Mobile Clouds: How to Find Opportunities

Mohammad Javad Salehi
Department of Electrical Engineering
Sharif University of Technology
Tehran, Iran
mjsalehi@ee.sharif.edu

Babak H. Khalaj
Department of Electrical Engineering
Sharif University of Technology
Tehran, Iran
khalaj@sharif.ir

Marcos Katz
Department of Electrical Engineering
University of Oulu, Oulu
Oulu, Finland
mkatz@ee.oulu.fi

Ghazal Fazelnia
Department of Electrical Engineering
Sharif University of Technology
Tehran, Iran
fazelnia@ee.sharif.edu

Parishad Karimi
Department of Electrical Engineering
Sharif University of Technology
Tehran, Iran
pkarimi@ee.sharif.edu

Javier Del Ser
Optima Area
Tecnalia Research and Innovation
Zamudio, Spain
javier.delser@tecnalia.com

***Abstract*—Smartphones can be regarded as resource pools which are capable of communicating with their outside world using both short-range and long-range links. Such communication capabilities provide a unique opportunity for sharing resources, resulting in new possibilities for end users. In this paper, we present a new data update and processing scheme, designed for local networks of mobile devices which are formed with resource sharing in mind.**

***Index Terms*—Mobile Local Networks; Mobile Clouds; Resource Sharing; Cloud Management.**

I. Introduction

Nowadays, the new trend in using cellphones is towards smartphones and at the same time, the introduction of new high-speed data networks such as HSPA and LTE has resulted in new services not available on old smartphones, e.g. cloud computing services. In these services, all devices connect to a number of powerful servers over the internet, and use their resources in order to provide users with new services. Now, what additional services can be obtained if such devices connect to each other instead of connecting to the remote servers, and share their *own resources* among themselves?

Throughout this paper, we will use the term **"Mobile Cloud"** for cooperative arrangement of mobile devices that have access to a central base station, in addition to their own local network. Such arrangements will provide the opportunity for sharing different resources, which results in new services. Although resource sharing in mobile clouds seems to be an attractive subject, different problems need to be solved before reaching a working platform. In our proposed framework, we focus on resource sharing only in one cloud and follow a centralized model in which all devices cooperate to determine one specific node as the cloud leader. Such leader would be responsible for all cloud-level decisions, as well as processing incoming data from all other nodes in order to find potentially suitable devices for sharing different resources. In this paper, we will also specifically focus on the data update procedure, and will propose a novel algorithm for processing all incoming data at the leader node.

II. Related Works

The main principles of resource sharing in mobile clouds are presented in [1] and [2]. In [3], a cooperative power saving strategy is proposed. In [4] and [5], cooperative methods for multimedia applications are studied. In [6], cellular-controlled short-range communication links are studied and new methods for bandwidth and power allocation are presented. In [7], cooperative web browsing for mobile phones is considered. In [8], high rate internet connection sharing using open Wi-Fi networks is studied, and in [9], a new Grouping Harmony Search (GHS) algorithm for enhancing such networks has been presented.

Protocols presented in Self-organized grouping (SOG) [10] can be used for managing mobility of the nodes in mobile clouds. Matchmaking algorithm [11] is another key protocol for resource sharing in grids, but suitable only for static topologies. In [12], a simple message interleaving idea is adopted to decrease the messaging overhead imposed on the network. This idea can impact the overall overhead in scenarios where constant messaging is needed.

III. The Proposed Algorithm

A. Data Update

In order to be able to determine which devices are suitable for resource sharing,the leader should be informed of different resources available in each device, as well as the processes running on them. Hence, all nodes in the cloud should send their resource information as well as tasks running on them regularly to the leader. The key point here is that not all status data change at the same rate, and also not all of them are of equal importance. We exploit such different change rates property and assign different update rates to each piece of information. In Figure 1, we have compared these two scenarios schematically. In this Figure, Type 1 messages contain slowest-changing data and Type 4 messages contain fastest-changing data. As can be seen in Figure 1, in the interleaving scenario we need to send about half data needed in the non-interleaving one.

