Abstract

Entrepreneurs, infrastructure providers, service operators and carriers are targeting the service, application and infrastructure unification over an all Internet Protocol (IP) platform while providing access technology convergence. Distinctive business goals and varying service logic in addition to distinctive resource requirements alongside scalability and extensibility over such converged infrastructure has to be addressed. Intra/Inter domain knowledge set over distinctive planes (application, service, control and network/transport) has to be induced, inherited and overridden. A decision-making system supporting dynamicity is required to handle such a platform effectively and efficiently. Multi Criteria Decision Making (MCDM) is used for decision-making framework. Ontology is used to model the structural hierarchy and semantics capturing. Ontology’s inability to capture uncertainty is complemented by Bayesian mapping. Software Defined Network Controller (SDNC) on the basis of the proposed framework is developed for multimedia call/request/session routing by using embedded hardware. System exhibits greater throughput with lesser call/session/request dropping probability at the expense of a susceptible delay. Moreover system latency with and without SDNC in provisioning and outsourcing modes are compared and evaluated.

© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).

Selection and peer-review under responsibility of Conference Program Chairs

Keywords: Policy-Based Network Management (PBNM); Quality of Service (QoS); Service Level Agreement (SLA); Multi Criteria Decision Making (MCDM) theory; Topology; Software Defined Networking (SDN); Call Dropping Probability; Throughput; Jitter

1. Introduction

Unified communication complements an all Internet Protocol (IP) infrastructure. Entrepreneurs currently are approaching towards the unified IP solutions by subscribing different access technology links from several distinctive service providers. The ultimate goal however is to provide any service, any time, anywhere over any device with reliability, redundancy generating decent revenues for vendors, network operators, service providers, carriers and businesses over an infrastructure while using the underlying resources effectively and efficiently. Controlled resource management and effectual infrastructure administration is a step forward towards this intent. However rule-based network management and control does supplement the administration of such heterogeneous and converged networks. But frequent variation, business logic maneuvers, service logic adaptation, global rules over the converged platform,
Policy-Based Network Management (PBNM) is another dimension to address the aforementioned issue of application, service, resource, business logic and infrastructure control and management. The underlying PBNM mechanism however is passive. But the dynamicity over the unified infrastructure, frequent variations over distinctive planes, service logic modifications, business logic change management and global rule adaptations has to be handled actively leading towards the dynamic management framework. Conventional network control and management involves managing two important entities; communication and behavior. The communication of corresponding entities over the service, control and network planes over a unified platform almost remains the same. However behavior of these devices has to be altered depending upon their planer location; e.g. router within the core will behave differently than the same router at the edge of the platform. The underlying behavior management becomes more complex over unified and converged architecture with frequent variations. The situation becomes more mingled when a device is situated at the intersection of two planes or lying at the border of the platform. Moreover, correlation functions among the mentioned communication and behavioral dimensions of different modules must be captured. So different techniques and theories have to be integrated and blended in order to address the multi dimensional network control and management problem.

Legacy network management/administration techniques, control technologies and methodologies cannot assure the required Quality of Service (QoS). Furthermore the performance requirements of unified services (voice, video, data, triple-play, quadruple etc.) over the converged system require diverse resources with varying set of QoS metrics. However, diversity of network control and management mechanism due to the subsequently stated technology merger (i-e wire-line and wireless resources and access technology unification) in addition to distinctive vendors fusion while offering different business logic introduce more obscurity. The root-causes of the said complexity are as follows: unified applications, distinct services, miscellaneous devices, classified equipment, homogeneous and heterogeneous transport technologies, signaling and control protocol stacks etc. In order to overwhelm the mentioned intricacy, to master the technology heterogeneity and to accomplish the service unification; the infrastructure management and control procedures has to converge all the multi-dimensional control and management information coming from distinctive sources with different granularity. The diversity and extent of the induced communicational and behavioral knowledge-base poses a multi-criter(i-on/ia) problem with multiple business objectives reflecting the global policies/rules over the infrastructure. These intentions are wrapped up by capturing the corresponding local/global knowledge base from different planes/domains over the unified and hybrid architecture posing multiple business objectives that are correlated with diverse technological and contextual infrastructure. This miscellaneous knowledge-base along with multiple planer goals in addition to different set of administrative configurations over the proposed framework has to be exploited dynamically.

