Demo: Location-Specific Public Broadcasts

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ABSTRACT

This demonstration presents the Location-Specific Public Broadcast system, in which localization and wireless broadcasts are combined to deliver a scalable, privacy preserving, and generic solution to location-based services. Other interactive location-based systems either preload information on the user devices, which are usually bulky, difficult to update and have to be custom-made for each venue, or fetch information from cloud based on location, which sacrifices user privacy. In our system, a wireless access point continuously broadcasts information tagged by locations of interest, and the mobile devices performing passive localization select and display the information pertinent to themselves. In this case, the location-specific information is stored only on the WiFi AP, and the phone app would be ultra lightweight with only the location calculation and information filtering functionalities, which can be used in any space. We envision our solution being adopted in public places, such as museums, aquariums, etc., for location-specific information delivery purposes, like enhancing interactive experience for visitors.

1 INTRODUCTION

Localization has been long-thought of as a technology that can enable personalized tour-guide apps in public spaces such as museums, libraries, aquariums, etc. Whereas localization itself has matured significantly over the years, the mechanisms of information delivery for this class of applications have remained under-explored. Just knowing a user's location does not solve the problem of sending the right information to the user's device. The most typical approach is to have all the information preloaded into a bulky mobile application and only display the appropriate fraction of the information according to user location. However, building such applications for every indoor space is quite expensive and faces the hindrance that users do not wish to download a different app [5] for every public space they visit. In this work, we ask: *Can we create a single generic application that can function as a personalized tour guide in any space?*

The key requirements from an indoor tour-guide system are as follows:

(1) The indoor space's administrators should have full control over what data is shared with the visitors.
(2) The administrators must also have advisory control over which content is viewed by the users at which locations inside the indoor space.
(3) Visitors to the indoor space must get access to the data without logging into any service, just as anyone can read information displayed next to a museum artifact.
(4) The number of visitors in the indoor space should have no bearing on the system's performance.
(5) The application used by the user should be generic and lightweight, with data cached only temporarily.
(6) No internet access should be assumed or required.

Nowadays, it might seem that accessing information through Internet is the most apparent approach. However, accessing content over the Internet has privacy implications. It is quite possible that visitors might not want to disclose their interests in certain art pieces (in museums), in certain topics (in libraries), or might not even wish to disclose their previous visits to certain buildings. When information kept on the cloud is accessed, unique IP addresses and other identity revealing information might be exposed to the cloud. We wish to enable a truly public broadcast and therefore the requirements listed above are important goals.

The core idea in this work is to instrument public spaces with a wireless broadcast infrastructure. It continuously broadcasts information about all points-of-interest in the vicinity, but the information is tagged by its own location. A mobile device using a generic app filters the broadcast information based on the device's own location and only presents information pertinent to the user's location. This way, all information is stored in one centralized location in control of the building's administrator, and can be altered or replaced easily and in real-time, for example, in a museum, change or replacement of exhibits could be needed. The system is infinitely scalable since the infrastructure only broadcasts information, and therefore is not affected by the number of visitors. The system is fully privacy preserving since the user's mobile phone accessing the information does not transmit its location or make any request for content. Fig. 1 depicts the overall functioning of the system.

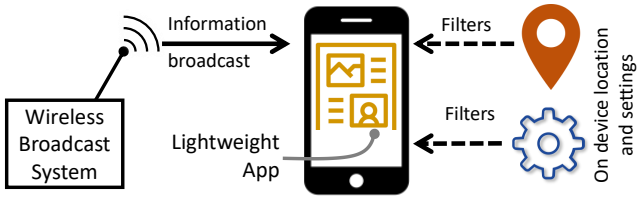

Figure 1: A light-weight app resides on the mobile phone. Information is fed from the wireless broadcast system and filtered on the mobile phone, based on location.

