A MINIMALLY INTRUSIVE WIRELESS SOLUTION FOR CONTEXT- AND SERVICE AWARENESS ENABLEMENT IN MOBILE COMMUNICATIONS

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Abstract: A wireless solution for context- and service-awareness in mobile communications is the theme of this paper. Respecting mobile users' desire for minimal intrusion of unsolicited advertisements, here we show how the novel push-advertisement technology and medium of 'wireless billboard channels' (WBCs) could be employed by service providers to broadcast advertisements of their wireless services to mobile terminals. While the word 'billboard' here seems to hint at in-your-face intrusiveness, in fact the service functions in the background in a near-transparent un-intrusive manner to the user. When combined with user-driven, dynamic, smart user-profile functionality, inclusive of smart optimisation of current user's 'always best connected and best served' (ABC&S) policies, the system has the potential to provide an effective, pro-active, wireless-based, context-aware and service-aware infrastructure.

The exposition here includes detailed descriptions of the WBC concept, its associated advertisement, discovery and association (ADA) functionality, full technical details of the WBC advertisement service description techniques, formats and attributes, and operational aspects, such as the WBC bit stream structure. It also includes discussion of algorithmic approaches towards optimising smart user profile functionality on mobile terminal which will drive the ABC&S decision-making in ways matched especially to the user needs, in particular those schemes utilising Personalised Information Retrieval (PIR) systems.

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1 INTRODUCTION

Wireless billboard channels (WBCs) originated as a foundational infrastructural component in the recently proposed Ubiquitous Consumer Wireless World (UCWW), (O'Droma, 2007) & (O'Droma, 2010), with the main role of direct-to-user push-based advertisement, discovery and association (ADA) service for wireless access network providers (ANPs) and application service providers (ASPs) promoting use of their networks and services, (Flynn, 2007). Through the WBC-ADA service, mobile users, as consumers, may discover the 'best' services and associate with them following a user-driven 'always best connected and best served' (ABC&S) paradigm, (O'Droma, 2006). The physical radio characteristics of WBCs include them being narrowband, unidirectional, point-to-multipoint (P2MP) broadcast channels. They could be created in a number of different stand-alone infrastructures, but for various reasons, economic as well as technological, it would be better that they are integrated into existing wireless broadcast infrastructures, such as a digital television or digital radio broadcast platform.

The WBC service advertisement concept has the attractive advantage of being non-intrusive service advertisement vehicle and infrastructure. This contrasts with the current approach of cellular operators and service providers seeking to attract roaming travellers to use their networks and services by intrusive unsolicited SMS text message advertisements. It is a phenomenon, for example, experienced by many on turning on their mobile phone on arrival in the airport of a new country. While it is of the nature of being a consumer to want to get best value and thus to want to know about competing prices and services, and to have the freedom to choose among them, usually this SMS promotional bombardment does not serve this need in a reasonably informative way. Another growth area of these intrusive unsolicited SMS advertisements is location-based services and other such like services on offer in the area of the mobile user's present location.

The WBC-ADA service described in this paper is well fitted for this advertisement need and service, and to a much wider extent. Moreover, as it functions in the background in a near-transparent un-intrusive manner, it is a comprehensive solution to this growing consumer problem of 'spam' SMS.

Following an exposition of the WBC concept and underpinning technology, how these channels may be made to serve as a wireless solution for context- and service awareness in mobile communications is presented in this paper. The approach, which facilitates both the minimally-intrusiveness criterion and background near-transparent functionality, is presented as well.

2 WIRELESS BILLBOARD CHANNELS (WBC)

Taking into consideration the potentially huge range of wireless services already available to mobile users, the demand for an efficient and easy mechanism for services' ADA adapted to the terminal's capabilities, user preferences and user location, is clearly foreseen. The approach we are proposing to facilitate ADA is to use WBCs that will provide mobile terminals with information about the services available to them. Each terminal can compare this information with its capabilities, the current user profile's preferences, the user location, and other context information such as the time of day, to select the best services to use to achieve a particular goal. As well as advertising the service, the WBC will also provide information to help with the process of discovering and associating with that service.

