Decision Management and Object-oriented Protocol and Services Reconfiguration in Future Internet Autonomic and Heterogeneous Telecommunication Environments

Eleni Patouni[1]

[1] Department of Informatics & Telecommunications,
University of Athens, Athens, Greece,
elenip@di.uoa.gr

Abstract. In recent years, the vast evolution in telecommunication systems is remarkable, as regards the fast development and incorporation of new technologies in the heterogeneous networking environment. One major issue concerns the complexity management in user connectivity, in relation with two fundamental alternative solutions: the development of interworking functions for handovers between heterogeneous systems and the introduction of mechanisms for dynamic adaptation and reconfiguration. This phd thesis focuses on the second solution, which is called to overcome the design limitations of the first one. Specifically, the addressed issues concern the introduction and impact of reconfiguration in local (per device) and network levels, for the component-based dynamic adaptation of mobile devices and network elements. In the context of this thesis, special emphasis is paid on the specification and the detailed design of the reconfiguration deployment in the protocol stack and the service level, using object-oriented models. In addition, the mechanisms' evaluation and assessment was realized locally in the mobile devices, as regards the possibility of their deployment and the feasibility of the approach. Special focus was paid on the global evaluation and assessment of the introduced mechanisms for protocol reconfiguration in the heterogeneous network environment, taking into account different types of mobile devices with varying capabilities: reconfigurable and autonomous mobile devices.

Keywords: Reconfiguration, Protocol Component, Decision Making, Requests Management, Load

1 Dissertation Summary

Following the rapid proliferation in the development of Future Internet technologies and the increased complexity of telecommunication systems (mainly mobile and wireless), a major arising problem concerns the seamless mobility and the increased user QoS needs between these systems. In addition, a key challenge related

---

[1] *Dissertation Advisor: L. Merakos, Professor*

to the abovementioned developments in heterogeneous systems, is the introduction of flexible mechanisms for increased complexity management in the user connectivity.

In this direction, two major alternative solutions have been emerged: the first one concerns the introduction of interworking functionalities for handovers execution between heterogeneous systems and the second one concerns the introduction of dynamic adaptation and reconfiguration mechanisms [1]-[5]. The first solution is inline with the traditional approaches for the introduction of novel functionality in the underlying telecommunication infrastructure. As proven in the literature, this approach raises several limitations compared to the gradual incorporation of new radio access technologies and also imposes "domino" effect in the specification of telecommunication protocols for each access subsystem. The second solution is able to overcome the abovementioned limitations –at the same time the introduction and specification of mechanisms for reconfiguration realization is required (clean-slate approach).

This thesis deals with issues that are related to the introduction and impact of reconfiguration in local (per device) and network levels [6],[7]. This analysis deals with the specification, the detailed design and the evaluation of the object-oriented protocol stack and services reconfiguration approaches as regards their application/deployment. It should be noted that Future Internet autonomous and heterogeneous telecommunication environments are considered. Specifically, we propose a novel framework that allows the dynamic adaptation of mobile devices and network elements. It is worth noting that two alternatives have been developed, the first one is based on reconfigurable protocols while the second one proposes the introduction of intelligence through autonomous components. The mechanisms evaluation and assessment was realised locally in the mobile devices and has proven the applicability and the feasibility of the approach [7],[8]. Next, special focus was paid on the overall evaluation and assessment of the introduced mechanisms for protocol reconfiguration in the heterogeneous networking environment.

The overall evaluation and assessment has taken into account the existence of different types of mobile devices with different capabilities, considering two main categories of mobile devices: reconfigurable and autonomous. Such categories are distinguished mainly based on their capabilities for local decision making between the available alternatives (handover, protocol reconfiguration or joint solution for both handover and protocol reconfiguration). The local decision is then validated by the network side. Therefore the assessment and evaluation of these mechanisms in the overall heterogeneous networking environment has focused on the management of the produced decision-making requests originating from two categories of mobile devices [6].

