
Design, development and evaluation of a novel Mobile Cloud Computing framework to optimize the performance of emerging mobile networks

ABSTRACT

The proposed Ph.D. Thesis will elaborate on the study, development and evaluation of a novel Mobile Cloud Computing (MCC) framework, towards efficiently exploiting data mining schemes and algorithms to optimize the performance of emerging 5G mobile networks. More specifically, the proposed research will be emphasized on the study and the investigation of computationally intensive operations for effective resource offloading in future mobile network architectures. In addition, the social networking dimension will be considered to optimize the proposed framework and ease the process of the interactions.

INTRODUCTION

MCC constitutes a service model, towards extending the cloud to the edge of the networks [1]. In this context, numerous mobile devices are closely associated with their users, who, in return, are getting involved in many cloud activities that extend the cloud boundaries into the entire cyber physical system. Furthermore, authors in [1] mention that a feature of mobile cloud applications is the functional collaboration, while it is argued that this fact is able to have social extensions as the collaborations among mobile users can create a knowledge centre helping in their daily activities. In this direction, this research proposal is based on researching network data mining and analytics schemes and algorithms with a focus on data sources related to mobile networks, towards developing a novel framework, which will be adopted in emerging 5G mobile network architectures. Contribution to the expansion of the MCC field and, especially, in understanding how the extraction of information from data sets can be transformed into an understandable structure for further use are key points for the process of enriching the technological thesaurus. Additionally, considering these issues from a

Ph.D. Research Proposal

social viewpoint, will enable to understand and adapt requirements to the mobile users' needs, optimizing their Quality of Experience (QoE) and the Quality of Service (QoS).

RELEVANT RESEARCH LITERATURE

A few research efforts have been devoted considering the issues of MCC, mainly in terms of outlining the definition and explaining this emerging concept [2]. Initially, authors in [3], [4] and [5] give an overview of the MCC including definition, architecture and applications. The MCC concept is presented as an integration of the cloud computing into the mobile environment, solving problems that are faced in mobile computing in terms of performance (i.e. bandwidth), environment (i.e. scalability, availability) and security.

Dimlo and Chandrasekhar [6] and Huerta-Canepa and Lee [7] argue that cloud computing can constitute the external source that a mobile device needs, because of the fact that it is resource constrained, and suggest the creation of a virtual cloud computing platform using mobile devices, whereas authors in [8] and [5] indicate that cloud computing can potentially save energy for mobile users. Additionally, Zhang et al. [9] propose a new elastic application model enabling the augmentation of the capability of resource-constrained mobile devices by using cloud resources.

On the other hand, authors in [10] introduce the concept of allocation of the cloud resources in order to maximize the system rewards, taking into account the cloud resource consumption and incomes generated from the users, being an important issue and propose a Security Service Admission Model (SSAM) based on Semi-Markov Decision Process. Also, a mobile cloud data processing framework is presented in [11] from a trust management and private data isolation viewpoint.

Christensen [12] presents an analysis on smart phones, context awareness, cloud and restful based web services, and explains how these components can interact in order to create a better experience for mobile phone users. Furthermore, Chun et al. [13] present the design and implementation of CloneCloud, which is a system that automatically transforms mobile applications to benefit from the

cloud, aiming to speed-up the execution time and decrease the energy consumption spent on mobile devices. Finally, Marinelli [14] introduces Hyrax, which constitutes a MCC client allowing mobile devices to use cloud computing platforms in order to enable integration.

RESEARCH DESIGN AND METHODOLOGY

In the early stage, the research methodology will be based on previous published works made by the author applied to and associated with the MCC concept. In later stages, this methodology will be extended resulting to more advanced works. More specifically, the initial design principles of the proposed novel MCC framework can be similar to the ones used in [15].

