Ontologies for Tracking Ubiquitous Interest

Terry Payne, Matthiew Sharifi and Roxana Belecheanu
Intelligence, Agents, Multimedia
School of Electronics and Computer Science
University of Southampton, UK
{trp, mns203, rab2}@ecs.soton.ac.uk

Abstract

Within a ubiquitous environment, intelligent displays can select the most appropriate material depending on factors such as the audience's preferences and diversity of interest. In addition, such intelligent displays should adapt according to how the audience responds. To do this, they need to determine the composition of the audience, in terms of numbers and diversity of interest. This can affect the choice of video clip shown, by taking into consideration the number of people in the local region, and the preferences of the individuals in that region. In this paper we introduce *BluScreen*, an agent-oriented market-place that uses ubiquitous wireless technology to determine an audience composition as part of the bidding process, and present an ontology that is used to describe the wireless devices (used to identify and track users) within the local region of a display.

1 Introduction

Access to an individual's preferences and interests has been one of the key challenges of mobile e-commece research [Sadeh, 2002]. By understanding the tasks an individual typically engages in, their preferences when performing the task, and context, autonomous agents can proactively provide relevant assistance. However, one of the major challenges in developing user profiles that can facilitate intelligent assistance is that of eliciting the preferences and typical behavior in an unobtrusive manor, though inference based on observable samples. For example, an adaptive calendar agent may monitor typical filing or deletion actions on incoming email, and then seek to automate this process based on a set of rules learned from a history of user actions.

The prevalence of small, wireless devices (such as phones and PDAs) provides a richer environment for capturing preferences and providing mobile assistance [Sadeh, 2002], where behavior can be inferred from context-based applications presented through the device, using medium-range wireless technologies such as 802.11 (WiFi). Short-range wireless technologies such as Bluetooth facilitate personal area networks, where devices communicate with peers within a localized space (typically 2-3 meters). By associating a primary device with a user (for example, a user's phone), this localization can be used to identify physical co-location with other users, or with other devices and applications. This paper introduces *BluScreen*, and illustrates how collocation can be captured within a semantically rich framework, and how such collocations can provide interest cues regarding *BluScreen* activities. The ontology used to represent devices and device collocations is then presented.

2 *BluScreen* & The Network Device Ontology

BluScreen is an agent-based advertising framework which displays advertising material on public screens based on provided or inferred preference profiles. An advert is represented by an agent that periodically participates in a market-based auction [Bothe et al., 2004], where the winner subsequently wins the right to temporarily display the advert. Various factors affect the auction and the way in which an agent may participate, including audience composition and combined preference, associated meta-data provided with the advert, and previous behavior (in terms of interest, presentation time and presentation location).

Each display is equipped with a Bluetooth sensor application that identifies Bluetooth-enabled devices[1] in the local environment, and records the encounter as a collocation event (encoded in OWL), in terms of location and duration. The duration of this collocation event is assumed to relate to a possible level of interest in the displayed material; for example, a user who is interested in the current advertising material will linger at the display during the advert, and thus this sustained presence may be identified and used to reward the advert (thus improving its chances of being reselected for display by the agent-based market place). Basic user preferences may be inferred by relating several of these events with the corresponding advertising material over a longer time period, shared between several displays.

The ontology used to describe device collocations was developed in OWL-DL using Protégé, and consists of four disjoint classes: *Connection_Session*, *Device*, *Net-*

[1] Only Bluetooth devices in discovery mode are detectable.

work_Adaptor, and *Networked_Location*. This division separates the concept of events, devices, network components, and locations respectively. The ontology has been designed to model a Bluetooth detection device ("sniffer"), which can relate to some physical location (over a given duration) through a network session, and also detect bluetooth discovery events with other Bluetooth-enabled devices.

The *Connection_Session* class provides a superclass for all session-based instances, and defines exactly one start session time and at most one end session time (the absence of an end session time indicates a current session). Two disjoint subclasses of events are defined, a *Network_Session* and a *Bluetooth_Discovery_Event*. A *Network_Session* defines a session during which a single *Network_Adapter* is connected to a single *Network_Provider_Device,* and includes several constraints that characterize the session, including having exactly one IP address and subnet mask. This class is divided into disjoint *Wired_Networked_Session* and *Wireless_Network_Session* subclasses, where the *Network_Provider Device* must be either a *Wired_router* or a *Wireless_access_point* respectively (specified by universal quantification in each case). *Bluetooth_Discovery_Events* define collocation events, whereby a *Bluetooth_Sniffer* detects a single *Bluetooth_Enabled_Device*.