As a whole, the introduced innovative mechanisms capture the two fundamental aspects of the reconfiguration procedure in mobile devices and network elements: a) the component-based, dynamic adaptation and reconfiguration of the protocol stack and the local evaluation and assessment and b) the overall evaluation for selecting the best alternative for the devices' connectivity (e.g. handover, protocol stack reconfiguration). The two abovementioned technical challenges form the two fundamental technical aspects of this thesis.

In detail, after studying the evolution of mobile telecommunication systems and highlighting their limitations, we present the future heterogeneous mobile telecommunication systems, their fundamental capabilities and their objectives. Such analysis also raises the technical challenges that form the framework of this thesis. Next, we introduce a methodology for the introduction and specification of the necessary functionalities for the protocol reconfiguration/self-configuration framework and the overall decision-making and management of the devices' connectivity in the heterogeneous networking environment. The initial analysis is realised using scenarios, deriving case studies and finally specifying the functionalities and the respective capabilities. Next, we specify and evaluate the framework and mechanisms for component-based protocol/services reconfiguration, considering two types of components, reconfigurable and autonomous and focusing on their dynamic binding and replacement during runtime. At this point, it should be noted that the introduction of dynamic reconfiguration capabilities in the protocol stack subsystem increases its flexibility but inevitably incurs performance penalties. In this direction, the qualitative and quantitative analysis of such mechanisms examines the applicability of the design approach.

As regards the second technical challenge, the decision-making approach for mobile devices' reconfiguration is specified, analysed and evaluated both on mobile devices and heterogeneous radio-network environments. The first case focuses on examining the alternative protocol configurations and identifying the best configuration. The cognitive decision-making approach for mobile devices is modelled using fuzzy-logic [9]. The produced results reveal that the introduced mechanisms do not affect the responsivity of the device or the user experience. Concerning the second case, we introduce and analyse the system model and the algorithmic framework for the network decision-making and management, as regards mobile devices' adaptation in heterogeneous radio-network environments [6]. We consider two main adaptation alternatives, handover and protocol reconfiguration. Two types of mobile devices are also assumed in our system: reconfigurable and autonomous. The goal of this analysis is to guide the mobile devices relocation for realising load balancing. In addition, the qualitative and quantitative evaluation of the introduced mechanisms and algorithmic framework is realised. The results also reveal that that transition to learning-capable dynamically self-managed mobile devices yields more efficient management of the decision-making requests. Moreover, the simulation results show the gain of using the proposed concepts in a system, in terms of applying load balancing techniques for requests management. Results show the number and percentage of dropped requests versus the amount of mobile devices and other key parameters. The outcome of this analysis reveals a quite unexpected conclusion: the introduction of autonomicity in the devices adversely impacts the requests management process in the network. The analysis quantifies how increasing the autonomicity level of the mobile devices affects the network load. At the same time, we propose a mechanism for maximizing the percentage of requests handled by the network, compared to the percentage of dropped requests. Moreover, our work reveals the degree of performance deterioration caused by increasing the autonomicity level in the management of requests [6].

1.1 Related Work

One path in achieving flexibility and intelligence in the systems and addressing the heterogeneity and complexity challenges, is realised through the emerging visions of reconfigurability, cognition and autonomic networking [1],[2],[3],[3] and [5]. The latter bring forward new adaptation capabilities in the different layers of the protocol stack and system resources. Such aspects have been addressed in the literature. Specifically, adaptable protocol stacks are seen as a technological enabler of next-generation networks which leverage the introduced adaptation and customization capacities to achieve two main goals: the dynamic adjustment of protocols' operation mode and the performance optimization of the operating protocols/protocol stacks. Such targets have been the main research objective of various approaches, which are classified into the following three main categories - a detailed survey analysis on dynamically adaptable protocol stack frameworks is available in our work in [10].

