



TrailTrade: A model for trail-aware commerce support



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ABSTRACT

Context-aware applications adapt their functionalities based on users' profiles and their current contexts. Complementarily, a trail is the history of the contexts visited by a user. Trails enable applications to explore the users' past behavior. In this sense, trail awareness is considered an evolution of the context awareness, because applications explore an additional and more complete information source. This article proposes a model for trail-aware commerce support, called TrailTrade. The model uses the dealers' profiles, contexts and trails to find deal opportunities and promote business transactions. Dealers may be people or companies offering and/or looking for something. TrailTrade supports the trade in goods and the exchange or sale of experience or knowledge. The model was implemented including an indoor location system and a deal assistant on mobile devices. The prototype was installed in a real environment and used to simulate a city composed of houses, a metro and a mall. This environment allowed a practical application in a scenario. This test evaluated the TrailTrade's functionalities, mainly its trail awareness support. The results were encouraging and show potential for applying TrailTrade in real situations, fostering negotiations through the past behavior of dealers.

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1. Introduction

The evolution of mobile devices and high-speed wireless networks has stimulated researches related to *mobile computing* [1–3]. In addition, the improvement and proliferation of *location systems* [4,5] have motivated the use of precise location to provide *location-based services* [6–9]. Beyond the location, additional information related to users and their contexts allow *context-aware computing* [10–12]. Based on contexts, *adaptive applications* [13] can modify their behavior to better support the users' needs.

Today, context-aware applications allow personalized services through users' profiles and their current contexts [14,15]. However, recent researches on adaptive applications indicate the relevance of consider the users' past actions in visited contexts [16,17] to make decisions. These actions can be applications used, contents accessed and business transactions conducted. This approach improves the adaptive services, because they use the history of users' actions, rather than only their current contexts and profiles. The past contexts are referred to as *contexts histories* [18] or, in a

short way, *trails* [19–21]. Dey et al. [10] briefly described the importance of using trails in the decision making process. Therefore, in this article *trail awareness* is considered an evolution of the *context awareness*. So, *trail-aware applications* are considered more capable than *context-aware applications* to make decisions and help the users in their purposes.

Context-aware computing has been applied in several areas, such as, education [14,15,21], logistics [17], health [22], competence management [23] and commerce [24]. *Context-aware commerce* [25–27] applications manage contextualized deal opportunities and, in the same way that occurs in any context-aware application, the decisions consider only the dealers' profiles and contexts. Applications dedicated to *pervasive/ubiquitous commerce* [24,28–38] also have the same restriction. Deal discovery guided by the dealers' trails is still an open research area. So, this article proposes TrailTrade, a model to explore trails to find and promote deal opportunities.

The article is organized as follows. Section 2 discusses works in two research areas, namely *trails management* and *context-aware/pervasive/ubiquitous commerce*. In particular, the section highlights the scientific contribution of TrailTrade. The third section describes the model, with an emphasis on its architecture and strategy to support the trail awareness. Sections 4 and 5 address the aspects of

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implementation and evaluation. Finally, Section 6 presents final remarks and directions for future research.

2. Related works

This section revises background concepts and discusses related works. Two strategic topics are addressed, namely *trails management* and *context-aware/pervasive/ubiquitous commerce*. This literature review shows that TrailTrade is the first model of trail-aware commerce.

2.1. Trails management

Applications based on past contexts need to store them for further use. Sometimes, *contexts history* [18,39] is called *trail* [19–21]. Bush [40] was the first researcher which employed the term trail to represent a history. Life logging [41–43] uses trails to enhance human memory through records of conversations, documents, location information, photos, audios, e-mails and videos, and many other types of personal and environmental data [44].

Trails management consists of techniques to store and use trails. Trails contain strategic information that can be used in advanced applications, such as recommendation systems [39], profile management [16] and prediction systems [45]. Trails can be used to personalize services and contents according to users' previous choices [18,46]. Typically, the application is based on well-defined domain representation through an ontology [18,20] or an entity-relationship model [46]. The domain definition facilitates queries and reasoning to discover users' preferences based on their past actions (trails).