The WBC should have the following characteristics (Flynn, 2007):

- *Simplex and broadcast:* Simplex here applies not just to the unidirectional physical nature of the channel but also to the unidirectional nature of the WBC service. This attribute has the additional benefit of easing the WBC physical deployment and operation. If the channel is duplex, then in a way it simply becomes another wireless access network infrastructure for two-way wireless communications, and thus in the end no different in its general attributes from any other wireless access network infrastructure. And if this, then bandwidth-spectrum allocation becomes a much more significant issue, as it has been for instance for existing cellular spectrum allocations.
- *Limited bandwidth:* Given the proposed usage – P2MP unidirectional service of advertisements – bandwidth requirements will be relatively narrow. This has the added advantage of enhancing the WBC likely success, e.g. of global agreements on spectrum allocations for them. With limited spectrum available, this would improve the

WBC's chances of becoming a worldwide standard.

- *Maximum coverage area:* These channels should ideally be available anywhere and at any time. No matter where it is (indoor or outdoor), a mobile terminal should have the ability to discover what services are available to it in the current location provided by local, regional, national or international service providers. Terminal mobility should not affect the ability to receive information on the channel.
- *Different versions for different areas:* The number and types of WBCs could correspond to the local/regional/national/international interests of advertisers and users. In practice there would be growth; perhaps a start-up situation would be one national WBC channel, advertising all the services that are relevant on a national level, which could include advertisements of local, regional or interregional significance. And then separate regional WBCs channels, advertising the services available in that region.
- *Operated by non-ANP service providers:* In consideration of the need for fair competition in the ANP marketplace and equity of access to WBC advertisement space, i.e. equally open to all ANPs, it is preferable for WBCs service providers (WBC-SPs) to be fully independent and physically separate from ANPs and their networks. This requirement may need the support of some regulation.

3 WBC-ADA MODEL

The main purpose of the WBC from the consumer's perspective is to allow wireless services to be discovered by mobile terminals. Service discovery is a networking concept whereby a client can automatically discover services that are available to it in a network. There are a number of protocols in existence that deal with service discovery. Three of the well-established protocols, namely Jini (Oaks, 2000), Service Location Protocol (SLP), (Guttman, 1999), and Salutation (Pascoe, 1999), were used as a basis for the development of the WBC-ADA model. Though very different, these protocols use the same basic model that relies on a central registry of service descriptions (SDs), which is accessible in a request-reply manner. A client makes a request for a service, based on the service type and attributes it would like, and receives a reply from the registry containing information about services that match the request. A WBC, however, is a simplex broadcast channel, which does not allow for requests to be made. The solution then is to broadcast periodically all SDs over the WBC (making allowance for flexibility, e.g., that some SDs be broadcast more frequently than others).

The flow diagram for the WBC-ADA model is shown in Figure 1 and described below:

A. Service providers register their SDs with a WBC-SP's central registry using some external method, e.g. via a web portal.

B. WBC-SP broadcasts all registered SDs, repeatedly, on a WBC (*service advertisement*) in compliance with the specific agreements with each advertising service provider client (e.g., frequency of re-transmissions).

C. Mobile terminals tune to WBC and listen, selectively, to broadcast to receive desired SDs (*service discovery*).

D. Each terminal freely associates with the chosen service provider (server) to use its service (*association*).

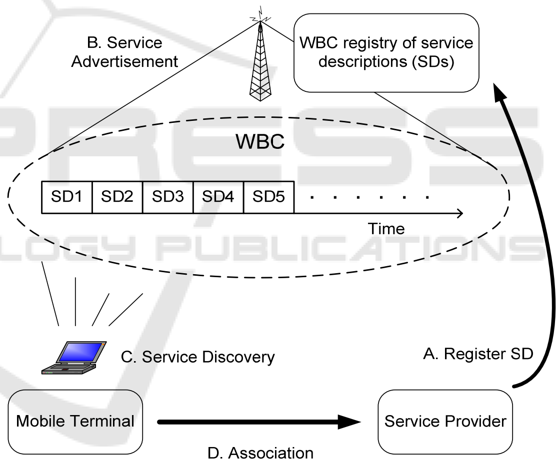

Figure 1: The WBC-ADA model.