- Adaptable protocols: This design approach introduces an extension protocol layer besides the generic part, for the implementation of custom protocol functions. This category employs a coarse granularity design since the fundamental design unit is a protocol layer or a set of them. Adaptable protocol stack frameworks include Conduits, JChannels and POEM [10].

- Composable protocols: this concept employs flat, hierarchical and graph-based models for building a customizable protocol/protocol stack out of fundamental protocol functions. Composable protocol stack frameworks include DiPS/CuPS , x-kernel, Coyote/Cactus, Appia, Ensemble, Horus, RBA, Da CaPo, ADAPTIVE, DRoPS, DIPS+, ACCORD and DPS [10].

- Reconfigurable protocols: This design allows for extending the traditional protocol stacks' composition schemes to support the dynamic binding and replacement of protocol components or even entire protocol layers during runtime, enabling service continuity and no loss of protocol data. Reconfigurable protocol stack frameworks include THINK, FRACTAL, GRPSFMT, DRAPS and Alonistioti [10].

At this point it should be noted that our approach falls under the category of reconfigurable protocols. The main advantage of our work is the detailed specification of a framework enabling the dynamic, semantic-based binding and replacement of protocol components during runtime operation of the protocol stack. In addition, the necessary support and state management mechanisms were defined, targeting transparency, robustness and seamless operation.

The reconfiguration decision-making procedure imposes significant research challenges, which have been the objective of some research activities. [9] presents issues related to the management and control of reconfigurable radio systems, also addressing the decision-making procedure. In [6], we model a reconfigurable system as a distributed transactional system and examine the global bounds of the asymptotic network response time and throughput. Our work uses multiclass queuing networks for the system model and is based on the findings by Balbo and Serazzi [11], [12] and Litoiu [13], [14] for the derivation of the network bottlenecks and the bounds of the response time under asymptotic and non-asymptotic conditions. Besides them, several approaches have been addressed for the development of approximation techniques to estimate performance measures such as queue lengths, sojourn times and throughput. The use of approximation techniques has greatly facilitated estimation and optimization of performance measures in finite queuing networks. Some of the defined optimization approaches in finite queuing networks are used in addressing some of these problems, as in [15], [16], [17] and [18]. In the aforementioned approaches the implications of reconfiguration decisions in network level are not addressed. Moreover, the system bounds for each framework are not discussed in consideration of the overall load and reconfiguration overhead in conjunction with the user and device classes and respective request patterns. In conclusion, the introduction and adaptation of such methods in order to discuss optimization issues in autonomic and reconfigurable telecommunication systems has not been considerably investigated in the literature and forms one of the key directions of this paper.

2 Results and Discussion

This section presents the key concepts and results of the second technical challenge addressed in this thesis. The first challenge is not elaborated herein due to space limitations - details are available in [7],[8] [19],[20] and [21].

2.1 Algorithmic Framework for Handling Decision-making Requests

The goal of this analysis is the definition and evaluation of the algorithmic framework for handling decision-making requests for protocol reconfiguration. The key phases of the algorithmic framework are presented in Figure 1.
The key metric of the proposed algorithmic framework is the user satisfaction metric, which forms a function of the network response time [6]. First of all, we define as network response time the response time experienced by a mobile device making a decision-making request to the network side. We differentiate the network response time per class of mobile devices. Therefore we define the response time of class c R_c as the response time experienced by a class c mobile device making a decision-making request. We also define as user satisfaction SA_c, the normalized distance of the network response time R_c from the maximum value of the response time $R_c^{\max}$ to the interval of the maximum response time minus the minimum response time $R_c^{\min}$. Therefore, user satisfaction is analysed as follows:

