement features to tackle the weaknesses of a pure content-based recommendation system. Me-Print uses a mechanism to group new tourists, so it can fill the information gaps. On the other hand, TripMatcher has a more complex way of matching similar tourists using statistics and computed predictions based on past travels and similar profiles.

DieToRecs [21] is also a web-based tourism recommendation system. It uses case-based reasoning (that may be a particular case of a knowledge-based paradigm) to provide recommendations which are obtained using tourist profiles and contextual information. The system provides two types of recommendations: single travel items and complete travel bags. Many single travel items (e.g. hotels, destinations, activities) form travel bags. This way DieToRecs can also allow the users to build their own travel bags by choosing preferred travel items.

Intending to simulate the process of interaction between current physical travel agents and the tourist DieToRecs implements algorithms to learn through interaction. Also, it uses a hybrid paradigm that takes advantage of both content-based and collaborative filtering approaches, while having the learning capabilities of a regular case-based system.

Hinze and Junmanee [22] also proposed a hybrid recommendation model for TIP. Their model is based on the three recommendation paradigms: content-based recommendation, collaborative filtering and knowledge-based recommendation. This hybrid model solves most of the problems for which pure models lack the solution. Especially in an area which deals with very rich information like tourism.

The main problems tackled by the TIP recommendation model are the cold start issue, the gray sheep individuals and over specialization. The cold start issue that happens when there is a lack of feedback information (associated to pure collaborative filtering approaches) is solved, since any user can be supported even without giving feedback. Also, gray sheep cases (tourists that don't fit in any group profile) are diminished. This happens because the system does not rely only on the user feedback information to recommend. Over specialization is another of the issues that this model pretends to eliminate. Since tourists don't want to be provided with the same recommendation over and over, the recommendation system widens the possible point of interest universe, helping tourists discover new interesting points of interest.

The proposed recommendation system by Casali, Godo and Sierra [23], uses graded BDI agents to deal with uncertainty and graded mental attitudes. Based on previously created tourism packages, the BDI model relies on the agent's beliefs (B), desires (D) and intentions (I). Using this model, the system calculates a preference level used to recommend the most suitable packages. Also, the ontology used allows the system to analyze every destination point described in the package, so although the system cannot propose a dynamically generated set of destinations, all package destinations are used to measure the tourist preference level.

In his work, Knoblock [6] used a set of software agents to retrieve travel information from the web. The tour planner, called Heracles, uses real-time collected data from the software agents to provide recommendations. Since it is constraint-based, the tourist needs to specify the desired criterion. This system does not recommend the conventional points of interest, but rater recommends a travel route along with choices of flights, hotels, ground transportations, and others.

The Heracles tour planner is based on online information to provide recommendations, and allows two possible ways of submitting recommendation requests: through supervised machine learning techniques, and through unsupervised grammar induction. Although the first can achieve high levels of accuracy, it requires a significant amount of user input data. On the other hand the unsupervised grammar induction does not need additional data, but the accuracy rate can be low.

Table 3. User Model Component Acquisition Techniques.

	Content	Collab.	Demog.	Knowledge
Proximo	-	+	-	-
TripleM.	+	-	-	-
Me-Print	+	-	-	-
DieToRec	+	+	-	+
TIP	+	+	-	+
gBDI	+/-	+/-	-	+
Heracles	+	+/-	-	+

TM (*TripleMatcher*), MP (*Me-Print*), DTR (*DieToRecs*), (+/-) means more information is needed.

Table 3 contains general information about each of the recommendation systems previously described. Table 4 describes the used information filtering methods, usually matching the implementation paradigm.

Table 4. Systems comparison

	Paradigm	Use Case	Rec. Res.
Proximo	Collaborative Filtering	Mobile Device (Indoor Items)	Items
TripleM.	Extended Content-Based	Web (Holiday Destinations)	Pre-Created Packages
Me-Print	Extended Content-Based	Web (Holiday Destinations)	Pre-Created Packages
DieToRec	Hybrid (Case-Based)	Web (Outdoor Destinations; Travel Bags)	Dynamically Generated Plans
TIP	Hybrid	Mobile Device (Outdoor Sights)	Dynamically Generated Plans
gBDI	Knowledge-Based	Web (Argentinean Destination Packages)	Pre-Created Packages
Heracles	Hybrid (Software Agents)	Web (Outdoor Destinations; Environment; Transportation)	Routes along with Points of Interest.

4 Conclusions

In recommendation systems, adaptation is very important. The implementation of agents capable to learn and improve, that acquire information from tourist interaction and feedback might as well be one of the best approaches. Transparency is also an issue when providing recommendation, since for many users, knowing how the recommendation is given is an important factor to trigger trust.

A tour simulation might help improve the final given recommendation, either being through simulating the tour and presenting reports or by allowing the tourist to previously see the tour points of interest using a 3D application.

The 3D representation of points of interest can present the tourist with an incredible level of detailed information. Although some communities that tend to create a virtual world parallel to what we know as reality are emerging, the virtual representation of objects like points of interest can be quite difficult. It not only deals with great amounts of visual information, but also with constant change. The slight change in the point of interest structure and the virtual representation might be rendered obsolete.

The heterogeneity of the described systems shows that there are many ways to improve recommendations. Trying to extract all their qualities and combine them into a single recommendation system reveals to be a challenge. This happens not only due to the high complexity resulting from this kind of system, but also because it can turn out to be a double-edged sword, that ends up providing inaccurate results or high performance drops.

Besides the desired recommendations, when a traveler goes on vacations, he would appreciate to have a quite simple tool in his pocket (e.g. in his mobile device) that can assist him in planning his staying. At the moment, several applications exist to do this, but they are very basic and don’t have a solid implementation to be used in the real world.

Some real tests have been done to some of these applications, and they have proved the utility of those systems, providing tourists with more knowledge about sights than if they had a simple map and/or prospects/bulletins. Tourists with this type of applications are able to dig more information on a sight, only with a simple click.

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