Ad Hoc Collaboration and Information Services Using Information Clouds

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Abstract

Future wireless communication environments offer many possibilities for new services. Users will not be satisfied with simply being connected, but they will require useful services built on top of the wireless networks. *iClouds* is an architecture which offers spontaneous mobile user interaction, collaboration, and transparent data exchange in mobile ad hoc networks. In this paper we present several services which we have built on top of the basic iClouds architecture. We have built a basic information exchange service, an information sprinkler, a virtual notice board, and an advertisement service which can significantly increase the coverage of advertisements.

1 Introduction

Wireless ad hoc communications offer many new ways for collaboration and information delivery. Given the success of wireless communications, such as mobile telephones, 802.11b, or Bluetooth, the demand for advanced services built on top of these ad hoc communication networks is likely to be high. Users will not be satisfied with simply being connected all the time; they will also require services that help them in their daily lives.

In this paper we present a set of services that can be deployed on our iClouds architecture [5]. iClouds is an architecture which supports mobile user interaction, collaboration, and transparent data exchange.

The motivation behind the iClouds architecture can be expressed as follows: "Whenever there is a group of people, they will most likely share common goals

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or have related motivations. Information of interest may be in possession of only a few of them." The iClouds architecture makes such information available to all the people in the (ad hoc) group. In this paper we concentrate on building services on top of the basic iClouds architecture. These services are aimed at exploiting the ad hoc information exchange that happens in iClouds.

To illustrate how iClouds operates, consider a person walking with a wireless-enabled PDA. The communication range of the wireless device defines a sphere around that node. We call this sphere or communication horizon an *information cloud* or *iCloud*. In practice this will not be an perfect sphere due to radio signal interference with buildings and other structures.

Limited connectivity (a few hundred meters at most) provides for a simplistic form of location awareness, since only communication partners in physical proximity can be reached; in this sense, limited connectivity can be viewed as a desired property.

When several nodes come close together, the devices can communicate with each other and exchange information depending on what information the users provide and need. This exchange happens automatically, without any need for direct user intervention.

We have identified several scenarios in which an infrastructure like iClouds can serve as a basis for value-added services:

- **Local Information Acquisition**. The city tourist office publishes information about the city which tourists are interested in. This could be information about sights, restaurants, or useful telephone numbers, such as taxi number, etc.

- **Ad hoc groups**. Information delivered through iClouds can bring people with common interests together to help them collaborate. Ad hoc groups based on interest were already studied in the Gulliver project [4] and similar services can be built on top of iClouds as well.

- **Advertisements**. A store can publish ads which are picked up by interested customers. These customers potentially pass the ads along to other interested users when they are away from the store, thus increasing the reach of the ads. Spamming can be naturally restricted since the social protocols of personal communication (optionally enriched by a rating scheme) and a recipient's "wish-list" limit the forwarding of ads (see section 2.2 for details). On the other hand, if any of the users who have received ads in this way actually make a purchase, the store could give a bonus to the person who passed the ad along. This bonus could be, for example, points or a discount on the next purchase.

This paper is organized as follows. Section 2 presents an overview of the iClouds architecture and communication mechanisms. Section 3 presents the services we have built on top of iClouds. Section 4 discusses related work. Finally, Section 5 concludes the paper and presents directions for future work.

2 iClouds System Description

In this section we will present an overview of the iClouds architecture on top of which we build our services. See [5] for a more complete description of the iClouds architecture, how the information is stored on the iClouds devices, and how it is passed from a device to another. Below we will present a brief overview of the iClouds architecture.

iClouds is part of our Mundo project [3]. Mundo project studies ubiquitous and pervasive computing infrastructures in an overlay network context. Different entities and devices have different roles in Mundo. A *Minimal Entity* (ME) is a small, trusted device which represents the user in the digital world. *Ubiquitous aSsociable objects* (US) are devices which augment the capabilities of the ME, by associating with a particular ME and personalizing themselves to suit the user's needs. *Smart ITems* (IT) are items and devices which do not support association, but have an identity and communication capabilities. A *Wireless group Environment* (WE) brings together two or more MEs with their associated US devices. WEs are formed as ad hoc networks. *Telecooperative Hierarchical ovErlaYs* (THEY) form the backbone of the network and allow mobile users to access data stored anywhere in the world.

iClouds is our most advanced project (in terms of realization) within the WE sub-domain. For a complete description about Mundo see [3].