$$SA_c = \frac{R_c^{\max} - R_c}{R_c^{\max} - R_c^{\min}} \tag{1}$$

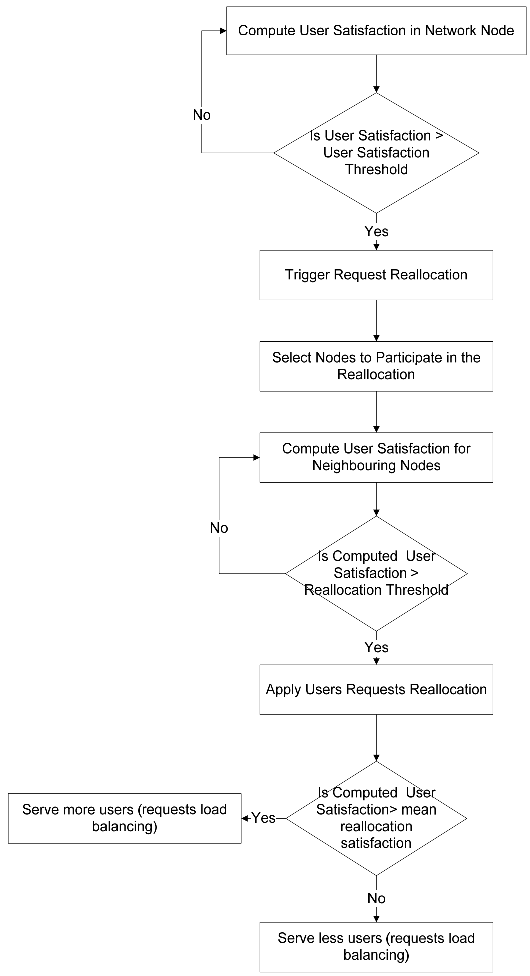

Figure 1: Flow diagram of the algorithmic framework for handling decision-making requests

At this point it should be noted that the maximum and minimum values of the response time are not static but dynamically varying based on the number of the decision-making requests and the average time between requests. For a given system, the response time and the respective maximum and minimum values of the response time can be computed using mean value analysis (MVA), an iterative technique for the analysis of closed queuing network models [17],[18]. This technique allows the computation of various performance metrics (e.g. response time) of any number of users iteratively (it introduces customers into the queuing network one by one, the cycle terminates when all customers have been entered).

However the computational complexity of MVA is very high and the storage requirements increase for networks with high numbers of mobile devices and classes. Therefore, instead of computing the user satisfaction, we compute an approximate value of the user satisfaction. This is realized by computing the bounds of the maximum and minimum response time. Therefore, the approximate value of user satisfaction is given below:

$$\overline{SA_c} = \frac{R_c^{Up} - R_c^{Ms}}{R_c^{Up} - R_c^{L}} \tag{2}$$

In this direction, the computation of user satisfaction requires to also compute the upper and lower bounds of the network response time and measure the network response time. To realize the bounds computation, we consider the analysis by Litoiu and Balbo, Serrazzi 1210],[12],[13],[14] and propose a methodology and respective analytical model for the computation of the approximate value of the user satisfaction metric. Such methodology concerns the bounds computation for the response time for distributed systems with multiple resources and workload mixes. The details on the methodology and analytical model for the bounds computation can be found at [6].

2.2 Results

The algorithmic framework for handling decision-making requests was evaluated through simulations. The simulations were realized using MATLAB Simulink tool. In this work, we developed four network nodes that manage the decision-making requests originating from mobile devices; such devices include both reconfigurable and autonomous mobile devices. In addition, we developed two separate load balancing systems that handle the decision-making requests per class.

At first, the use of the presented algorithmic framework was evaluated. Specifically, the user satisfaction degree is dynamically computed per class of mobile devices, using the outcomes of the previous subsections for the global bounds of the network response time for the case study system. Each of the network nodes is considered as a system with the same resource demands with the one analysed in [22].

In addition, in order to approach the behavior of a real system as regards the dynamic alteration of the network response time, we consider that it follows a gamma distribution.

