Peer Support in a Mobile World

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1 Introduction

Even with the emerging technological advances, it is likely that in the near to medium term future the resources available to the mobile user will be at least a magnitude lower than that available to the wired user. The scarcity of resources such as bandwidth, battery power, and screen size pose fundamental challenges in developing effective wireless services. At the same time, the demand for such wireless services is growing rapidly. Users crave the freedom and flexibility in lifestyle that a wireless platform can provide and want similar electronic services to those available on wired platforms. Further, the next generation of electronic services will have significant multi-media content that will further stress the mobile infrastructure.

The data management and networking technology solutions proposed to overcome the severe physical constraints in a mobile environment have brought us several steps towards a pervasive mobile information and communication infrastructure. However, to continue keeping up with the emerging multi-media services, this position paper advocates that technological solutions need to be coupled with socio-economic techniques. The basic proposal is to develop and facilitate peering relationships between multiple mobile units so that they can collectively combat the problems in a resource-scarce mobile environment. The well known social phenomenon summarized in the phrase "Unity is Strength" needs to be embodied in future mobile environments. To achieve this goal, technology solutions are necessary that enable peering mobile units to collaborate on different levels. Further, social and economic models need to be developed that provide the incentive for mobile units that are contending for the same set of scarce resources to cooperate with each other and work towards the collective good.

In the rest of this position paper, the above ideas are further developed and the associated research topics are identified. Also, two examples are briefly described from recent research papers that employ the idea of peering in different contexts.

2 Collaborative Peering

Two mobile units are defined to be peers if they share the same mobile environment at a given time. Peer groups are dynamically formed as users congregate in work and social settings. This could be the case in an airport waiting lounge, or in the entertainment district of a city, or on a public transport vehicle. There can be many reasons for peers to collaborate. Below we discuss some of the commonalities between peer mobile units that motivate collaboration.

- **Peers share the same context:** The peers are co-located in the same location area, and they share the same context, at least geographically. Thus, geographic contextual information such as weather, traffic news, restaurant locations in the vicinity, breaking hot news items, etc. are all examples of information that could be shared between peers. This common set of interests presents a very natural reason to form peer groups. In the absence of good Internet connectivity, peers can collaboratively

use their caches and share information with each other. An example system of peers sharing their information in a mobile environment is described in [1].

- **Peers have limited resources:** The basic motivation is that in a resource scarce situation, mobiles can join forces to enter into peering agreements that enable them to pool their resources and complete a pending task.

  Limited Bandwidth: A fundamental challenge faced by the mobile user is the poor connectivity to the wired infrastructure with a relatively thin, sporadically lossy and sometimes unavailable data pipe. Each of the peers has a limited bandwidth connection to the Internet which by itself is insufficient for bandwidth hungry multi-media services. If peers collaborate to join forces and aggregate their individual available bandwidth, then more can be accomplished towards this goal. Examples of frameworks to enable sharing bandwidth are described in [2, 3].

  Limited Battery Life: Even with the best planning, it is possible for mobile units to find themselves with inadequate battery power and unable to complete the task at hand. This presents another opportunity for peers to collaborate. Since transmitting is more power intensive than receiving, an interesting research issue is to find ways to exploit this fact in delegating tasks to peers and get the required work done.

- **Peers have different expertise:** Mobility introduces more uncertainty but also presents new opportunities for producing better results. Mobile units equipped with different software often represent different computational capabilities and user skills. Thus, beyond lack of the necessary resource to complete the work, delagating tasks to peers could be guided by the quality and timeliness of the results. This is particularly important in establishing temporary alliances and outsourcing some of the tasks in a mobile commerce environment.

3 Support for Peering

To enable easy and flexible peering relationships, considerable infrastructure support is necessary. Below, a few of these research issues are described briefly.

- *Establishing Shared Context:* For any peer collaboration to take place, there is a need to establish a peer community with a shared context. Thus, mechanisms to discover peers and their capabilities in a seamless, distributed and power conserving manner are necessary. Towards this direction, subscribing/publishing data dissemination schemes can be combined with requesting/advertising workflow schemes. A key issue for interoperability and coordination among peers is the implementation of a context-catalog storing inherently distributed, application-specific and constantly changing metadata.

- *Data management support:* While there has been significant research work in developing mobile and disconnected data management protocols, the interactions typically proceed in a client-server fashion, with the identities of the participants known in advance. Data management (including update transactions) using peering is a promising research topic. As a starting point, data access protocols

such as the group locking mechanism [4] that involve cooperation between peer clients could be applied in this context with appropriate modifications. In contrast to the current cooperative protocols, peer protocols should be continually adaptive and profile driven. New language constructs are required to express personalized options offering a finer grain of control and balance between data availability and currency, the amount of wireless communication and the cost of maintaining consistency [5].

- *Socio-Economic models:* Ultimately, the success of such collaborative systems rests on the socio-economic incentive system that enables each of the peer systems to work for the common good. As has been shown in [6], free-loading is a serious problem in peer-to-peer systems such as Gnutella, where a large fraction of peers do not contribute to the system, and many that do contribute, do not have the most valuable resources. Thus, without an appropriate incentive system in place with rewards and penalties, effective resource trading will not occur and the peering mechanism will ultimately collapse. A strongly related issue that also needs to be effectively addressed is the sharing and pricing of proprietary data among peers.

- *Security and privacy support:* Enabling peers to interact directly has serious security and privacy implications. The heterogeneous peers may have different security frameworks and some may have none at all. In a highly dynamic environment where new and unknown peers appear and disappear in the environment, the most stringent security guarantees will be required for commercial success. At the same time, high overhead authentication protocols will make the system cumbersome to use. The balance of the above two issues presents a significant challenge.

- *QoS support:* Since the main focus of the peering arrangements is resource aggregation, effective resource aggregation mechanisms for a better overall quality of service (QoS) are necessary.

In summary, this position paper argues for collaboration between peer mobile units as a mechanism to solve some of the existing and emerging issues in mobile systems, and outlines some of the research issues in building such collaborative peering systems. This is an exciting and rich research area, but in addition to technological solutions, the socio-economic aspects of making collaboration work need to be studied.

References

[1] M. Papadopouli and H. Schulzrinne. "Effects of power conservation, wireless coverage and cooperation on data dissemination among mobile devices", *Proceedings of ACM SIGMOBILE Symposium on Mobile Ad Hoc Networking and Computing*, Oct. 2001.

[2] M. Papadopouli and H. Schulzrinne. "Network Connection Sharing in an Ad Hoc Wireless Network among Collaborative Hosts", *Proceedings of NOSSDAV*, Jun.1999.

[3] P. Sharma, S. Lee, J. Brassil and J. Lopez, "Dynamic Link Striping: Breaking the WAN Bandwidth Barrier in Piconets," *Proceedings of LAN/MAN workshop*, Mar. 2001.

[4] S. Banerjee and P. K. Chrysanthis, "Group Two-Phase Locking: A Scalable Data Sharing Protocol," *IEICE Transactions on Information Systems*, Vol.E82-D, No.1, pages 236–245, Jan. 1999.

[5] S.Weissman-Lausac and P. K. Chrysanthis, "Personalizing Information Gathering for Mobile Database Clients," *Proceedings of the ACM SAC 2002*, Mar. 2002.

[6] E. Adar and B. Huberman, "Free Riding on Gnutella," *First Monday*, vol. 5, no. 10, Oct. 2000.