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Fast track article

Towards an adaptive mediation framework for Mobile Social Network in Proximity

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ABSTRACT

Mobile Social Network in Proximity (MSNP) is a new form of social network in which users are capable of interacting with their surroundings via their mobile devices in public mobile peer-to-peer (MP2P) environments. MSNP brings opportunity to people to meet new friends, share device content, and perform various social activities. However, as the fundamental topology of MSNP is based on public MP2P network, many challenges have arisen. Existing related works restrict the MP2P social network to operate in specific platforms and protocols. Enabling MSNP in a dynamic public MP2P also requires a more flexible loosely-coupled service-oriented solution. Applying the service-oriented MSNP environment will enhance the interoperability of MSNP participants. However, the latency issue while performing dynamic service discovery and the resource constraint issue of devices, prevent the efficiency of MP2P-based service-oriented MSNP systems. In this paper, we propose an adaptive mobile-hosted service-oriented mediation framework for MSNP. The framework supports proactive service discovery by using *context-aware user preference prediction* scheme to reduce the latency caused by the service discovery process. In order to resolve the resource constraint issue, the mediation framework applied the Enterprise Service Bus architecture to support the runtime resource changes, and utilise resource-aware workflow mechanism to enable the dynamic adjustment of the execution behaviour at runtime based on the combination of *fuzzy set* and *cost and performance index* scheme.

1. Introduction

Today, many urban areas such as Tartu, Estonia [1] and Taipei, Taiwan [2], Melbourne, Australia [3] have implemented free public Wi-Fi hotspots to enable mobile device users to access Internet ubiquitously. The free public Wi-Fi together with the evolved smart mobile devices (e.g., smart phones, personal digital assistants (PDAs), or handheld media players) enable mobile device users to access the Internet and participate in various online social network services (SNS) without spending the more expensive mobile Internet (e.g., 3G/4G) connection fees. Indeed, accessing SNS (e.g., Facebook [4], Twitter [5], Google+ [6], etc.) has become one of the most popular activities for mobile device users. With the powerful capabilities of recent smart mobile devices, such as shooting high quality photos, recording high definition videos, mobile users can use their mobile device as content provider to provide various content to their social network participants.

Mobile-device-based social network activity is not limited to centralised SNS. Enabling mobile social network (MSN) in mobile peer-to-peer (MP2P) environment has become an interesting research topic to numerous researchers [7–11]. With the free public Wi-Fi hotspots and Zero-configuration network technology [12], it is possible that in the near future, mobile

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users are capable of sharing various content to their nearby mobile users to form a Mobile Social Network in Proximity (MSNP) without a centralised management service. Moreover, MSNP environments allow mobile users to potentially meet with new friends in the real world.

1.1. Overview of mobile social network in proximity

MSNP represents an environment in which mobile users utilise their mobile devices to perform social activities with each other in proximal distance. The fundamental aim of MSNP is to enable communication in a fairly close range so the participants can potentially meet each other. Fig. 1 illustrates an MSNP environment. In order to improve the interoperability, Web service has been utilised as the common communication interface.

In an MSNP environment, each mobile device is a mobile Web service consumer and also a provider [13]. When two peers join the same wireless network, they utilise standard communication technologies such as DPWS [14], or Zeroconf [12] to exchange their service description metadata (SDM). For peers who do not have Mobile IPv6 [15], we expect each of them has its own backend Cloud storage to synchronise its IP address as a small text file in its Cloud storage (or alternatively utilising public DNS servers if available). The URL of the text file is described in a peer's SDM. Hence, when a peer (e.g., Fig. 1, P2 and P4) moves out from the current network, the other peers (e.g., Fig. 1, P1 and P3) in its previous network can still interact with it via mobile Internet.

Since P1 and P3 have previously exchanged their SDM with P2 and P4, they have cached the SDM of P2 and P4 in either their local memory or synchronised to their Cloud storages. When P1 and P3 receive requests from other peers in the same network that are performing service discovery, P1 and P3 can also provide P2 and P4's SDM to these peers. Instead of having the SDM directly sent to the peers by P1 and P3, P1 and P3 can synchronise the cached SDM to their Cloud storages, and simply provide the URL link to the other peers.

Similar concept is applied to content sharing and mashup, say for example, P1 intends to mashup the content provided by P2 and P3. When P1 invokes P2 and P3 for the content, P2 and P3 will simply reply with the corresponding metadata documents, which contain the description about where the content can be retrieved from the Internet. For example, P2 has uploaded the content to a social network site (SNS) as public accessible content. Hence, in P2's response metadata, it contains the URL link of the uploaded content.

Taking into account that mobile devices usually have limited processing power, it is reasonable for an MSNP peer to delegate some of its processes to its backend Cloud utility service (CloudUtil). In Fig. 1 for example, P1 utilises its backend CloudUtil for semantic service discovery. Furthermore, CloudUtil can be used to directly access the content uploaded by other MSNP peers in Social Network Services (SNS) to discover useful content for P1's mashup (if the content has been described in Really Simple Syndication (RSS) feed format).

A content provider in MSNP can also actively push recommendation to other participants based on the participant's service preference. Due to privacy concerns, MSNP peers may prefer not to share their private information. However, when a list of available services (described semantically) is provided to the participant, the participant can simply reply which service type it is interested in.

1.2. Challenges in mobile social network in proximity

1.2.1. Service discovery latency

Enabling service-oriented MSNP environment involves numerous challenges, in particular, since Web service has been applied as common communication interface, and in most cases, MSNP participants do not have pre-knowledge about other peers. In order to support the service discovery process, each MSNP peer can use semantic Web standards (i.e. SAWSDL [16], OWL2 [17]) to describe its services. While performing service discovery, an MSNP peer has to retrieve and process the other participants' service description metadata at runtime to enable dynamic Web service binding. Such a process can cause high latency when the environment consists of large number of mobile Web service providers. Moreover, the dynamic nature of MP2P requires the service discovery process to be fast in order to enable the further interaction processes, because MSNP peers can move out from current Wi-Fi network and join another, or it can switch to 3G/4G mobile Internet. As mentioned in the previous section, the dynamic IP problem can be overcome by utilising Cloud storage or Mobile IPv6. However, the prerequisite is that the service description metadata must be disseminated. Otherwise, the communication cannot be established.

The previous test result [18] has shown that the push-based service discovery approach performs better than the pull-based when the MSNP environment consists of large number of participants. Push-based service discovery requires numerous information, in particular, the receiver's preference. In a classic design [10], a participative peer will provide its user preference profiles to the others. However, considering the privacy issue, some users may prefer not to share their profile. An alternative solution to still enable push-based approach is to provide a list of available services with semantic annotation, and let the searcher to identify which service provider it is interested in and perform further action. It is applicable because context information can be compared in order to identify the similarity of the user's current context and the context occurred in the user's previous query records. Based on the context information, the system is capable of predicting what service is potentially of interest to the user. Moreover, if the user's past records cannot fulfil the accuracy of the prediction process, the system can use social context to enable collaborated prediction. For instance, retrieving the past query records

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