In turn, the unified framework computes the policy/decision/rule for dynamic control and management. The computed rules/policies/decisions govern the behavior of the underlying framework by enforcing these rules/policies/decisions at macro granularity (call/session/request level) over the platform (shown in Fig.1).

Conventional frameworks to address the aforementioned dynamic management and control issues take technology-oriented and technology-independent information into account exclusively (devices, interfaces, protocols, architecture, topology etc. related to the physical infrastructure). However, the application related data sets, service specific metrics over the service plane, control orientations and procedures over the control plane, transport relevant metrics at the border of the multi-homed heterogeneous platform must be considered in addition to the technology dependent and technology independent data. The systems considering the business objectives may not be able to function at higher granularity (application/service/session/request level). Moreover the systems targeting the issues stated above might not be able to provide required dynamicity for effective and efficient control and management.

Platform’s multi-dimensional, multi-facet and multivariate information domains (constituting the corresponding planes) are synchronized locally but they are asynchronous globally shaping up the Globally Asynchronous Locally Synchronous (GALS) system. The static and dynamic knowledge-base (inter/intra-domain/planer/layer cross-domain/planer/layer) over the framework are termed as intrinsic and extrinsic information corresponding to those distinct planes/domains constituting the multi criteria problem with multiple objectives. Moreover the information sources representing different domains (e.g. service, control, transport and network planes) might be highly structured and orchestrated locally (inter-domain/plane) but may have higher probability of asynchronous and un-structured information repre-
sentation globally (intra-domains/planes). QoS profiles of the links, authentication/authorization information, Service Level Agreements (SLA) compliance and traffic management issues at private-public network border constitute a multidisciplinary problem. The information coming from different sources with different dimensions reflects the complexity over the platform. The multi-dimensional information is handled by MCDM while the inter/intra domain semantics are captured by ontology while the planer and behavioral uncertainty is addressed by Bayesian.

Space limitation forces us to present the core dynamic decision-making mechanism within the framework. The ingredients of the decision-making framework include the information model, semantics capturing, representation of its communicational, behavioral and functional features and components. Information sharing and dissemination for the control and management of the dynamic framework is an important constituent of the framework and is carried out by revamping the signaling protocols (e.g. Session Initiation Protocol (SIP)\(^1\), Diameter\(^2\) and SNMP\(^3\)). Language, an integral component of the underlying framework is deeply rooted inside the framework. It sticks all the constructs, micro/macro rules, business objectives and administrative instructions. Dynamic Decision-making while complementing the Software Defined Networking Controller (SDNC) and its enforcement in two different modes for call/request/session routing at the private-public network border is emphasized solely in this work.

The rest of the paper is organized as follows: Next Section outlines the platform’s architecture. Section 3 describes the MCDM, its tuning and integration for the application over the framework. Section 4 validates the proposed solution by presenting the experimental setup and observations. Section 5 presents the related work and finally section 6 concludes the paper with future work remarks.

2. Proposed Architecture

Divergence of access network technology, service and application unification, different business logics from diverse operators, scalability and adaptability over an infrastructure characterize the requirement of management at the network border while taking into account the core network data. Knowledge base orientations from the aforementioned distinctive domains need effective and efficient data manipulation with dynamic infrastructure control. This is what is targeted in one of the modules (Policy Server encompassing the core of the decision-making framework) over the proposed architecture.

The architecture shown in Fig. 1 provides a cost effective converged platform while highlighting the application/service unification. It focuses the network border traffic management issues with application, service, business logic and technology unification. The devices and modules from different vendors are integrated over a single platform. Moreover diverse services from public (internet) and private (local) networks all together are converged onto the unified architecture. The core objective is the accommodation of dynamic modifications/variations during the decision-computation (decision-making). Additionally multiple criteria extracted from the contextual information, planer variations, inter/intra domain induced data and inter plane/domain semantics complement the former decision-making for efficient control and management of a multi-homed platform. Enhanced conventional mechanisms and techniques are used to avoid the overheads and compatibility issues. Application, service, control, network/transport and routing issues pose a multi-criteria problem. They are handled together by using classical layered approach without affecting standard mechanisms.