3.1 WBC SD Format

The WBC SD format is based around some of the fields used in the well-established service discovery protocols mentioned above.

3.1.1 Service Type

Every wireless service is assigned a service type, which is a field that indicates the basic function performed by the service. The purpose of the *Service Type* field is to allow similar services to be grouped together in a WBC broadcast as this makes it possible to apply power saving techniques.

A hierarchical structure for the *Service Type* field is considered as this allows the order of SDs on a WBC broadcast to be more structured. It is a five-octet field, composed of four subfields.

```
Service-Type ::= SEQUENCE
{
   division   OCTET STRING(SIZE(1)),
   category   OCTET STRING(SIZE(1)),
   type       OCTET STRING(SIZE(2)),
   version    OCTET STRING(SIZE(1))
}
```

The *division* subfield specifies whether it is, for example, an access network's communication service or an application service. The *category* subfield describes what category of services within its division a service falls into. The *type* subfield specifies the actual type of service, within its category. The *version* subfield allows new versions of templates for service types to be published. This could be used to update service types or to create subtypes.

3.1.2 Scope List

The *Scope List* field identifies which scopes the service belongs to. Scopes are a way to administratively group services together. A service may have as many scopes as necessary. Mobile terminals are also configured with scopes. A terminal will only pay attention to SDs that belong to one of the same scopes as itself. Services may also belong to a *default* scope, meaning that all terminals will pay attention. If a terminal receives a SD that has neither one of the same scopes as itself nor the default scope, then it will ignore that SD.

An example of uses for scopes would be to advertise services that are only available to a certain group of people, e.g. government officials, emergency service employees, employees of large corporations, etc.

A scope list is a list of one or more scopes.

```
ScopeList ::= CHOICE
{
   defaultScope    SEQUENCE OF Scope
                   OPTIONAL,
   notDefaultScope SEQUENCE OF Scope
}
```

Any advertiser that wishes should be assigned a globally unique scope. For this reason, the *Scope List* field should be large enough so that scopes do not run out; or a variable length scheme is incorporated. For a fixed length, a 32-bit field seems more than sufficiently large to cater for future expansion.

```
Scope ::= OCTET STRING(SIZE(4))
```

3.1.3 Length

The *Length* field is an integer that specifies the length of the *Attributes* field in bytes. As 65,535 bytes is more than enough to accommodate any possible list of attributes, it could be defined as:

```
Length ::= INTEGER(0..65535)
```

This means that the *Length* field has a fixed size of two bytes.

3.1.4 Attributes

The *Attributes* field is the main one in a SD. It carries the information for advertisement, discovery and association of a service. Advertisement attributes are used by a terminal to decide if its user wants to use the service (based on information stored in the user profile). Discovery and association attributes are used to enable a user/terminal to use the service. The format of the *Attributes* field depends on the service type. The size of the field is not fixed, meaning that the total size of the SD is not fixed. Perhaps service providers would pay more for advertisement of a larger SD than for a smaller one.

3.2 WBC SD Encoding

One of the desired properties for the WBC is that it should use as little bandwidth as possible. In Jini, SDs are Java objects, and passing the descriptions involves serialising the objects. Serialised Java objects are a very inefficient way of encoding data. In SLP, the SDs are encoded as text which, while more efficient than Java objects, is still not efficient enough. The Salutation SD, which uses the Abstract Syntax Notation (ASN.1), (ITU-T, 2008a), is the most efficient approach in this case. ASN.1 data can be encoded in a number of different ways, depending on which encoding rules are followed. The Packed Encoding Rules (PER), (ITU-T, 2008b), give the most efficient encoding (close to optimal). For this reason we chose for the SDs to be ASN.1 structures and encode them using the PER.