2.1 iClouds Architecture

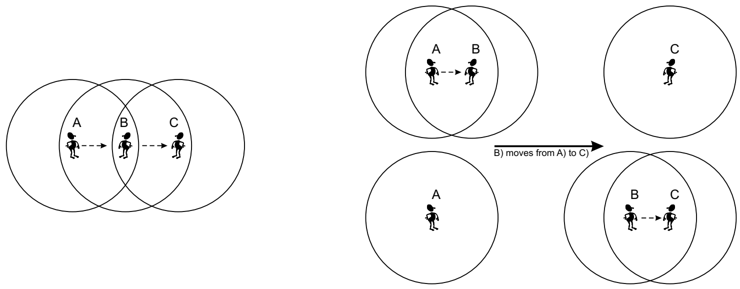
iClouds devices are small mobile devices (like PDAs) with mobile communication support for a maximum of a few 100 meters; one example is a PDA with 802.11b support. There is no need for any central servers in the iClouds architecture; instead, each device is completely independent.

The diameter of the iClouds communication horizon (see Figures 1(a) and 1(b)) should not exceed a few hundred meters. We want to give iClouds users the option for spontaneous collaboration and when two iClouds users "see" each other, they should be within a short walking distance from each other (a couple of minutes at maximum). To allow for this easy collaboration, we specifically exclude multi-hop communication. Therefore, iClouds does not require any routing protocols; all communications happen directly between the concerned parties. However, as described below, iClouds supports indirect multi-hop communication through information passing or moving.

Information can pass through several nodes, as shown in Figure 2(a), assuming certain conditions are met. We call this scenario *information passing*. In Figure 2(a) information can only pass between A and B or between B and C, since A and C are not in communication range. (Their communication horizons overlap, but the devices themselves do not fall into the other's communication horizon.) In this situation, information can pass from A to B and on from B to C if and only if it passes from A to B and it would also pass from A to C, if C was in communication range with A. In other words, information passes only if B and C both want the same information from A.

(a) Communication horizon (b) iClouds with 3 peers

Figure 1: Information clouds



(a) Information Passing (b) (physical) Information Moving

Figure 2: Two types of information flow in iClouds

The other way in which information is transported with iClouds involves physical movement of nodes, as shown in Figure 2(b). We call this scenario *information moving*. In Figure 2(b), B gets some information from A. B then later encounters C who is interested in the same information and B passes it along to C. Again, a prerequisite for information to pass from B to C is for B and C to share interest in the same information.

2.2 iClouds Communications

The two most important data structures found on the iClouds device are two information lists (*iLists* for short):

- *iHave*-list (information have list or information goods)

  The iHave-list holds all the information the user wants to contribute to the iCloud.

- *iWish*-list (information wish list or information needs)

	pull (from Bob)	push (to Bob)
iHave-list	Standard search	Advertise
iWish-list	Active service inquiry	Active search

Table 1: Information Flow Semantics (from Alice's point of view)

In the iWish-list, the user specifies (using search patterns) what kind of information he is interested in.

Each iClouds device periodically scans its vicinity to see if known nodes are still active and in communication range and also to see if any new nodes have appeared. If any new nodes are in range, the iClouds devices align their information goods and needs. This is achieved by exchanging iLists. Items on the iWish-lists are matched against items on the iHave-lists. On a match, information items move from one iHave-list to the other.

We have two main communication methods for transferring the iLists. Peers can either *pull* the iLists from other peers or they can *push* their own iLists to peers they encounter. In addition, either of these two operations is applicable to both lists, which gives us four distinct possibilities of communication. We summarize these possibilities, along with their real-world equivalents, in Table 1. In the Table, we consider two iClouds users, Alice and Bob, who meet on the street. The semantics are shown from Alice's point of view.

The information flow semantics correspond to normal person-to-person interaction in the real world, as Table 1 implies. We elaborate more on this in [5].

3 Services

We have developed four services: basic information exchange, information sprinkler, advertisements and virtual notice board.

3.1 Information Exchange

Most people tend to collect all types of information, such as their favorite movies, cinemas, bars, restaurants, city attractions, theaters and the like. Often they keep detailed information (prices, opening hours, programs) in small notebooks or, as is becoming more common, in PDAs. This enables the users to share their valuable information with others by publishing it into their vicinity. Other people are free to collect the information they are interested in.

