An Architecture Concept for Mobile P2P File Sharing Services

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Abstract: File-sharing in mobile networks has differing demands to a P2P architecture. Resource access and mediation techniques must follow constraints given in 2.5G/3G networks. Enhancing the eDonkey protocol, we reconcile decentralized operation with traffic control.

1 Requirements for Mobile P2P File Sharing Services

P2P systems in mobile environments face multiple challanges: highly varying online-state (presence), hierarchical network structure, and limited device capabilities. Network operators desire traffic control while preserving the experience of wired P2P.

In order to share resources, P2P applications need to support two fundamental coordination and control functions: *a) resource mediation* mechanisms, i. e., functions to locate resources or entities, and *b) resources control* mechanisms, i. e., functions to permit, prioritize, and schedule the access to resources. *Pure P2P* architecturesare implementing both mechanisms in a fully decentralized manner. *Hybrid P2P* systems utilize central entites, e. g. the eDonkey index servers collect and distribute file location information for all peers.

User-provided content and decentralized resource storage made P2P applications successful. However, resource mediation is more effective centralized, while decentralized resource control could be outweighted from bandwidth costs.

Mobile Requirements The two main restrictions of the air interface, a relative low effective bandwidth[1] and high latencies [Me99], make it essential to reduce the signalling overhead as much as possible to achieve acceptable performance. Besides, the limitations of transmission power and battery capacities, cause the upload bandwidth to be significantly lower than the downstream channel. Traffic between peers, i. e. signalling and download

[1] 3G: ideal micro-cell environment 348 kbps, TDD mode nominal 2 Mbps, high speed downlink packet access 10 Mbit/s. 2G/2.5G: bit rate limit 171 kbps, typical achievable 28-50 kbps.

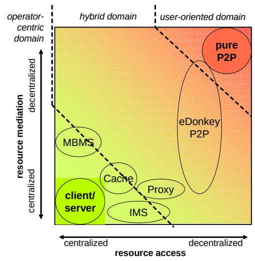

Figure 1: Classification of optional mechanisms for mobile P2P services

should be limited, since all mobile-to-mobile transmissions use twice the amount of air interface resources compare to mobile-to-fixed-network transmissions.

One of the most important requirements of mobile network operators is to maintain control over the network and to charge for provided services. Futhermore, operators would like to keep traffic in their own domain in order to avoid costs due to interdomain traffic. This is true for both mobile and fixed-line operators. The control mechanisms for a mobile P2P system must be carefully chosen in order to avoid designing a centralized system. Also the business model used for charging should comply with P2P applications, e. g., reward users for sharing. On the other hand, a mobile P2P system can benefit from the existing infrastructure of a mobile communication system. The network providers know the Location, online status and the service agreement of the mobile user, which might be useful to avoid signalling overhead and to increase service quality.

2 Solution Space for Mobile P2P Systems

An initial step in the design of a mobile P2P architecture is to find out on how current control or transport mechanisms of GSM/GPRS and UMTS can be used for providing mobile P2P services. The mechanisms are classified in terms of centralized/decentralized control and evaluated with respect to their usability for two fundamental synchronization and control functions of P2P applications: *resource mediation* and *resource access* (cf. Sec. 1). Fig. 1 provides a two-dimensional cartography, in which the basic P2P control functions form orthogonal axes and the degree of decentralization is used as the range of the axes. In addition, the cartography visualizes the architectural choices of operators and users for providing application services: the domain of *operator-centric* architectures, which is characterized by a strong centralization of control, and the domain of *user-centric* architectures, which reveals a strongly decentralized nature of control.

The suitability of five transport, control and synchronization mechanisms available or used in GSM and UMTS, Internet and P2P protocols are investigated with regard to mobile P2P. Pure P2P architectures were not considered here for mobile P2P since they are not efficient in signalling [Td03] and they do not easily meet the control requirements of mobile network operators.

The **IP Multimedia Subsystem (IMS)** is a infrastructure-centric enabler for multimedia services [IMS04]. IMS allows integration of presence and service-level information into the mediation function. It is able to provide *centralized mediation* services for a mobile P2P system. The IMS can efficiently organize direct connections between peers. For example, the access control may remain under the authority of the peers (*weakly decentralized access* control) except for improvements, e. g., better scheduling of resource access. IMS support could be used for reducing signalling traffic in a mobile P2P system. However, it is unclear how wired peers would collaborate with mobile peers unless they learn their IP address using SIP.

A **Cache** temporarily stores resources requested from dependent nodes. This mechanism is also applicable to file-sharing networks to minimize redundant traffic [LBBSS02]. In principle caching is an opposite concept to P2P systems, as it transfers access control from the network edge to network center (*weakly centralized access control*), which is controlled by the operator. But in a mobile scenario with expensive resources user control appears a less viable approach. The decentralized offering of user-provided content is not affected. As end-to-end communications between mobile devices utilize twice the air interface (cf. Sec. 1), caching P2P content close to the GGSN can decrease overall cost for transmitting popular files. Resource mediation is weakly centralized since caches should be ask first and then additional mechanisms locate the originating resource, this might be done decentralized. **Proxies** can be used as gateways between closed subnets and the Internet. Furthermore, proxies are able to control at *central* locations the communication between peers, e. g., for locating mediation entities in operator-supported mobile P2P networks.