The following is the SD format specified in ASN.1.

```
ServiceDescription ::= SEQUENCE
{
   service-Type    Service-Type,
   scopeList       ScopeList,
   length          SDLength,
   attributes      Attributes
}
```

The encoded SD ASN.1 structures are broadcast on a WBC. The *Service Type* and *Scope List* have the same format in every SD so a terminal that receives a SD knows what is the type of service and to which scopes it belongs. For the *Attributes* field, however, the format depends on the service type. This field makes no sense unless the terminal knows what its format is. Therefore, for each service type an attribute template should exist, as there is in SLP, which lays out the format of the attributes for a particular service type. This way, advertisers, WBC-SPs and terminal manufacturers know what format to follow. Attribute templates would form additions to the basic WBC standard.

One of the benefits of using attribute templates is that terminal software only has to be programmed to understand the meaning of service types that are relevant to that terminal. For instance, a terminal with no video capabilities has no interest in SDs for video services. Another benefit is that as new service types come into existence, new templates can be published, without having to make changes to the main WBC standard. However, this could leave some terminals unable to understand the new formats, while other smarter terminals will be able to update their WBC software appropriately. It is necessary then, for a terminal to be able to ignore *Attributes* fields whose format it does not understand. This is why the *Length* field is needed, to tell terminals how many bytes they must ignore before the next SD begins.

4 SERVICE TYPES AND TEMPLATES

While WBCs would be used for ADA of access networks' communication services –for many its primary goal–, the focus of this paper is on the application services.

The vision for next generation networks (NGN) is for all-IP networks where terminals will receive application services from service providers over IP. There are many different service types currently available to terminals and in NGN that number will be greater. A service type should include all services that perform a similar function. For example, a voice-call service should be one service type rather than having many different service types depending on the Voice over IP (VoIP) protocol being used. These, instead, should be included as attributes of the voice-call service.

In addition service types can themselves be put into broader categories. For example, communication services, information services, location-based services, etc. This allows similar service types to be grouped together on the WBC broadcast. The ITU-T Focus Group on Next Generation Networks' (FGNGN), (ITU-T, 2004) Working Group 1 is concerned with NGN services. Drawing on its NGN Release 1 Service Classification (Carugi, 2005) as a guide to what services will be available in NGN, possible service categories and types advertised to users/terminals over the WBC would include, but by no means are limited to, the following:

- *Communication Services* – Voice call; Video call; Push-to-talk; Conference call; Multimedia interactive communication service; Incoming call; Voicemail; Call diversion.
- *Messaging Services* – SMS; MMS; Email; Fax; Instant messaging; Chat rooms; Bulletin boards.
- *Information Services* – News; Weather; Sport; Finance; Yellow pages directory.
- *Entertainment Services* – Games (download / play on-line / on-line multiplayer); Music (download / streaming); Video clips (download / streaming); Ringtones / Logos / Icons / Screensavers / etc (download); Television (streaming); Radio (streaming); Competitions; Gambling; Dating; Voting / Surveys (maybe related to TV programmes, e.g. reality TV).
- *Educational Services* – mLearning (lectures, tutorials, labs, tests, examinations).
- *mCommerce Services* – mPay facilities; mShopping portals; mBanking and share trading; Bookings and ticketing; M-market type services (eBay).
- *Location-Based Services* – Nearest restaurant, cinema etc; Local weather; City guide; Walking/driving directions; Car parking; Traffic information; Public transport services / timetables; Location-based advertising; Location-based dating.
- *Emergency Services* – Police, Fire brigade, First medical aid, Rescue service, Alerts for natural disasters (in the area), etc.
- *Terminal reconfiguration services* – upgrades of mobile software, operating systems and applications.
- *Other Services* – On-line data storage; Cloud computing; Organisational services – calendar / address book etc; Virtual Private Network (VPN); Social networking.