Specifically, given a randomly generated value R_g, the next generated value follows a gamma distribution (as in [23]) in the interval [A, B], where $A = R_g - e$ and $B = R_g + e$, $e = \frac{R_c^{Up} + R_c^{L}}{\alpha}$. The shape parameter for the gamma distribution equals to $(\frac{A+B}{2}) \Big/ b$, where b is the scale parameter. R_c^{Up} and R_c^{L} are the upper and lower bounds of the network response time respectively computed for the specified number of mobile devices and think time. a is an integer – for this simulation work we consider that $a \in [2,5]$. In addition, if $A < R_c^L$ then $A = R_c^L$; correspondingly if $B > R_c^{Up}$ then $B = R_c^{Up}$. This way A and B are always within the upper and lower bounds of the network response time. It should be also noted that each network node behavior can be dynamically altered during simulation, e.g. the number of mobile devices can be changed due to low balancing actions. Therefore, the global bounds of the network response time are dynamically computed for each class of mobile devices (using equations (15) and (17) in our analysis in [6]).

An important metric in this work is the think time metric, which represents the average time between requests and therefore affects the response time and respective bounds (details on the computations are available in [6]). In this model we define the think time z as the time interval between two handover or reconfiguration decision requests. Therefore

$$z = \frac{1}{E_{HO}} \tag{3}$$

where E_{HO} is the expected number of handovers in a system. Based on the analysis in [24], E_{HO} is a function of the call-to-mobility ratio denoted as ρ . E_{HO} is given below considering that the ratio of Access Routers (ARs) to Mobility Anchor Points (MAPs) equals 1.

$$E_{HO} = \frac{1}{\rho^2} + \frac{1}{\rho} \tag{4}$$

Therefore, the think time z for both classes of mobile devices is analysed as follows:

$$z = \frac{1}{\frac{1}{\rho^2} + \frac{1}{\rho}} \tag{5}$$

Next using equation (2) the user satisfaction is also dynamically computed for each class of mobile devices N. For the simulation, we consider that the user satisfaction threshold is 0.075. If the user satisfaction is found to be lower than this threshold, then the requests reallocation procedure is triggered. We also consider that the reallocation threshold of the nodes is 0.3 – this means that the nodes with user satisfaction lower than this value do not participate in the reallocation procedure. Thereafter, the reallocation procedure is applied following the concepts. The mean reallocation satisfaction is computed and the nodes with lower value than the mean reallocation satisfaction should allocate a percent of the serving mobile devices to the nodes with higher user satisfaction than the mean reallocation satisfaction. Simulation results include the dynamic variation of the total number of mobile devices per class, due to the load balancing procedure. It should be noted that the load balancing system may fail to reallocate some requests and drops them - this is expected when the negotiation procedure fails, e.g. when the satisfaction threshold of all nodes is lower than 0.3.

In addition, we can dynamically compute if node requests are dropped and the actual percent of the times the load balancing system has to drop some requests over the total execution times of the load balancing. Secondly, the absence of the presented algorithmic framework in the same system was evaluated. More specifically, we consider that the mobile devices generate requests to the mobile nodes; we measure the network response time and using the global bounds of the response time derived from the analytical model we dynamically compute the user satisfaction. Since in this system we consider the absence of the proposed algorithmic framework for load balancing, we simply measure the user satisfaction over the simulation per class of mobile devices and we assume that when user satisfaction equals zero, then 5% of the node requests are dropped.