The main features of the hybrid **eDonkey File-sharing Protocol** [E03] are: it doesn't rely on a single server, a file can be downloaded from several different peers at once (*swarming*), and files can be shared by a peer before they have been completely obtained (*decentralized resource access*). Peers exchange source information (*hording*).

3 The Mobile P2P Architecture

To meet the requirements of operator-managed services with P2P-based content distribution, a hybrid P2P architecture has been selected. The chosen architecture is based on the eDonkey P2P file sharing protocol, because of its popularity and its proven robustness. The eDonkey architecture has been enhanced by three additional components to meet the specific requirements of the mobile environment. The additional entities are *caching peers*, *crawlers*, and *proxies*.

The proposed architecture is shown in Fig. 2. All peers inside the mobile domain are served from one or more central index servers. End-to-end communications between peers connect through the P2P proxy or utilize a cache, depending on content popularity. The architecture enhances eDonkey signalling to include information, e. g. presence information, from the mobile network domain. The crawling peers support the index server with resources that are unknown in the operator domain.

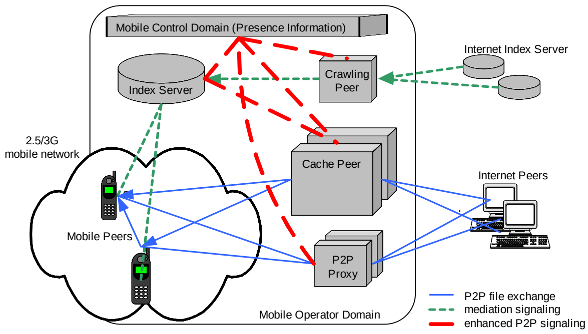

Figure 2: Mobile P2P Architecture Overview

Index Server. Our proposed design has a provider-operated *index server* which mediates resources inside the mobile infrastructure. Mobile peers are forced to connect to only this index server (proxy disallows other server connections). It favors local resources, and hides outside sources as far as possible. This should enable the operator to keep traffic inside the own network. Furthermore, the index server collects access statistics to support caching of popular files.

The **cache peer** stores popular files at the network core to reduce the amount of expensive air-interface usage. The peer cache owes it name to the fact that we recommend to implement it as an ordinary peer that has a special relationship with the index server. If the access characteristic measured at the index servers signals multiple downloads of a popular file, caching is initiated. For downloading of files, the cache peer uses the same mechanism as an arbitrary peer. As such, the completion of chunks is signalled to the index server, which informs the requesting peers.

Crawlers. Since mobile peers can only reach the index server in the operator domain, the index server should be able to locate any resource in the global P2P community. Normally, an indexing server would list files that are shared from directly-connected peers. Instead, the MoPi indexing server utilizes the *crawler* to request unknown resources from internet index servers.

The **P2P-Proxy** handles direct communications to outside hosts. It enables the peers to be contacted from outside peers, and as such fully participate in the global P2P community (e. g. eDonkey High-ID communication class [E03]). Users should be encouraged to use the P2P proxy (e. g. special traffic rates) to avoid the use of external index servers, which could undermine the caching functionality.

The proposed P2P components offer a value-added service. All components are optional, i. e. some operators would not offer content caching, but a mobile P2P service utilizing the index server, crawler and proxy to enforce using local resources. Our current development of integrated features in this architecture is still ongoing.

Other approaches range from simple solutions, like remote controlling via a mobile phone [M02] to complex models. Joltid [J03] caches resources but operates covertly, interfering all peer communication using “men-in-the-middle”. The Project JXTA is a support for J2ME (Java 2 mobile edition) describing a mobile P2P messaging mechanism. The NTT DoCoMo approach [KIS+03] uses one-to-one proxy elements to remedy mobile device restrictions. P2P topology information is also taken into account and provides an efficient multicast overlay. The P2P research group [IR04] of the IRTF is also currently working on mobile P2P fundamentals.

4 Conclusions

In this paper we have presented a new architecture for mobile P2P systems. We discuss the applicability of current access and mediation control mechanisms and as a result we introduced caching peers, crawlers and proxies as an enhancement to the eDonkey file-sharing system. With the eDonkey index server, these four components converge the resulting overlay network to the core structure in 2.5/3G networks. Our architecture combines fundamental P2P concepts with the requirements of mobile networks. Users remain in charge of access control, while the operator gains control on mediation of resources. Thus some of the P2P traffic can be kept within the operator’s network. Popular content will be cached at a central instance to reduce traffic and to remedy bandwidth shortages observed in today’s access networks. Unlike other mechanisms that oppress P2P traffic, our architecture offers a network-supported service that allows peers to cooperate with the global community.

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