Additionally, a prediction and quantification approach of the Technical Debt applied to the MCC field will be introduced related to the one in [16]. The presented equation below, which quantifies the Technical Debt in cloud service level, is characterized by generality and extensibility, indicating how customizable the formula can be by applying it in the MCC field and differentiating or adding more parameters accordingly [16]:

$$\begin{aligned}
 TD_i &= 12 * \left\{ \left(1 + \frac{\Delta\%}{\lambda}\right)^{i-1} * ppm * [U_{max} - (1 + \beta\%)^{i-1} * U_{curr}] - \left(1 + \frac{\delta\%}{\lambda}\right)^{i-1} * Cu/m \right. \\
 &\quad \left. * [U_{max} - (1 + \beta\%)^{i-1} * U_{curr}] \right\} \\
 &= 12 * [U_{max} - (1 + \beta\%)^{i-1} * U_{curr}] \\
 &\quad * \left[\left(1 + \frac{\Delta\%}{\lambda}\right)^{i-1} * ppm - \left(1 + \frac{\delta\%}{\lambda}\right)^{i-1} * Cu/m \right], \text{with } i = 1, 2, \dots, \lambda.
 \end{aligned}$$

Furthermore, once the proposed novel MCC framework aims to be adopted in emerging 5G mobile network architectures, this network architecture can incorporate principles for optimal and balanced provision of multimedia services, exploiting a resource prediction system simultaneously. A similar approach is proposed in [17] enabling the long-term prediction of multimedia services future demands, based on the history of previous network resources usage.

Ph.D. Research Proposal

Finally, this work aims to be extended in specific research topics, which will be the following:

- Design, development and performance evaluation of schemes and algorithms adopted in 5G mobile computing networks.
- Study of social networking models for efficient exploitation in the proposed MCC framework.
- Data mining techniques applied to emerging mobile systems design.
- Human mobility and connectivity models for future mobile users.
- Algorithms and protocols for 5G mobile networks and systems.

SIGNIFICANCE AND ORIGINALITY OF RESEARCH

MCC is a very intriguing and emerging subject with a transdisciplinary nature. However, only a small number of research efforts have been devoted, considering the issues of MCC. Henceforth, it is deduced that the need to conduct research related to MCC issues from a network data mining viewpoint is imperative, because of the research gap that exists. By developing and evaluating a novel MCC framework along with researching the extraction of information from data sets and transforming it into an understandable structure for further use associated with the MCC, will enable to contribute to knowledge providing new and useful work to other researchers in this field.

TIMESCALE (PROJECT MANAGEMENT)

In order to successfully fulfil the research project goals, each task is planned and organised in such a way that there will be efficient time in order to be analysed, practiced, executed and evaluated. The research project schedule, including the tasks performed, is presented briefly in the table below (Table 1).

Ph.D. Research Proposal

Table 1. Brief presentation of the project schedule including the tasks

Task Name	Duration	Start	Finish
Outlining specific research directions – Preliminary research design development - Submission of papers in International Scientific Conferences with High Impact Factor (i.e. IEEE ICC, IEEE Globecom, IEEE Infocom etc.).	1 year	09/10/2014	09/10/2015
Submission of papers in International Scientific Journals and Conferences with High Impact Factor (i.e. IEEE ICC, IEEE Globecom, IEEE Infocom etc.).	1 year	10/10/2015	09/10/2016
Submission of papers in International Scientific Journals and Conferences with High Impact Factor (i.e. IEEE ICC, IEEE Globecom, IEEE Infocom etc.) - Writing up of the Ph.D. Thesis.	1 year	10/10/2016	09/10/2017