978-1-4673-3125-8/12/$31.00 ©2012 IEEE

Mode 1	Type 1	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Type 2	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Type 3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Type 4	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Mode 2	Type 1	✔																		
	Type 2	✔			✔			✔			✔			✔			✔			✔
	Type 3	✔		✔		✔		✔		✔		✔		✔		✔		✔		✔
	Type 4	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Fig. 1. Interleaving (Mode 1) vs. non-interleaving (Mode 2) scenario

B. Data Processing

After receiving status data from other nodes present in the cloud, the leader node should process this data to find potentially suitable devices for resource sharing. For this goal, we first define an exact profile for each resource including criteria used for declaring a device suitable for sharing that resource. The leader will then use this information to create a complete mesh graph for each resource, whose nodes are potentially suitable devices for sharing that resource. All links in these graphs represent an opportunity for resource sharing between two nodes, and should be processed by the leader node.

For the leader node to be able to handle link processing properly, we use the following coloring scheme to distinguish between the states of each link:

1) Blue: The link is not processed yet.
2) Green: The link is processed promptly and opportunity for resource sharing is detected.
3) Red: The link is processed promptly and the opportunity is not found.
4) Black: The link is not processed promptly, i.e. timeout has occurred.

Based on this scheme, all links would have blue coloring at first. At each step, the leader node processes blue and black links in all graphs. Also, each green or red node becomes black after a given timeout period. The leader node would then introduce potentially suitable pairs of nodes to each other and the subsequent procedures will be performed by the nodes themselves.

IV. Performance Analysis

In order to analyze the interleaved messaging effect, let's suppose there are a total of N message types denoted by $t_1,\cdots,t_N$; such that t_1 messages contain slow-changing data, and t_N messages contain fastest-changing data. We also define the base time interval to be the time needed for updating t_N messages. By defining a_i, $(1 \leq i \leq N)$ as the multiples of the the base time interval needed to update t_i messages, we will have a_N=1, and $a_i > a_j$ for $i < j$. If we define $K_1(T)$ as the total number of messages needed for sending status information in non-interleaving scenario for a time duration of T base intervals, we will have:

$$K_1(T) = T \times N \tag{1}$$

In addition, $K_2(T)$, denoting the total number of messages needed for sending status information in interleaving scenario

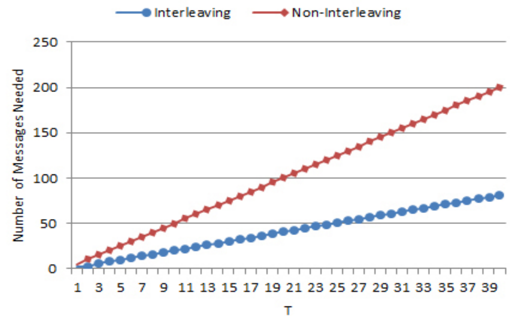

Fig. 2. Number of messages needed for information update in Interleaving and Non-interleaving scenarios.

for a time duration of T base intervals, would be equal to:

$$K_2(T) = \sum_{i=0}^{N} \frac{T}{a_i} = T + \sum_{i=1}^{N-1} \frac{T}{a_i} \tag{2}$$

In Figure 2, we have plotted (1) and (2) as functions of T. As can be seen here, number of messages needed in interleaving scenario is about half of that in non-interleaving scenario, which shows the efficiency of the interleaving concept.

For calculating the amount of processing overhead imposed on the leader, first we suppose that there is only one resource that can be shared among different nodes, and there are a total number of N nodes which can share this resource. These nodes have random movements, and hence with probability P their connection status might be changed at each step. If we define X(n) as the number of nodes which can share the resource and are connected to the cloud at step n, we will have:

$$X(n+1) = (1-P).X(n) + P.[N - X(n)] \tag{3}$$

Now, if we define Y(n) as the number of blue links which should be processed by the leader node at step n, we will have:

$$Y(n) = [(1-P)X(n).P(N-X(n))] + \binom{P(N-X(n))}{2} \tag{4}$$

We have also simulated the aforementioned behavior of nodes for different values of P and N, and compared the results with (4) in Figure 3. As can be seen from Figure 3, even for large values of N and P, i.e. N=40 and P=0.6, the number of links to be processed by leader node in each step is smaller than 200, which is quite reasonable according to high processing power in recent smartphones.