Data server along with Application Servers (AS) creates the service plane. Call Server (CS), Session Border Controller (SBC) and Policy System/Server (PS) constitute the control plane. The wireline and wireless access technology convergence at the private-public network border embodied the network/transport plane over the unified architecture.
Some of the functions and/or mechanisms over the planes are overlapping (some of control and transport responsibility is shared by SBC and PS while sitting at the edge of the platform). Detailed information about the modules, components sub-modules/sub-components, the inter/intra communication and their corresponding behaviors over the proposed framework are available in 4.

Policy system manages the multi-application, multi-service and multi-vendor platform provisioning the diverse technology merger with greater dimensionality while detaching the distinct planes (application, service, control and transport planes). Decoupling mechanism of the underlying planes guides the system to distribute Call Admission Control (CAC) functionality. Profile and resource based CAC functions are being handled at CS and SBC respectively. SLAs, business logic, routing rules, application data, services information, links (accesses) latest states (QoS etc.) and profiles are taken into account for decision computation. QoS of the external links are gauged by analyzing the captured metrics via SNMP5 traps (shown in figure 1). Tweaked Diameter2 protocol is chosen for information sharing and dissemination between PS and SBC. More details about Diameter and its application over the platform are available in 6. In order to avoid complexity routing rule computation (by taking into account all the knowledge base from different information domains and the variations taking place over the proposed architecture) at the network border is focused in this paper while emphasizing the multimedia communication. Multi Criteria Decision Making (MCDM) theory is used to address the multi criteria problem targeting multiple objectives. Moreover it has to accommodate the varying set of attributes and parameters. Global and local intra-domain and inter-domain knowledge-base over different planes (application, service, control and network/transport) is handled by ontology modeling. Ontologies however are incapable of uncertainties apprehension over the aforementioned distinctive planes. Bayesian is thus integrated with ontology in order to capture the uncertainties over the said planes.

3. Decision-Making Framework

MCDM, the core component of the decision-making framework, is highlighted while introducing the rest of the ingredients precisely (except the lingua franc, the language over the platform that is an ongoing work). MCDM encompasses choosing the best alternative, given a set of alternatives (outbound/inbound available links over the architecture). The set of criteria (data deduced from the service logic, business logic, predefined configurations/settings over the proposed platform, dump of the platform current and latest resources in addition to the contextual information) and sub criteria (in case of voice the service and business logic sub-criteria metrics might be Jitter, Cost, Time of the Day) are established from the infrastructure, contextual information, dynamics over the platform and a-priori rules. Moreover the application and service profiles, reciprocal and straight SLAs, QoS, layer 2 (OSI model) technology convergence have to be handled qualitatively and quantitatively. Additionally the user profiles and the corresponding authorization and authentication have to be dealt subjectively. The parameters extracted qualitatively, quantitatively and subjectively in addition to the subsequently mentioned issues constitute a multi-criteria problem with multiple objectives. Multifaceted orientation of the attributes, parameters with multiple diversity do not allow direct application of MCDM methods. Their tuning, tweaking and integration is indispensable.

Layered and planer approach is followed for corresponding mapping of diversifying datasets. Information fusion, metrics deduction and parameter extraction from the application, service, control and business logic in addition to the feedback for frameworks stability is presented in Fig. 2. The G’s, C’s and A’s with the obvious subscripts are the corresponding goals, criteria and alternatives respectively over these distinct layers presenting the relevant information. The underlying mapping compliments the hierarchy construction by outlining the goals, setting the criteria, sub-criteria and alternatives. Fig. 2 highlights the deduction of the corresponding goals, criteria/alternatives metrics,
business logic and policies from distinctive planes (service, application, control network and transport, access technology planes). Decision Matrix (DM), (Eq. 1) presents a simple use-case having 7 set of attributes (columns; criteria) and 5 distinct links (rows; alternatives) that are inferred and/or extracted over the framework for the application of MCDM methods.