REFERENCES

- [1] D. Huang, "Mobile cloud computing," *IEEE COMSOC Multimed. Commun. Tech. Comm. MMTC E-Lett.*, vol. 6, no. 10, pp. 27–31, 2011.
- [2] N. Fernando, S. W. Loke, and W. Rahayu, "Mobile cloud computing: A survey," *Future Gener. Comput. Syst.*, vol. 29, no. 1, pp. 84–106, 2013.
- [3] H. T. Dinh, C. Lee, D. Niyato, and P. Wang, "A survey of mobile cloud computing: architecture, applications, and approaches," *Wirel. Commun. Mob. Comput.*, vol. 13, no. 18, pp. 1587–1611, 2013.
- [4] M. Goyal and S. Singh, "Mobile Cloud Computing," *Int. J. Enhanc. Res. Sci. Technol. Eng.*, vol. 3, no. 4, pp. 517–521, Apr. 2014.
- [5] P. Bahl, R. Y. Han, L. E. Li, and M. Satyanarayanan, "Advancing the state of mobile cloud computing," in *Proceedings of the third ACM workshop on Mobile cloud computing and services*, 2012, pp. 21–28.
- [6] U. F. Dimlo and R. Chandrasekhar, "Mobile Cloud Computing," *Int J. Adv. Comput. Electr. Electron. Engg.*, vol. 3, no. 1, pp. 271–276, Mar. 2014.
- [7] G. Huerta-Canepa and D. Lee, "A virtual cloud computing provider for mobile devices," in *Proceedings of the 1st ACM Workshop on Mobile Cloud Computing & Services: Social Networks and Beyond (MCS '10)*, San Francisco, California, USA, 2010, p. 5.
- [8] K. Kumar and Y.-H. Lu, "Cloud computing for mobile users: Can offloading computation save energy?," *Computer*, vol. 43, no. 4, pp. 51–56, Apr. 2010.
- [9] X. Zhang, A. Kunjithapatham, S. Jeong, and S. Gibbs, "Towards an elastic application model for augmenting the computing capabilities of mobile devices with cloud computing," *Mob. Netw. Appl.*, vol. 16, no. 3, pp. 270–284, 2011.
- [10] H. Liang, D. Huang, L. X. Cai, X. Shen, and D. Peng, "Resource allocation for security services in mobile cloud computing," in *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*, Shanghai, 2011, pp. 191–195.
- [11] D. Huang, Z. Zhou, L. Xu, T. Xing, and Y. Zhong, "Secure data processing framework for mobile cloud computing," in *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*, Shanghai, 2011, pp. 614–618.
- [12] J. H. Christensen, "Using RESTful web-services and cloud computing to create next generation mobile applications," in *Proceedings of the 24th ACM SIGPLAN conference companion on Object oriented programming systems languages and applications - OOPSLA '09*, New York, USA, 2009, pp. 627–634.
- [13] B.-G. Chun, S. Ihm, P. Maniatis, M. Naik, and A. Patti, "Clonecloud: elastic execution between mobile device and cloud," in *Proceedings of the sixth conference on Computer systems (EuroSys '11)*, Salzburg, Austria, 2011, pp. 301–314.
- [14] E. E. Marinelli, "Hyrax: cloud computing on mobile devices using MapReduce," DTIC Document, 2009.
- [15] G. Mastorakis, E. Markakis, E. Pallis, C. X. Mavromoustakis, and G. Skourletopoulos, "Virtual Network Functions Exploitation through a Prototype Resource Management Framework," in *Proceedings of the 6th IEEE International Conference on Telecommunications and Multimedia (TEMU2014)*, Heraklion, Crete, Greece, 2014, pp. 24–28.
- [16] G. Skourletopoulos, R. Bahsoon, C. X. Mavromoustakis, G. Mastorakis, and E. Pallis, "Predicting and Quantifying the Technical Debt in Cloud Software Engineering," in *Proceedings of the 19th IEEE International Workshop on Computer-Aided Modeling Analysis and Design of Communication Links and Networks (IEEE CAMAD 2014)*, Athens, Greece, 2014, (under review).
- [17] Y. Kryftis, C. X. Mavromoustakis, J. M. Batalla, G. Mastorakis, E. Pallis, and G. Skourletopoulos, "Resource Usage Prediction for Optimal and Balanced Provision of Multimedia Services," in *Proceedings of the 19th IEEE International Workshop on Computer-Aided Modeling Analysis and*

Ph.D. Research Proposal

Design of Communication Links and Networks (IEEE CAMAD 2014), Athens, Greece, 2014, (under review).