Subsequently, the processing of black links as well as blue ones is included in the simulation. The results are plotted in Figure 4. As can be verified from Figure 4, timeout has no considerable effect on the processing power needed in the leader node. The reason is the random movement of the nodes, which leads to disappearing nodes before the timeout occurs.

In the next step, we assume more general conditions, in which nodes can also change their capability of sharing a given resource at each step with a probability of P_C. Under these

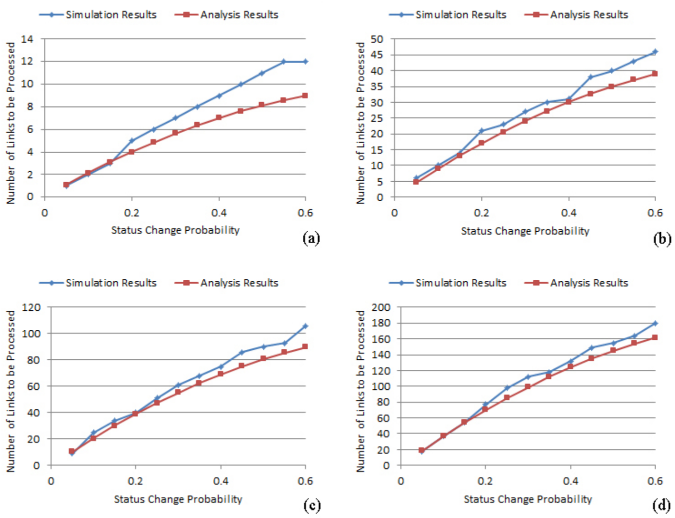

Fig. 3. Number of links to be processed by the leader node as a function of P, for (a) N=10, (b) N=20, (c) N=30, (d) N=40

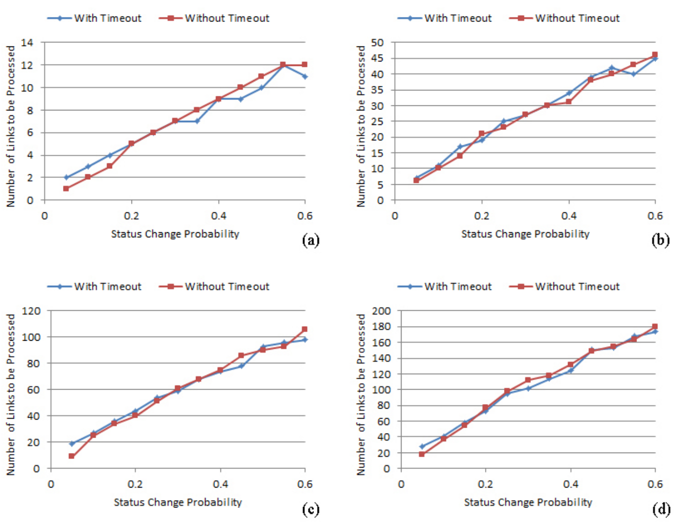

Fig. 4. Number of links to be processed in the leader node as a function of P, considering timeout in links, and for (a) N=10, (b) N=20, (c) N=30, (d) N=40

assumptions and for different values of P_C, we have plotted the results in Figure 5. As shown in Figure 5, number of links to be processed in the leader node increases as P_C increases.

As mentioned earlier, in our analysis, we have assumed only one resource. The effect of more resources can be easily incorporated by combining the results for individual ones.

V. Conclusion and Future Work

In this paper, we proposed and analyzed a data update manner as well as a data processing algorithm in the leader node, both targeted for resource sharing in the mobile clouds. The results demonstrate the feasibility of algorithms for small number of nodes, which is usually the case in mobile local networks.