Consider a traveling salesman who is interested in movies after a long business meeting. Although not familiar with the city, where his customer is located, his iClouds device will learn about all kinds of cinemas just by passing by locals while visiting the customers in the city. In this scenario, the information exchange happens transparently as the salesman is walking on the streets.

This service is identical to the basic iClouds functionality, i.e., information sharing. Naturally, it depends on the contributions from the users to be useful.

3.2 Information Sprinkler

One particular type of an iClouds device is an *information sprinkler*. Such sprinklers are fixed nodes, with wireless communications, which only publish information. Information sprinklers would typically be deployed in places like shopping malls, train stations, tourist offices, etc. Their role would be to publish information relevant to their location to passersby. For example, in the case of a shopping mall sprinkler, this could be information about special offers in the mall or electronic discount coupons. An information sprinkler in a tourist office would publish information about current events in the city, such as concert, exhibitions, and other events.

Information sprinklers do not collect any information themselves; they simply publish the information their owner has entered into them. In iClouds terms, an information sprinkler has an empty iWish-list and the published information is on the iHave-list. In addition, they use *push* communications to better reach the people passing by.

Besides its wireless communication capability to reach other iClouds nodes, an information sprinkler would typically have a second connection (e.g., via a wired network) to a database. This database is the source for the information to be published and allows for easy information management, e.g., update, removal or insert of items to publish into iClouds.

Information sprinklers are owned and operated by an entity which wants to share information. Hence, the potential problem of not having information to share, as in the basic case, does not exist here.

3.3 Virtual Notice Board

The counterpart to the information sprinkler is the *virtual notice board*. Virtual notice boards collect messages published by iClouds users to a dedicated notice board. Notice boards would normally be deployed at places with high passerby frequency and they would be dedicated to a certain topic.

The notice board also contains an information sprinkler that broadcasts the notices. The broadcasts are picked up by other users that regularly pass by the notice board. We can also think of the virtual notice board as an information sprinkler that allows for user contribution. As an example, a virtual notice board deployed at a sports center could help people to find new sports partners.

3.4 Advertisements

As mentioned in section 3.2, information sprinklers in shopping malls can pass out advertisements or discount coupons. However, because the sprinkler is fixed, only people who actually visit the mall are able to receive the advertisements. iClouds allows us to have the people who visited the mall to carry the ads with them and further pass them on to other people.

Figure 3 shows an example of this. Let's say, Alice is interested in the latest DVDs. Her habit is to visit a media mall once a week. There her iClouds device

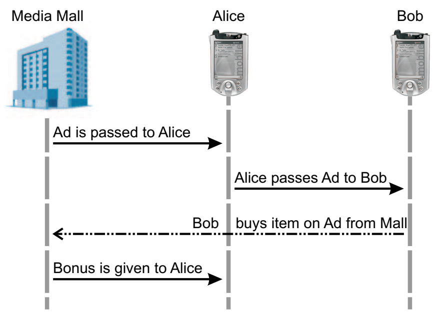


Figure 3: Advertisement passing in iClouds

collects all kinds of ads about items which are of interest to Alice (i.e., has specified on her iWish-list), such as DVDs, video games, etc. (Figure 3, Step 1).

Later Alice encounters Bob on the street far away from the media mall. Bob is also interested in similar items, but does not have the time to go to the mall all that frequently. Being in communication range with Alice, Bob's iClouds device learns about the ads that Alice has collected (Figure 3, Step 2). This allows Bob to learn and maybe later buy one of the advertised products from the media mall. If Bobs buys something at the media mall based on an ad he received from Alice, Alice will get some bonus from the media mall, e.g., a discount on her next purchase or loyalty points (Figure 3, Steps 3 and 4).

This scenario requires us to add some elements to the basic iClouds interaction. The media mall will need to sign the ads they send out, to protect themselves against forged ads. Likewise, Alice will need to include her public key with the ad and sign it when she passes it to Bob. This way, when Bob buys the item, the media mall will have proof that Alice passed the ad to Bob. When Alice later comes to the media mall, she can prove that she has signed the ad and is therefore eligible for the bonus.

If the chain of intermediate people is longer, e.g., Alice passes the ad to Charlie, he to David, David to Bob, and Bob goes to the store, all the intervening people can also get a bonus. How much bonus they would get would depend on the particular item, price, and store's own policies.