Some of these listed service types may not be suitable for advertising on the WBC, and other (suitable) service types may have been omitted. Also, some of the service types may belong to more than one service category.

Each service type needs a service template to specify the attributes that are included in a SD for advertisement, discovery, and association. Making decisions between different services is automatic, based on preferences specified by the user in his/her profile and by taking into account the cost, quality and supported features of the available services.

After selecting a service by the user, the terminal (operating in a background mode, i.e. without disturbing the user) will choose the 'best' available instance of the desired service and will associate with it by using information obtained from the WBC. The first thing needed is the client-side software to be installed on the terminal (if not already installed/pre-loaded). For this an attribute is needed, which tells the terminal how to download this software. There should then be an attribute specifying the software itself and its version so that the terminal can see if it needs to be updated. Rather than having an attribute that says where to get the software (or software update), it could be better to have one software-download service (which would also be advertised as any other service on the WBC), which allows for downloading of all additional software needed to use services advertised on the WBC. Having installed the software, there are some attributes specific to a particular service (e.g. IP address and port numbers) that also need to be known.

Each service type needs a service template, which is an ASN.1 specification of the attributes used to define a service of that type. Considering the voice-call service as an example, a list of attributes for its advertisement and association is presented in Table 1.

Table 1. Attributes for the voice-call service type.

Attribute		Meaning	Use
For advertisement	Cost	Contains information about the cost of using the voice-call service (e.g. cost per minute to various recipients in different regions, countries etc).	Used by a terminal to compare the cost of the service from one SP with the maximum cost for the call that the user wishes to pay, and with that for the same service offerings from other SPs.
	Quality of Service (QoS)	Contains third-party measurements of the quality of this service (e.g. calls dropping rate, sound quality, etc).	A terminal selects the service (provider) that is expected to perform 'best'.
	Protocols	Specifies which communication protocols are used by this service.	A terminal may not support the use of certain protocols. Reconfiguration requirements and decisions.
	Features	A list of features apart from the basic that might differentiate one voice-call service from another (e.g. ability to send text during a call, music playing in the background, etc).	Used by a terminal to compare additional features desired by the user in order to choose the 'best' service.
For association	Software	An identifier that tells a terminal what software is needed to access this service.	A terminal can see if this software is already installed. If not, it can be downloaded from a software-download service provider, etc.
	Supported versions	The version numbers of the software that are supported by this service.	A terminal can see if the version of the currently installed; software is suitable/up to date. If not, then if a new version may be downloaded, based on WBC advertisement information.
	Software parameters	Information about this particular service needed by the terminal software (e.g. IP address and port numbers). This may have different fields for each value of the software attribute.	A terminal software uses this information to associate with the service.

Specified in ASN.1, the coded voice-call service definition itself would have the following form:

```
VoiceCallService  ::= SEQUENCE
{
   cost        VoiceCallCost,
   performance
               VoiceCallPerformance,

protocols      VoiceCallProtocols,

features       VoiceCallFeatures,
   software    SoftwareIdentifier,
   versions    SoftwareVersion,
   softParams
          VoiceCallSoftwareParameters
}
```

It is worth noting that the ASN.1 service specifications are designed in such a way as to accommodate also future service types and updates.