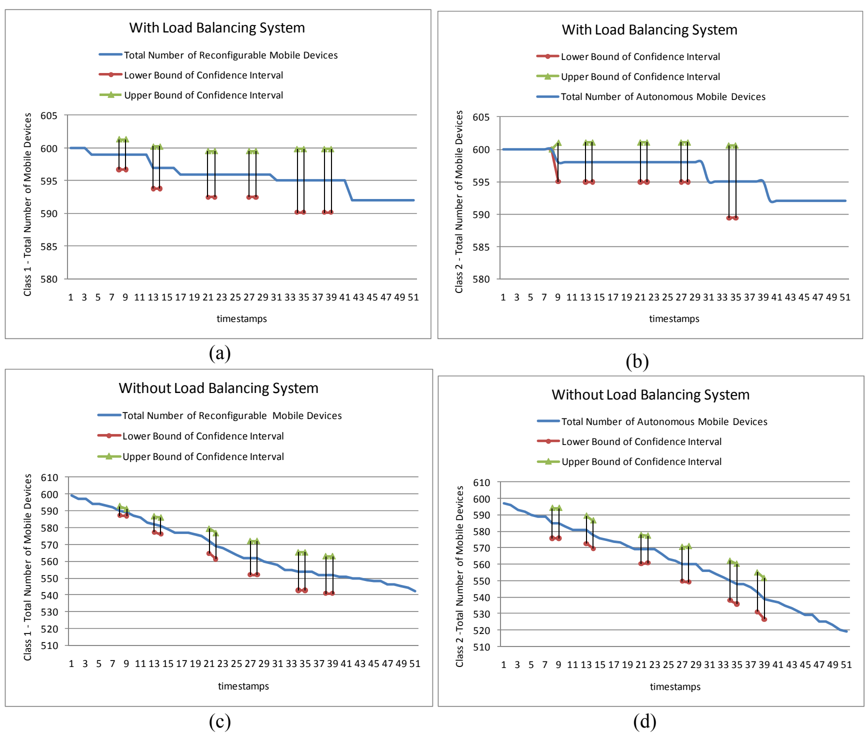

Figure 2: Total number of mobile devices: a) applying the load balancing system for reconfigurable mobile devices, b) applying the load balancing system for autonomous mobile devices, c) without applying the load balancing system for reconfigurable mobile devices, d) without applying the load balancing system for autonomous mobile devices

Figure 2 presents the variation of the total number of mobile devices for each class (also including the respective 95% confidence intervals), both with and without the application of the load balancing system. As seen in Figure 2 a and b, the application of the load balancing system results in dropping 1.33% of the total number of mobile devices (8 out of 600), whereas a legacy system results in dropping 9.67% of class 1 requests and 10.17% of class 2 mobile devices (58/600 and 61/600 respectively), as seen in Figure 2 c and d. At this point we should note how the type of mobile devices affects the load balancing behavior. The results show that the introduction of the load balancing system leads to the same behavior in terms of requests handling and dropping for both reconfigurable and autonomous mobile devices. Such outcome is quite unexpected and reveals that the optimization of the load balancing system is request- independent. In addition, if we consider the absence of load balancing system, we come to the conclusion that the system tends to drop more requests coming from autonomous mobile devices compared to the requests generated by reconfigurable mobile devices. This outcome of our analysis reveals one drawback of the introduction of autonomicity/intelligence in the mobile device.

In addition, simulation results include the load balancing failure percent when the load balancing system is applied– that is the percent of times the load balancing fails to reallocate the user requests over the total number of load balancing triggers. This percent was derived from simulation results versus the total number of mobile devices and the user satisfaction factor.

As analysed in [6], both classes of mobile devices have similar load balancing failure percentages, which do not increase in a linear manner as the number of mobile devices increases. The highest percentage is presented for mobile devices values between 200 and 300 – this also varies based on the SA threshold. Such low values of load balancing failures are expected since the load balancing system fails to reallocate the requests only when all system nodes are saturated (node SA lower than user satisfaction threshold) or close to being saturated (node SA lower than reallocation threshold). Again, we observe that the autonomous mobile devices tend to have greater load balancing failure percentages compared to reconfigurable mobile devices.