A *Device* is a generic device that may have an owner, a name, and zero or more *Network_Adapters*, where each *Network_Adapter* provides the capability of being connected to a network. An instance of a *Device* may also be characterized as either a *Bluetooth_Enabled_Device* or a *Network_Provider_Device* (or both). In addition, any device that has at least one *Network_Adaptor* is also characterized as a *Networked_Device*. A *Bluetooth_Enabled_Device* must have at least one unique Bluetooth MAC identifier, and may participate in *Bluetooth_Discovery_Events*. A *Bluetooth_Sniffer* is a subclass of a *Bluetooth_Enabled_Device,* which is responsible for detecting *Bluetooth_Discovery_Events*. A *Network_Provider_Device* is a device which has a physical location that provides network access, and which belongs to a subnet. The identification of the subnet facilitates the grouping together of several provider devices connected to the same subnet (e.g. a university school or department). Two subclasses of *Network_Provider_Device* exist; that of a *Wired_Router*, and a *Wireless_Access_Point* (of which the latter also has a unique WiFi MAC identifier).

A *Network_Adapter* is a component that may be built into, or connected to a *Device*, and that provides network capability (when connected to a *Network_Provider_Device*). A *Network_Adapter* is used by at most one *Device*; it has a single unique MAC identifier; but can participate in zero or more *Network_Session*s. Two disjoint subclasses have been defined: a *Wired_ethernet* adaptor, and a *Wireless_adapter*.

The *Networked_Location* class provides a simple mechanism for referring to some location that has at least one *Network_Provider_Devices*. This class should be extended or related to other ontologies to link to existing locations (e.g. office or work spaces, or transient, event-based locations, such as venues used for a specific conference).

Instances are not defined centrally, but are described and published in various locations, and may be accompanied by addition assertions relating to other ontologies (e.g. FOAF or Dublin Core). Typically, an organization or organized event would provide assertions about a *Networked_Loaction* and the *Network_Provider_Devices* that exist within that location. The device owners may also publish details about *Bluetooth_Enabled_Devices*; additional assertions about inferred advert preferences may be published. A Bluetooth Sensor application runs continuously on a *Bluetooth_Sniffer* and records details about: 1) any *Network_Adapters* associated with the device; 2) current and past *Network_Sessions*; 3) a list of all encountered *Bluetooth_Enabled_Devices*; and 4) current and past *Bluetooth_Discovery_Events*. These assertions are then retrieved and used to reason about current *Bluetooth_Discovery_Events* (i.e. those with no end session time) detected by a specific *Bluetooth_Sniffer* which is attached to a given *BluScreen* display.

3 Discussion

Whilst this ontology provides a rich description of networked devices, further development on meta-data to support advertisements is necessary, and is currently under development. To date, one *BluScreen* has been deployed, and has been used to gather *Bluetooth_Discovery_Events*. In addition, two further *Bluetooth_Sniffer* devices have been deployed to generate additional events, to support related work on Familiar Strangers [Lawrence et al, 2004], whereby users may occupy adjacent physical spaces at the same time. These assertions are being used to explore methods for identifying communities of individuals that share implicit common behaviors, but that may not explicitly define stronger associations though ontologies such as FOAF.

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References

[Bothe et al., 2004] S. M. Bohte, E. Gerding and H. La Poutre, Market-Based Recommendation: Agents that Compete for Consumer Attention. *ACM Transactions on Internet Technology*, Vol. 4, No. 4, November 2004, Pages 420–448.

[Lawrence et al., 2005], J. Lawrence, T. R.. Payne, and D. De Roure, Communities of Collocation. *UK UbiNet Workshop*, Bath, UK, 2005.

[Sadeh, 2002] N. M. Sadeh, M-Commerce: Technologies, Services, and Business Models. John Whiley & Sons Inc, New York, NY, USA, 2002.