$$\begin{bmatrix}
AT_A1 & D_1 & J_1 & PLR_1 & TB_1 & AB_1 & CP_1 \\
AT_A2 & D_2 & J_2 & PLR_2 & TB_2 & AB_2 & CP_2 \\
AT_A3 & D_3 & J_3 & PLR_3 & TB_3 & AB_3 & CP_3 \\
AT_A4 & D_4 & J_4 & PLR_4 & TB_4 & AB_4 & CP_4 \\
AT_A5 & D_5 & J_5 & PLR_5 & TB_5 & AB_5 & CP_5
\end{bmatrix} < - L_1$$

Access Technology Attribute $AT_A$, Delay ($D$), Jitter ($J$), Packet Loss Rate ($PLR$), Total Bandwidth ($TB$), Available Bandwidth ($AB$) and Contextual Parameter ($CP$) respectively characterize the consequent column vectors (vertical) illustrating the corresponding criteria within the DM. Row vectors (horizontal) represent 5 links $L_1$, $L_2$, $L_3$, $L_4$ and $L_5$ respectively each having the 7 metrics (criteria columns). MCDM methods are tweaked and integrated for their application. The alternative links are graded and ranked. Calls/sessions/requests are routed to these graded links keeping in the ongoing context, pre-configured policies and business logic over the infrastructure. More details about the application of MCDM methods can be reached at 7.

MCDM theory over the framework can handle the multiple objectives along with distinct attributes/parameters coming from diverse sources reflecting the assorted dimensionality. But inter-planer and intra-planer relationships, semantics variants, knowledge inference, information deduction and frequent variations cannot be addressed merely by deploying the MCDM theory. At present the issue is addressed by integrating ontology with MCDM. Though ontology development is not within the scope of this work and it is not possible to present the ontology on a piece of paper representing even a particular domain. Snapshot of an SLA, service, QoS and MCDM ontologies however is shown in Fig. 3. But frequent dynamics over the infrastructure, application, service, control and transport planes coinciding and inter-intra domains uncertainty and instances variations can not be taken into account by ontology only. Ontology mapping by using Bayesian addresses the mentioned issue 8,9. The snapshot of blending ontology with Bayesian is shown in Fig. 4. Modular diagram of the system intending the MCDM, ontology and Bayesian integration is shown in Fig. 5. Business objectives, application/service logic orientations are defined over the infrastructure a-priori. Novel context is triggered at the arrival of each session/request/call. Moreover change up to a predefined threshold over the platform reflects a contextual change resulting in the overloading and overriding of new rule set. Consequent ontologies are inherited. Ontology feedback augments the hierarchy induction throughout the ontology overloading and the Bayesian feedback stabilizes the overall system while fading the uncertainty strongly. A controlled trigger bus concatenates the system modules and components.

4. Experimental Setup for System Validation

The proposed system has the ability to manage all kinds of traffic. SIP-based multimedia traffic (voice and video apps and services) however is emphasized. Computed decisions are enforced at private-public network border in sourcing and provisioning modes for call/session/request routing dynamically. Decision-making framework manages routing and flow control at higher layers thus enabling the intelligent and dynamic networking leading towards the development and deployment of Software Defined Networking Controller (SDNC) sitting at the edge. SDN primar-
operations at lower cost. Framework’s dynamic decision-making routing is complemented by SDNC’s native switching/forwarding capability. SDNC; part of the decision engine over the proposed infrastructure grabs the network and transport planes datasets sitting at the edge while taking into account the infrastructure’s core datasets by induction, deduction and reasoning at application, service and control planes. SDNC that facilitates the higher layer dynamic routing cab be detached from the decision engine accordingly depending upon the administrative configuration and infrastructure requirements. Decoupling of the planes (application, service, control and network/transport planes) complements the novice business logic adaptation, rapid deployment of innovative functions, improved amalgamation of applications, services and IT processes while taking into account the infrastructure variations and fluctuations are the key features and hence facilitating the dynamic control and management. Upper part of the Fig. 6 elaborates the complexity of the underlying platform showing the associated planes, the layered approach adopted over the architecture, corresponding mapping of applications, services, network control and management functions and interfaces. The bottom portion of the Fig. 6 shows conventional rigid management with tight coupling of the planes and the modified management and control mechanism complemented by the proposed framework. SDNC supplements the decoupling process. Decision-making framework overrides the SDNC in order to decouple the control and management plane from routing/forwarding/switching (note that the routing here is not typical and conventional routing rather its dynamic routing at higher layers i-e. at application and/or service layer).

