

Show me the way: proximity layered feedback services in smart cities

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Abstract—The advent of Bluetooth Low Energy (Bluetooth LE) technology and its native implementation within the main smartphone manufacturers is accelerating the integration of these sensors in smart cities. Bluetooth LE beacons are being novelty used to provide proximity-adapted feedback in the field of shopping, access control, and home entertainment. However, the potential of this technology for learning purposes is unexplored. This manuscript gives an overview of previous work where proximity and feedback have been tackled. The proximity layered feedback model is presented as an approach to provide suitable ambient feedback services in smart learning cities. An ecology of pilots is described as an instantiation of this model in potential learning scenarios to stimulate discussion. Finally, further research is introduced.

Keywords: ibeacons, NFC, feedback, ambient displays, lifelong learning

1. Introduction

Situated learning [1] stress the importance of knowledge and skill acquisition in the same context in which they need to be performed; leading also to the concept of communities of practice [2]. Several authors have stressed the difference between a simulated environment and authentic experiences in the physical world [3, 4]. Learning in the city is directly bound to sustainable learning and the intrinsic motivation from lifelong learners to make the best of their time by learning from the opportunities available in daily life environments. Smartphones facilitate the exploration of cities following predefined field trips [5], or by authoring new ones [6].

In contrast to regular cities, smart cities can be equipped with sensors with the aim to provide adapted feedback services for lifelong learners. Hence, technology and feedback must be smoothly embedded in daily life activities with the aim to provide adapted learning opportunities. The results of the literature review from Börner et al. on Ambient Displays for Learning (ADL) expose that the explicit use of ADLs is not a prominent research topic, although implicitly ambient displays are already used to support learning activities fostering situational awareness by exploiting feedback [7]. Recently, Hattie [8] classified types of feedback according to: 1) *who is providing the feedback information?*; 2) *how is the information provided?*; 3) *what level of information is provided?*; 4) *what is the question that is being addressed or what is the*

purpose of feedback information?. Previously, Hattie [9] stated that every feedback instance must answer to the following questions: *where am I going?*; *how am I going?*; *where to go next?*.

Herby we present the Proximity Layered Feedback (PLF) model (Fig. 1) that aims at giving adapted feedback services on ambient learning displays based on the proximity measure provided by the Bluetooth LE beacons (Fig. 3) and NFC tags (Fig. 4). Additionally, we will present a ecology of recently developed smart artefacts at the Technology Enhanced Lab of the Open University of The Netherlands (OUNL) (Fig.2) to promote discussion and to instantiate this model in real use case scenarios.

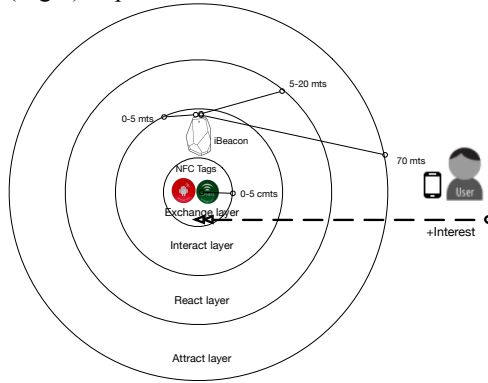


Fig. 1. Proximity Layered Feedback

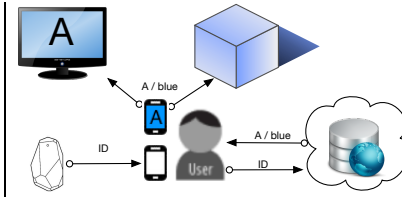


Fig. 2. Ecology of resources in the PLF



Fig. 3 Beacons

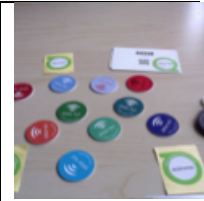


Fig. 4. NFC tags

2. Related work

Starting from the interactional perspective Michellis & Müller [10] derived their audience funnel framework after deploying and observing a public display installation. The framework is based on attention indicators and allows modelling the interaction between displays and their audience. The possible interaction is covered in six different phases. These phases are passing-by, viewing and reacting, subtle interaction, direct interaction, multiple interactions, and follow-up actions. The authors also discussed means to overcome the thresholds between the phases. Specifically they proposed to raise attention to reach the second phase, arouse curiosity to reach the third phase, and further motivate the audience to reach the other phases. Finally the authors suggested that public displays need to be balanced right to capture attention without annoying the audience and that the design should allow an effortless transition from one phase to the next in line with a shift from implicit to more explicit interaction modalities.