The possibility of bonus serves as an incentive for people to collect and pass ads along. However, there is no incentive for Bob to present the ad to the store. To improve the chances that Bob will tell the shop that he got the ad from Alice, the store could make the offer valid only with the ad (i.e., the ad is in fact a coupon) or give Bob a small bonus (possibly smaller than what Alice gets).

There is still the possibility that Bob gets the ad from Alice, but strips Alice's signature from it, thus being able to claim the coupon, but not giving any bonus to Alice. This can be solved by having the store ask for Alice's public key before passing the ad to Alice. The information sprinkler would add Alice's public key before signing the ad and sending it to Alice. In a similar vein, when Alice passes the ad to someone, she will take that person's public key and add it into the ad with her own public key before signing it. This way, the ad contains the identities of the passer and receiver for each step on the ad's path. Any ad presented by someone without a valid path of sender/receiver signatures would be considered invalid.

3.5 Privacy Issues

iClouds devices are linked to their owners, broadcast information, and are traceable, hence they raise the question of user privacy. To protect user privacy, the basic iClouds design is as follows:

- iWish-lists never leave the device, unless explicitly allowed by the user. Therefore it is not possible to construct a user profiles.
- For each item on the iHave-list, users can specify, if they want to mark it private. It will then be unavailable to other parties.

The comparatively short communication range constitutes a natural protection for user privacy. Nobody outside the range (a few hundred meter at most), is able to track the user.

Our new services maintain the user privacy under the above conditions. The basic information exchanges and information sprinklers are not different from the basic iClouds operation and privacy is therefore respected. In the virtual notice board scenario, the user chooses, what information she is going to publish. Therefore if she doesn't like to give away her identity, she can use an alias for her postings to the notice board. In the advertisement passing scenario, the store needs to verify the identity of the person who passed the ad. However, this only means that she is able to prove that the ad was signed with her private key. This can be achieved simply by having her sign the ad again and comparing the two signatures. There is no need to let the store know her identity, hence, her privacy is protected even in this case. Note that the store is already in possession of the public key, since it is required for the information sprinkler to pass the ad. However, the public key alone does not contain any personal information.

3.6 Prototype

To gain more practical experiences with iClouds and the services, we have built a prototype and set up a testbed. Due to lack of space we omit technical details here. For more details about the prototype, see [5] or visit the iClouds project website [6].

4 Related work

The Proem Platform [7] targets very similar goals. The main difference to iClouds is that they focus on Personal Area Networks (PAN) for collaboration. We believe that it is fruitful to focus on a wider area (mobile networks that cover several 100 meters in diameter) and that it is not necessary to encounter communication partners physically for information exchange.

Sharing information among mobile, wireless users is also subject of the 7DS Architecture [8, 9]. In contrast to iClouds, in 7DS the users are intermittently connected to the Internet and cache information, i.e., HTML pages, which is accessed during that time frame. Later these caches are used to fulfill requests among the nodes.

The Usenet-on-the-fly system [1] makes use of channels to share information in a mobile environment. In contrast to iClouds, the information spreading is limited by a hop count in the message. This has the disadvantage, that an unlucky user might be one hop to far away from the information source, although she might be interested in receiving the information.

Spontaneous user collaboration was investigated by the Meme Tags project [2]. Meme Tags are small devices with an LCD screen and bidirectional infrared communication support. Because of this, they allow only for short-range, face-to-face communications. iClouds uses longer range communication methods, such as 802.11b, and allows for a much greater flexibility in information sharing and collaboration.

Basic information services require contributions from users. This is true for many current systems. The Usenet news is certainly one of the most prominent and successful systems. Tveit [10] proposes a peer-to-peer based network of agents, that support product and service recommendations for mobile users. Recommendations are provided by aggregating and filtering individual user input. Tveit focuses on infrastructured wireless networks, e.g. mobile phone networks. Another example that exploits small user contributions from a wider community is the *Vipul's Razor* project [11]. This is a collaborative spam detection and filtering network. Spam is not recognized by sophisticated scanning software, but by the individual user. This recognition is propagated to the Razor network, so that all users can benefit from one user's effort.

5 Conclusion

In this paper we have presented several new services for the future wireless world. Our services include basic information sharing, an information sprinkler, virtual notice board and advertisement passing. They are built on top of our iClouds architecture, which supports spontaneous user interaction, collaboration, and transparent data exchange, based on ad hoc peer-to-peer communication.

For future work, we want to setup a combined information sprinkler and notice board at our department and make the Windows CE version of iClouds available to our students. We hope to gain experience in user acceptance and usability.

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