SIPp$^{10}$ is used to generate extensive multimedia service requests (SIP INVITE). OpenSIPS$^{11}$ is tweaked to act as SoftSwitch and SBC respectively. Master SBC is tuned to act as Policy Enforcement Point (PEP) while supplementing its built-in functionality. More particulars about the information sharing, role of the devices, interfaces and modules over the framework for decision-making at private-public network border are available in$^{7}$. Adapted MCDM methods (Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)$^{12}$, Extended TOPSIS and Grey Relational Analysis (GRA)$^{13}$ are incorporated with AHP$^{14}$). Tuned, integrated and modified MCDM methods are applied over the platform shown in Fig. 11 (7 criteria metrics representing 5 alternative links (Eq. 1)). PS operating as Policy Decision Point (PDP) is provisioned for online and offline decision computation depending upon the administrative configuration of the system. Throughput, Call Dropping Probability (CDP) and Delay are plotted using these integrated methods and are shown in Fig. 7. Experimental results show better throughput for distinctive links. Moreover substantial decrease in aggregated call drop (Fig. 8) is also observed. The substantial throughput increase and reasonable call drop is due to the fact that now the proposed decision system is taking into account contextual dynamics and variation with multiple objectives by considering the inter/intra-domain and inter/intra-plane dependencies along with semantic and relational dynamics. Moreover the linguistic quantification of the business objectives and other administrative and configurational parameters by Saatys scale (AHP integration with the 3 MCDM methods) assists in factual and true numerical conversions while taking planer inter-dependence into account. TOPSIS and Extended TOPSIS must show well-defined disparity regarding aggregated CDP. Moreover Extended TOPSIS accommodates the dynamics over the infrastructure while capturing uncertainty in addition to upper and lower bounds of an attribute. But the curves for these two methods show almost identical behavior while overlapping at some points. The similarity and conduct of these two methods is due to the fact that the experiments are performed over the test bed using simple use case having few metrics with
limited dynamism. A complicated use case can establish a clear distinction between used MCDM methods regarding CDP. Extended TOPSIS throughput surpasses the neighboring MCDM methods twice due to the fact that the upper and lower bounds translate qualitative and quantitative behavior effectively. Aggregated GRA throughput of 5 distinct links shows significantly better value than other MCDM methods. Since GRA takes into account latest platform’s conditional and environmental information in addition to contextual data. The cost of this improvement is an add-on delay system has to bear while computing the decisions shown in Fig. 9. The reasoning and inference with semantics dynamics and context of the ongoing request/call are the main causes of additional delay. Moreover the intra-domain/plane correlations and semantics dynamics are also sources of add-on delay. System shows linear behavior for delay evaluation i.e. delay rises as the number of calls rises. Moreover the call-delay introduces no or little impact on multimedia services due to the fact that decisions are calculated and enforced during call setup time span. System latency with and without SDN controller is evaluated and compared in provisioning and outsourcing (online and offline) modes (Fig. 10.). SDNC is gluing the orthogonal traffic engineering principles at the border of the platform in addition to the call/request/flow classification/marketing/tagging mechanisms. In order to accomplish this binding it has to take into account the core network control plane information in addition to network/transport plane information over the border. The former and latter are the root causes of the aforementioned latency in the two modes. Outsourcing mode requires more resources than provisioning mode due to adaptations dynamics and variants. Moreover on-the-fly outsourcing setup has to capture the real-time conditional and environmental infrastructural datasets. Additionally SDNC is accommodating the whole stake (lower and upper layers data) alongside the mentioned information. Hence on-the-fly outsourcing mode shows highest latency.