The literature review did not find any work addressing trail management or trail-awareness in the commerce domain. However, generic models for trails management which can be applied in any domain were found [18,20,41]. Trail-aware systems are based on trails management. Therefore, the generic models found support TrailTrade development. Life annotation [41] proposes the annotation of the places visited by users of mobile devices, thereby composing their trails. However, Life annotation [41] does not standardize trails information, which makes it difficult to query them. Hong et al. [18] proposes a mechanism to store trails based on an ontology. However, the work focuses only on techniques to take decisions. In addition, the proposal does not support the creation of services to query the trails. UbiTrail [20] uses an ontology to standardize the trails storage. Furthermore, the model has a mechanism that supports the creation of query

services for trails. Thus, UbiTrail was chosen for trails management in TrailTrade.

2.2. Context-aware and pervasive/ubiquitous commerce

The use of mobile devices and pervasive/ubiquitous technologies [47–49] to support commerce is commonly classified as *context-aware commerce* [25–27] or *pervasive/ubiquitous commerce* [24,28–38]. Galanxhi-Janaqi and Nah [35] and Roussos et al. [36] show that *u-commerce* is based on the infrastructure and experience of e-commerce and m-commerce. U-commerce often involves the electronic identification of physical products and seamless provisioning of business and consumer services in ubiquitous computing infrastructures [47–49]. Gershman [37] indicates as prerequisites for the success of u-commerce: (1) always be connected with clients; (2) always be aware of clients' contexts (where they are, what they are doing and what is available around them); and (3) always be proactive, identifying real-time opportunities to meet client needs.

Some proposals focus on commerce in goods. iGrocer [30] is a smart assistant to aid clients in the purchase process in supermarkets. iGrocer uses consumers' nutritional profiles to suggest the purchase of products or even warn about items that should be avoided. This is particularly practical for elderly people or those who need help to follow a specific diet. iGrocer also identifies the desired products through barcode, and gives the user the nutritional information. In order to suggest products for the consumer, the assistant also combines the client's nutritional profile with a database of nutritional information. MyGrocer [33] is similar to iGrocer [30]. However, MyGrocer emphasizes the stock control of products in food-related businesses and households. MyGrocer uses sensors on the shelves and elsewhere to indicate the available quantity of a product, warning when something is missing or finishing. Lin et al. [28] propose a generic architecture called the Pervasive Activity Manager (PAM). PAM assists clients through complementary product information to help decision about buying an item. PAM uses services provided by the stores, malls, or even other customers.

Other proposals focus on the services market. EPARK [29] assists clients and employees in the parking management process. Some of the features are display parking maps, book a parking space, and extend the booking time for a parking space. UTAS [38] uses a mobile device to assist tourists in situations where language is an obstacle. In addition, the system warns about delayed or canceled flights, obstructed roads, and restaurant or concert bookings. MUCS [24] uses the ubiquitous computing technologies to identify business opportunities. The system proposes a generic

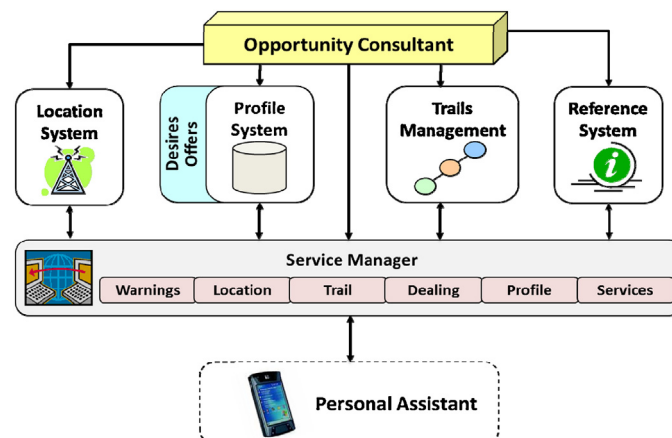


Fig. 1. The TrailTrade architecture.

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