2 DESIGN

The broadcasting system transmits all its intended messages in a cyclic fashion. The mobile app only uses some of these messages based on the user's location and other settings. The app is also expected to cache information pertaining to locations nearby to

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reduce latency of displaying information to a user as they move into a new location. Given the human navigation speeds, which are much slower (order of seconds) than wireless packet transmissions (order of milliseconds), the wireless broadcast might easily cycle through all information before the user moves far enough that un-cached information is required by the app. The impact of this system on the app design is noteworthy. A single application will be globally suitable and the broadcast wireless packet format can be standardized. As a result, public spaces can freely modify their content without having to constantly update the app for their visitors. The app itself can be kept extremely light-weight—it can just embody user-interface templates and obtain the relevant content from the wireless broadcasts. Functionalities like filtering content based on the user's reading level or age can also be built into the application.

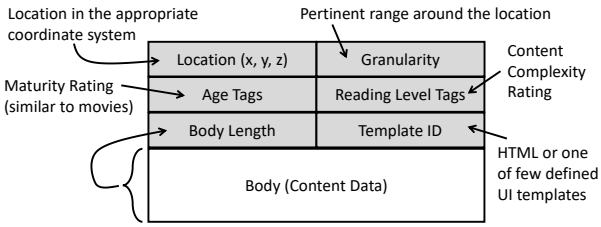

Figure 2: An application level protocol to enable unidirectional broadcast information flow that contains sufficient information for rendering content on the mobile application.

To enable a location-aware broadcast infrastructure, localization and communication would have to work together, yet communication and location are not coupled; meaning, localization is not assumed to be a by-product of communication. The application on the user's mobile phone can receive its location through any localization mechanism including GPS (for outdoors), or WiFi-FTM or UWB localization (for indoors, such as in a museum). Of course, we assume the central broadcaster knows the locations in the same coordinate frame of reference as the users' devices.

Figure 3: (a) Example templates used by the mobile application. Allows the broadcast system to specify how content will be rendered on the users' devices. (b) Mobile phone equipped with UWB.

Including location information in Wi-Fi broadcasts is an application layer construct. We propose an application protocol that involves control data specific to the mobile application. In particular, the application frame (see Fig. 2) includes details about the location and the range within which this data is relevant, tags about the age appropriateness and reading level of the content, meta-data selecting a particular layout template on the mobile application, and the data itself (called body). The layout template allows the broadcast infrastructure to decide the formatting and layout of visual elements on the user's device (see Fig. 3). Alternatively, a full HTML style browser can be enabled with all graphical content embedded into the HTML body in base64 format to function without the typical GET requests (which cannot be performed in broadcasts). The mobile device would typically display the contents that pertain to the location of the user. However, since all information is broadcast, the mobile device can also cache information about nearby locations. This allows the mobile phone to quickly display new information when the user moves to a different location (such as wandering in a museum), without any perceivable delay. Additionally, the mobile application can also implement a "near-me" functionality where it can provide a sneak preview of interesting spots near-by, to help the user decide where they would like to go next.

3 RELATED WORK

Localization based personalized information to visitors at museums and other such public spaces [1–4, 6] has existed for long, however, as far as we know, all previous attempts have either loaded the information on the device and then selectively displayed it based on location, or transmitted the pertinent information from a beacon like device [1, 6]. This is the first work to explore a broadcast of information while the filter of the information lies with the user's device.

4 DEMONSTRATION

We demonstrate the capabilities of our system in an art gallery setting using our customized UWB anchors and various mobile phones equipped with UWB tags as the localization solution. A Raspberry Pi with WiFi adapter serves as the broadcaster AP, which continuously broadcasts information of exhibited art pieces tagged with their locations. The client application filters, caches, and displays information of the nearest art piece based on the user's current location. Since most mobile phones ignore broadcasts when not associated with an AP, in our demo the mobile phones will be associated with the broadcaster AP, but will not transmit any packets once associated. This limitation gives away users' presence, but still protects their privacy of location and interests.

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