Conclusions

Reconfigurability is seen as one of the strong candidate concepts for the support of the convergence of heterogeneous systems, the evolution and migration of future communication systems, and the introduction of substantial flexibility in mobile systems. Furthermore, reconfigurability provides the ground for the development of yet more advanced concepts like cognitive and autonomic communications. In order to meet these expectations, a major issue is to establish a framework for enabling reconfiguration in all protocol layers, as well as plug-and-play solutions for protocol stack formation and activation. In this thesis, a generic architecture, respective interfaces, protocols and mechanisms for protocol stack and protocol component synthesis have been designed, implemented and illustrated. Finally, performance issues have been studied and the key performance metrics of protocol reconfiguration have been evaluated and discussed. Based on the quantitative and qualitative design considerations set for the protocol reconfiguration attributes, as well as the discussion on limitations of other related frameworks, the proposed generic architecture satisfies the requirements related to flexibility, delay overhead, generic protocol component design, as well as plug and play capabilities.

In this thesis, we have also discussed the modeling and the impact of the network decision making process regarding handover and protocol reconfiguration in a heterogeneous networking environment, assuming two classes of mobile devices. The thesis has proposed an algorithmic framework for the management of the decision making requests for reconfiguration or handovers. Simulation results have also been presented for the alternative applications of the algorithmic framework for request relocation in a system, in terms of the percentage of reconfiguration or handover requests handled or dropped by the network. The outcome of this analysis shows how the increase in the autonomicity level of mobile devices affects the network load. Our work provides proof and tangible results of theoretical assumptions and statements relevant to the gains and applicability of autonomicity concepts for the first time in the literature, also addressing the pros and cons of introducing autonomicity in the mobile devices. Future work includes the extension of the presented concepts to advanced load balancing schemes (e.g. use of learning schemes) that will enable more proactive management of the decision-making requests handling.

References

1. M. Dillinger, K. Madami and N. Alonistioti, “Software Defined Radio – Architectures, Systems and Functions”, Wiley series in Software Radio, 2003, ISBN 0-470-85164-3.
2. J. Mitola III, “Cognitive Radio for Flexible Mobile Multimedia Communications”, Mob. Netw. Appl Journal, vol. 6, no.5, 2001, pp. 435–441.
3. S. Haykin, “Cognitive Radio: Brain-Empowered Wireless Communications”, ”, IEEE J. Sel. Areas Commun., vol. 23, no. 2, Feb. 2005, pp. 201–220.
4. S. Dobson, S. Denazis, A. Fernández, D. Gaïti, E. Gelenbe, F. Massacci, P. Nixon, F. Saffre, N. Schmidt and F. Zambonelli, “A survey of autonomic communications”, ACM Trans. Auton. Adapt. Syst, vol.1, no. 2, 2006, pp. 223-259.
5. J. O. Kephart and D. M. Chess. "The Vision of Autonomic Computing," IEEE Computer, vol. 36, no.1, 2003, pp. 41-50.
6. E. Patouni, N.Alonistioti and L.Merakos, “Cognitive Decision Making for Reconfiguration in Heterogeneous Radio Network Environments”, in IEEE Transactions on Vehicular Technology (TVT), special issue on “Achievements and the Road Ahead: The First Decade of Cognitive Radio, vol. 59, issue 4, May 2010, pp. 1887-1900.
7. E. Patouni, S. Gault, M. Muck, N. Alonistioti, K. Kominaki, “Advanced Reconfiguration Framework based on Game Theoretical Techniques in Autonomic Communication Systems”, Annals of Telecommunication Journal, vol. 62, no. 9-10, 2007, pp. 1099-1120.
8. N. Alonistioti, E. Patouni, V. Gazis, “Generic architecture and mechanisms for protocol reconfiguration”, Mobile Networks and Applications Journal, Special Issue on Reconfigurable Radio Technologies in Support of Ubiquitous Seamless Computing, vol. 11, no. 6, December 2006, pp. 917-934.
9. A. Merentitis, E. Patouni, N. Alonistioti and M.Doubrava, “To Reconfigure or Not to Reconfigure: Cognitive Mechanisms for Mobile Devices Decision Making”, in the

Proceedings of the 68th IEEE Vehicular Technology conference, 21–24 September 2008, Calgary, Alberta,