5 WBC BIT-STREAM STRUCTURE

5.1 Data Scheduling

A SD contains the values of all the attributes that are specified in the service template. These are encoded into binary data using the PER of ASN.1. Depending on the service type and the values of certain attributes, SDs are not all going to be the same size. The WBC broadcasts SDs continuously so that terminals listening to the channel can receive the service descriptions they need. The simplest approach is to broadcast all the SDs, one after the other and when the end is reached, start at the beginning again (called a *flat broadcast*). This, however, might not be the most efficient way, or the way desired either by the advertisers or by the WBC-SP seeking ways to make their business more profitable. Also from the consumer's perspective 'flat broadcast' can result in inefficiencies and delays. If a certain SD is demanded by terminals more frequently than another, then it makes sense to broadcast it more frequently. The priority should be to minimise the average *access time* of the entire system. Access time is that time from the moment when a mobile terminal first starts accessing a data item (SD) on the WBC, until the moment it receives full data item (SD). Minimising that time, averaged across all required SDs by all terminals, is a common-sense goal.

There are quite a few data scheduling algorithms; however, most of these are pull-based, meaning that they rely on the clients making requests on a back channel for certain data items to be broadcast. These algorithms are not suitable for the WBCs, which are simplex broadcast channels. Hence only push-based algorithms, such as the Broadcast Disks and Priority Index Policies, were considered. A modified and improved version of the Broadcast Disks algorithm was elaborated and described in (Ji, 2008) for data scheduling on WBCs.

5.2 Data Indexing

Efficient use by mobile terminals of their limited battery energy is another factor. Any techniques to reduce power consumption thereby extending their battery charge-life are attractive especially if they are cost-neutral. Power is saved by minimising the time spent by terminals for listening to the WBC channel to receive the required SD (referred to as *tuning time*). Tuning time could be reduced by the use of indexing because without it, a terminal would have to tune into the WBC and listen to the broadcast continuously until the required SD is transmitted. By adding indexing data to the broadcast, terminals can tune in, find out when the required SD will be transmitted, then tune out and wait until that time to tune back in again. By adding redundant data to the broadcast, however, the average access time is going to be increased.

There are several indexing schemes that aim to provide a good trade-off between having a low tuning time and a low access time. All these schemes have several features in common: the attribute that the data items (records) are indexed by is called the *key* (in the case of the WBC, the key is the service type); the order of the records in the broadcast sequence is arranged by the value of their keys; the broadcast sequence is divided into fixed size parts called *buckets*; the indexing tells the client in which bucket to look to find the first record with the required key (as buckets are of a fixed size, the client will know the exact time that a particular bucket will be broadcast).

Short description and comparison of the main indexing schemes are provided in (Flynn, 2010). It may be that flat-broadcasting schemes could be adapted to accommodate non-flat broadcasting as well. Based on these, a new 'Simple Indexing Scheme' was elaborated for use in WBCs as described in (Flynn, 2010).

6 SMART USER-PROFILE FUNCTIONALITY

In future networks, the ultimate goal of service providers will be to provide services to mobile users in ABC&S mode, i.e. at the 'best' QoS and cost levels, and by applying personalisation and context awareness. As described in (Stavroulaki, 2009), personalisation supports different user types and roles, whereas context awareness considers the state of the user (user identity and roles), mobile terminal (capabilities) and environment (location and time zone). To achieve this, proper management of user preferences and terminal capabilities is required by means of accurate description and representation of information along with the configuration and update of user profiles.

The user profiles could be structured with two groups of parameters as proposed in (Stavroulaki, 2012):

- *Observable parameters* – these include the services that are currently running on the user terminal, corresponding QoS parameters, and context parameters such as user location, time zone, service rank, etc.
- *Output parameters* – the value of these is dynamically changed over time depending on the value of observable parameters. The main output parameter is the so called *utility volume*, which provides a ranking of service-QoS pairs by order of user preferences. The latter, of course, may change over time and may vary depending on the user context. An approach for dynamically learning of user preferences w.r.t. the perceived QoS level per service with the use of Bayesian statistics concept is presented in (Stavroulaki, 2009).