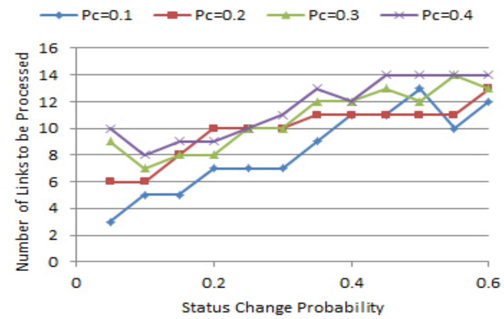

Fig. 5. Number of links to be processed in the leader node as a function of P, for different values of P_C

There are many other problems to be solved, such as consistent leader selection in mobile clouds and design of protocols needed for sharing each specific resource. Also, malware detection and incentive algorithms for creating mobile clouds are other two interesting topics which are currently under investigation.

References

[1] Qi Zhang, H.P. Fitzek, M. Katz, *Evolution of Heterogeneous Wireless Networks: Towards Cooperative Networks*, 3rd International Conference of the Center for Information and Communication Technologies (CICT) - Mobile and wireless content, services and networks - Short-term and long-term development trends, 2006

[2] F.H.P. Fitzek, Marton V. Pederson, M. Katz, *A Scalable Cooperative Wireless Grid Architecture and Associated Services for Future Communications*, European Wireless 2007, 2007

[3] F. Albiero, H.P. Fitzek, M. Katz, *Cooperative Power Saving Strategies in Wireless Networks: an Agent-based Model*, Wireless Communication Systems, 2007. ISWCS 2007. 4th International Symposium on, 2007

[4] F. Albiero, M. Katz, H.P. Fitzek, *Energy-Efficient Cooperative Techniques for Multimedia Services over Future Wireless Networks*, Communications, 2008. ICC 08. IEEE International Conference on, 2008

[5] Qi Zhang, H.P. Fitzek, M. Katz, *Cooperative Power Saving Strategies for IP-Services Supported over DVB-H Networks*, Wireless Communications and Networking Conference, 2007.WCNC 2007. IEEE, 2007

[6] F.H.P. Fitzek, M. Katz, Qi Zhang, *Cellular Controlled Short-Range Communication for Cooperative P2P Networking*, Wireless Personal Communications: An International Journal, Volume 48 Issue 1, January 2009

[7] G. P. Perrucci, F. H. P. Fitzek, Q. Zhang, M. Katz, *Cooperative Mobile Web Browsing*, EURASIP Journal on Wireless, Communications and Networking, Volume 2009, January 2009, 2009

[8] D. Leroy, G. Detal, J. Cathalo, M. Manulis, F. Koeune, O. Bonaventure, *SWISH: Secure Wi-Fi Sharing*, Computer Networks, Vol. 55, N. 7, pp. 1614-1630, May 2011

[9] I. Landa-Torres, S. Gil-Lopez, J. Del Ser, S. Salcedo-Sanz, D. Manjarres, J. A. Portilla-Figueras, *Efficient Citywide Planning of Open WiFi Access Networks using Novel Grouping Harmony Search Heuristics*, Accepted for its publication in Engineering Applications of Artificial Intelligence, May 2012

[10] A. Padmanabhan, S. Wang, S. Ghosh, R. Briggs, *A Self-Organized Grouping (SOG) Method for Efficient Grid Resource Discovery*, GRID 05 Proceedings of the 6th IEEE/ACM International Workshop on Grid Computing, 2005

[11] R. Raman, M. Livny, M. Solomon, *Matchmaking: Distributed Resource Management for High Throughput Computing*, HPDC 98 Proceedings of the 7th IEEE International Symposium on High Performance Distributed Computing, 1998

[12] S. S. Manvi, M. N. Birjie, *Device Resource Monitoring System in Wireless Grids*, ACT 09 Proceedings of the 2009 International Conference on Advanced Computing, Control, and Telecommunication Technologies, 2009