10. V.Gazis, E.Patouni, N.Alonistioti and L. Merakos, “”A Survey of Dynamically Adaptable Protocol Stacks”, IEEE Communications Surveys and Tutorials, vol.12, no.1, January 2010, pp.3-23.
11. G. Balbo, and G. Serazzi, “Asymptotic analysis of multiclass closed queueing networks: multiple bottlenecks”, Performance Evaluation Journal, v.30 n.3, Sept. 1997, pp.115-152.
12. G. Balbo, and G. Serazzi, “Asymptotic analysis of multiclass closed queueing networks: common bottleneck”, Performance Evaluation Journal, vol.26, no.1, Jul. 1996, pp.51-72.
13. E Marin Litoiu, “A performance analysis method for autonomic computing systems”, ACM Transactions on Autonomous and Adaptive Systems, vol.2 n.1, March 2007, p.3-es.
14. M. Litoiu , J. Rolia anu d G. Serazzi, “Designing Process Replication and Activation: A Quantitative Approach”, IEEE Transactions on Software Engineering, vol.26, no.12, Dec. 2000,pp.1168-1178.
15. R. Onvural, “Survey of closed queueing networks with blocking”, ACM Comput. Surv. vol. 22, no.2, 1990, pp. 83-121.
16. H. G. Perros, “Queueing networks with blocking- a bibliography”, ACM Sigmet. Perform. Eval. Rev, vol. 12, no. 2, 1984, pp. 8-12.
17. J. M. Smith and S. Daskalaki, “Buffer space allocation in automated assembly lines”, Op Res., vol.36, no. 2, 1988, pp.343-358.
18. L. Kerbache and J. MacGregor Smith, “Asymptotic behavior of the expansion method for open finite queueing networks”, Comput. Ops Res., vol. 15, no.2, 1988, pp.157-169.
19. E. Patouni, O. Holland and N.Alonistioti, “Cognitive Functionalities for Mobile Terminal Self-Recovery and Protocol Auto-Configuration”, in the Proceedings of the IEEE International Symposium on Personal, Indoor and Mobile Radio Communications 2008 (PIMRC 2008), 15-18 September 2008, Cannes, France,
20. E. Patouni, S. Gault, M. Muck, N. Alonistioti, K. Kominaki, “Autonomic Communications: Exploiting Advanced and Game theoretical Approaches for RAT Selection and Protocol Reconfiguration”, in the Proceedings of the Autonomic Networking Conference, Paris, France, September 2006.
21. E. Patouni and N. Alonistioti, A Framework for the Deployment of Self-Managing and Self-Configuring Components in Autonomic Environments, in the Proceedings of the International IEEE WoWMoM Workshop on Autonomic Communications and Computing (ACC 06) , Niagara-Falls / Buffalo-NY, 26-29 June, 2006
22. P. Magdalinos, S. Polymeneas, P.Gliatis, X. Fafoutis, A. Merentitis and C.Polychronopoulos, “A Proof of Concept Architecture for Self-Configuring Autonomic Systems”, presented at the ICT-MobileSummit 2008 Conf., Stockholm, Sweden, June 10 – 12, 2008.
23. K. Y. Jo and S.R. Ali, “Design and analysis of large-scale wireless communications networks”, in Proc. of the ACM Int. workshop on Performance monitoring, measurement, and evaluation of heterogeneous wireless and wired networks, New York, NY, USA, 2006, pp.18-24.
24. T.C. Schmidt and M. Waehlisch, "Analysis of Handover Frequencies for Predictive, Reactive and Proxy Schemes and Their Implications on IPv6 and Multicast Mobility", in Proc. ICN 2005. 4th International Conference on Networking, Part II, ser. Lecture Notes in Computer Science, P. Lorenz and P. Dini, Eds., Berlin Heidelberg: Springer-Verlag, vol. 3421, pp. 1039-1046, Apr. 2005.