A generic intelligent iWBC client, which sits on the mobile terminal and operates in the background in support of the mobile user becoming fully aware of all relevant wireless services available (in the current location) and advertised according to the structured WBC format, has been designed and successfully implemented (Ji, 2011). Information about available services is proactively pushed to the terminal which, with the help of this application, can thus discover the services and all the necessary details about their offerings, sufficient to make informed ABC&S decisions about using them, including knowing how to associate with the access networks to obtain these services in the best possible way through the ADA procedure. Hence this novel iWBC application amounts to a significant advance in consumer-driven ABC&S capabilities and services.

Through the WBC system, including the iWBC client application, all wireless service advertisements, become a background activity. That is, the data is captured, analysed and filtered according to individual user's ABC&S policies and presented to the user as and when s/he likes. It is only when the user seeks to use a service that s/he might become aware of the service offerings garnered from the WBC advertisements by the iWBC application. The iWBC would then present these over a friendly user interface allowing the user to assess options and attributes in an information-structured and comparative manner, and make an ABC&S choice decision on which service to use.

In fact it can all be even more transparent and un-intrusive to the user, if the ABC&S decisions are also made in the background following default (e.g., lowest price) or preset ABC&S policies and profile settings. This 'full transparent ABC&S' mode will mean a minimum disruption to the user, and yet it will still be user-driven ABC&S.

(Ji, 2011) demonstrates a practical use case example when a new 'best' wireless service instance is becoming available in the current area of the mobile user. In this case, the iWBC client application automatically discovers this new service offering by a background extraction of this information from the WBC's service descriptions, logs this information in the terminal's database, examines it in accordance with the consumer-driven ABC&S policies and makes decisions on its usage, informing the user of the new service offerings, and so on.

7 PERSONALISED INFORMATION RETRIEVAL

The UCWW environment presents a shift from the currently dominating subscriber-based wireless access towards a consumer-centric one (O'Droma, 2007) & (O'Droma, 2010). Allowing the user to choose a provider for a particular service from a list of alternatives opens the opportunity for stronger competition between providers and a better service for the user as a result. However, giving the user the freedom to choose should not become an overwhelming burden when the number of options, as well as factors that choice depends on, is too large.

A possible solution is to introduce an extra feature to the WBC-ADA system that facilitates the user's choice by suggesting a ranked list of providers for the desired service as per the past experience of other users in the same physical context. The retrieved list of service providers could then be adjusted and personalised for the user and their physical context by utilising the context parameters in the user profile.

Systems which retrieve information that is both relevant to the submitted queries and personalised for the user are known as *personalised information retrieval* (PIR) systems. They have been the subject of extensive research in the last couple of decades with a major application in Web search as well as in other areas such as eLearning and news dissemination (Ghorab, 2012). For example, a PIR framework for a wearable computer in ubiquitous computing environment was proposed by (Hong, 2005). This framework is particularly oriented towards retrieving personalised information from objects in physical proximity to the user in a typically cluttered with data environment. Although the iWBC client application would also work on wearable devices in a ubiquitous computing environment, it will need to retrieve information from a relatively less heterogeneous data source (the stream of SDs broadcast on WBC) than the complete variety of objects in physical proximity to the user. Thus, the design principles for a typical PIR system (for example, a PIR system for Web search) may be followed, taking into account also the physical context of the user.

In order to provide personalised results, an iWBC PIR client must gather and store data about the information needs of the user. There are two approaches to representing and storing the gathered information. It can be either stored in an individualised *user model* (Zhang, 2007) & (Speretta, 2005) or in an aggregated one (Agichtein, 2006) & (Smyth, 2006). A recent survey proposes a classification of PIR systems with respect to the scope of personalisation into three categories: *individualised personalisation*, *community-based personalisation*, and *aggregate-level personalisation* (Ghorab et al. 2012). The individualised personalisation is limited to the information gathered about the user who queries the system. Similar to it, the community-based personalisation also employs a user model for providing personalised information retrieval. However, it also allows sharing of information between users. The aggregate-level personalisation, on the other hand, makes no use of an explicit user model and decisions are based on aggregate usage data.