As an extension of the audience funnel framework, Wang et al. [11] presented the peddler framework. The framework does not only model distinct interaction states, but continuously captures and reacts upon the user's interest and attention state. Based on this information the framework adapts the display content and tries to attract, re-

tain, and if necessary reacquire attention. Targeting on advertisers the framework rests upon the AIDA model [12] a basic strategy from advertising and marketing: attract attention, maintain interest, create desire, and lead customers to action. Consequently Wang et al. [13] also implemented a prototype of a public advertising display based on their framework with the goal “to lead the [user] into a more attentive stage, ideally resulting in a purchase.” To do so a product animation tries to attract the attention from persons passing by the display. The prototype captures persons in front of the display, including their position and orientation relative to the display. Whenever a person starts to look at the display the animation is slowed down. The appearance of personalised product recommendations then reflects the subtle interaction phase, followed by a direct interaction phase where the person is allowed to explore product details (and purchase the product). The display also reacts when a person loses interest, either by starting to animate the product or showing different products. Discussing the prototype the authors highlighted once more the importance of choosing an appropriate design that allows drawing the user attention in a subtle and unobtrusive way, depending on the context of use. They concluded that for an effective attention-aware display design, the effort invested into shifting between the periphery and the focus of attention should not outweigh the importance of the presented information in relation to the primary task or activity.

3. The Proximity Layered Feedback (PLF) model

This model aims to describe what kind of feedback services are more suited according to “*how is the information provided?*” and “*what level of information is provided?*” [8] based on the proximity of the user to the feedback source. With this focus in mind the PLF model identifies four different levels of proximity:

1. Attract layer. 70 to 20 meters distance. Aimed at providing feedback to call the attention of the learner.
2. React layer. 20 to 5 meters distance. Aimed at providing feedback to arise an specific interest from the learner
3. Interact layer. 5 to 0 meters. Aimed at providing direct feedback to the learner.
4. Exchange layer. 5 to 0 centimetres. Aimed at gathering information that is exchanged between the learner and the feedback source.

The PLF model will not only describe feedback given in those layers, but also the one provided when approaching (*Where am I going? How am I going?* [9]) or moving away from the source (*Where do I go next?* [9]) in the transitions from one layer to the other.

4. An ecology of resources in the PLF model

The proposed ecology of resources comprise the following devices:

- Beacons (Fig 3.). Bluetooth LE beacons are being increasingly used in malls to provide proximity-adapted feedback for shopping purposes. Analogously, these

devices could be used in field trips to enrich the city with information (architecture, biology etc.), or to identify risky points within the city (due to pollution, frequented by thieves, etc.), or, guiding routes (bureaucracy procedures, tourist routes, running routes, etc.). Beacon manufacturers are offering open APIs¹ the extension of these devices to further fields.

- NFC Tags (Fig. 4-5). Recent work [14] reviews the potentials of Near field communication in formal learning scenarios. Here we propose to extend its functionality to be integrated within informal scenarios in the city.
- Ambient displays. The Feedback Cube is enriched with sensors (accelerometer, gyroscope, hall sensor, mic.) and provides visual and audio feedback. Figure 6 illustrates how the Feedback Cube lights a different colour based on users learning performance during the week (estimated time VS invested time).
- Smartphones are progressively equipped with more sensors like NFC readers or Bluetooth LE. The work from Tabuenca et al. describes how the 3LHub APP² can be used to identify learning patterns within daily life spaces [15]. Additionally 3LHub features video playlist streaming on HDMI enabled display based on the NFC tag that is tapped [16] with the smartphone.

Figure 2 illustrates how the resources in this ecology can be combined to provide proximity-adapted feedback. As the user approaches to the beacon, the app queries the cloud-based database to determine which is the feedback that better fits the current proximity (letter: A, color=blue). As a consequence the background of the mobile APP and the ambient monitor turn blue, display the letter A, and the Feedback Cube lights the colour blue and plays the audio titled “A”.



Fig 5. 3LHub Digital Media Player [16]

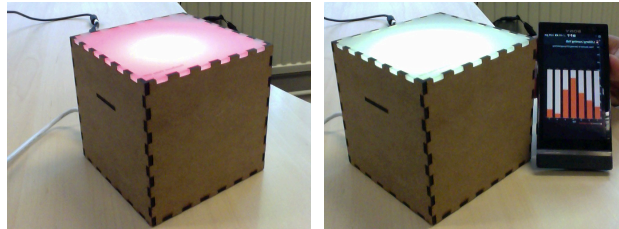


Figure 6. Feedback cube & 3LHub [17] (a) Low learning performance during the week. b) High learning performance

5. Conclusions & future work

This manuscript presents the PLF model and a set of prototypes developed at the TEL lab of the OUNL with the aim to promote debate and brainstorming on the potential uses in smart city learning scenarios. In future work, we will make use of these prototypes for further research on effective feedback services for lifelong learners in smart

¹ Estimote Beacons API: <http://estimote.com/api/>

² Lifelong Learning Hub APP. <https://sites.google.com/site/lifelonglearninghubproject/>

cities. Additionally, we will evaluate these prototypes in real case scenarios in order to gain insight on how to facilitate non-intrusive interactions towards learning.

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