A community-based PIR (Teevan, 2009) & (Sugiyama, 2004) would seem to suit WBC needs best as it offers personalised results to the user based not only on their previous behaviour and experience but also on the experience of other users who have used the service in a similar context. There are three aspects of a PIR system which need to be addressed in the design: information gathering, information representation, and implementation and execution of personalisation (Gauch, 2007). An immediate next step in the WBC research is to decide what information about users should be tracked, how this information will be gathered and stored in a user model and then how user models will be used for retrieving personalised results. The research literature offers a wide spectrum of solutions for each of the stages of PIR (Ghorab, 2012). The majority of them have been developed for the needs of Web information retrieval. However, they should be easily adaptable for the needs of selecting providers of services in NGN.

From another point of view, user modelling and PIR can be a feature that can make the concept of WBC-ADA attractive to the current wireless service providers. Instead of having third-party organisations providing the PIR service for all users, PIR can be distributed between SPs. That is, PIR can be a service that a user will request from a particular provider they are subscribed to or have used as a consumer. For example, consider the following scenario. User A is receives PIR services provided by SP X. User A needs to make an international phone call and tunes on WBC to receive information of a provider that can allow them make the call for a fixed price under 1€. The iWBC client finds a number of providers who satisfy this user request and returns a personalised ranked list. The top provider in the list is Y and the user selects it for the phone call. That is, the user has used the PIR provided by X to find out that Y is the provider that best suits their requirements for a phone call at their particular physical context. In this case, even though X will not provide the phone call, X can still be motivated in providing the best PIR for that user. Thus, the competition between providers can stay healthy and they can preserve their user base.

8 CONCLUSIONS

Advertisement and discovery are part of an important R&D challenge to find solutions for the automated enabling of the entire process of advertisement, discovery and association (ADA) of wireless services and for the evolution of wireless communications. It will contribute significantly to continuity of connection to wireless services provided to mobile terminals. To facilitate this, a wireless equivalent of the shop window and billboard advertising, called a wireless billboard channel (WBC), was presented in this paper. This would provide access network providers (ANPs) and application service providers (ASPs), with a very active dynamic means to advertise (i.e. proactively 'push') their presence and services through WBCs operated by non-ANP service providers. The pro-active push advertisement nature of the WBC would correspond well to ANP and ASP competitive desires to use all means to reach the mobile users from their existing 'loyal' subscribers through to the impulse buying consumers. Advertisement and discovery of wireless communication services and application services deployed and accessible in a particular area/location, and procedures for terminal association with these, are defining characteristics of contemporary networks.

WBCs would also benefit the users due to automated discovering functionality of terminals scanning the WBCs and updating service offerings and availability information, matching these against user profiles and proposing, and enabling casual or persistent consumer-type association links for different user-desired services. The result of this process will be more up-to-date information for user-driven always best connected and best served (ABC&S) decisions. Ideas on smart user profile functionality and user-driven ABC&S decision-making based on personalised information retrieval (PIR) systems adapted to this UCWW context have been set out and discussed.

Implicit in this vision is the global standardisation of these proposed WBCs as a vehicle and a wireless infrastructural support for ADA procedure. Practically it makes sense to have several WBCs directed at different geographic extensions.

The utilisation of the Digital Video Broadcast - Handheld (DVB-H) standard – a standard for broadcasting digital television to handheld devices (ETSI, 2004) – as a candidate carrier technology for WBC was extensively studied, e.g. in (Ji, 2010a). DVB-H extends the DVB-Terrestrial standard with time-slicing and other additions to greatly reduce receiver's power consumption. Designed for handheld devices, it allows for high terminal mobility and thus is ideal for WBC use. A 'WBC over DVB-H' prototype system was designed, implemented, evaluated and successfully tested, e.g. (Ji, 2010b) & (Ji, 2009).

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