5. Related Work

Rule based management and control frameworks have been characterized by different forums, standard bodies and authors (i.e. IMS by 3GPP, ITU and ETSI, Autol by EU FP7 IST, FOCALE etc.)\textsuperscript{15,16,17}. MCDM\textsuperscript{18} and ontology\textsuperscript{19} are used independently and autonomously for PBNM. Objective weights are generated by using AHP\textsuperscript{20}. Semi dynamic network management is presented in\textsuperscript{21}. GRA and AHP are integrated for asset allocation in stock exchange\textsuperscript{22}. But to the best of our knowledge, there is no reported work that uses MCDM, ontology integration while capturing uncertainty by ontology-Bayesian mapping and SDNC for dynamic network management and control. IMS, an existing solution however generates extensive signaling and control traffic due to its inherited and native layered approach, distinctive control interfaces and diverse information sharing at a fine granularity. Authentication, authorization and accounting functionality integration might create security loop holes with other interfaces. The proposed solution in
this work can avoid this massive signaling and control traffic as it works at different granularity (i.e. call, session and/or request level rather than individual packets). It provides decision-making and its enforcement at higher OSI layer (Application and/or Session layer) while taking into account lower layers data.

6. Conclusions

A decision-making framework with dynamicity support has been proposed. Dynamic routing of multimedia sessions/calls/requests at private-public network border by enforcing the computed decisions (outsourcing and provisioning modes) over the platform is investigated. Test bed that supports flexibility, adaptability and extensibility is developed. Service, control and network/transport planes are dealt with independently and exclusively in order to isolate the operational, business, technology dependent and technology independent procedures and processes. SDNC binds the traffic classification/marketing tagging mechanisms (on call/request/flow level rather than individual packets) and traffic engineering principals at the private-public border (both mechanisms are orthogonal) while complementing the dynamic routing at higher layers. It is aware of the network border information sitting at the border while taking into account the application, service and control plane data. Ontology is used to capture the semantics variations over the infrastructure. Tweaked MCDM methods (TOPSIS, Extended TOPSIS and GRA are integrated with AHP) are applied over the framework. Inability of ontology’s uncertainty modeling is handled by Bayesian mapping. The system supports online and offline decision computation. Higher throughput and aggregated lower CDP is observed at the bearable cost of susceptible delay. SDNC that uses the proposed framework is scalable, extensible, flexible and easy to embed within conventional network devices and interfaces (core, border and edge devices and interfaces for dynamic control) offering centralized dynamic management.

A dedicated language that stems from the integrated framework for the specification of goals, criteria, alternatives, business rules, routing policies, ontologies and network programming all together is an ongoing work.

References

1. J. Rosenberg, SIP: Session Initiation Protocol, IETF-RFC 3261 (June 2002).
2. V. Fajardo, Diameter Base Protocol, IETF-RFC 6733 (October 2012).
3. B. Wijnen, D. Harrington, R. Presuhn, Architecture for Describing SNMP Management Frameworks, IETF-RFC 2271 (January 1998).
4. S. A. Musthaq, A Framework Implementing Multi-Criteria Least Cost Routing for IP Multimedia Services, PhD Dissertation, INFO - Dépt. Informatique (Institut Mines-Télécom-Télécom Bretagne-UEB) (January 2012).
5. S. Boros, Policy-Based Network Management (PBNM) with SNMP, IETF-RFC 3460 (Oct 2000).
6. S. A. Musthaq, C. Lohr, A. Gravey, Decision engine for sip based dynamic call routing, in: AIMS’11, Springer-Verlag, Berlin, Heidelberg, 2011, pp. 86–99.
7. Sajjad Ali Musthaq, Christophe Lohr, Annie Gravey, An Integration of Semantics in Multi Criteria Decision Making for Converged Multi-Media Network Management, IEEE GlobeCom Dec, 5-9 Houston, Texas USA (2011).
8. G. Pilato, A. Augello, M. Missikoff, F. Taglino, Integration of ontologies and bayesian networks for maritime situation awareness, in: Semantic Computing (ICSC), 6th International Conference on, 2012, pp. 170 –177. doi:10.1109/ICSC.2012.25.
9. S. Mittal, A. Aggarwal, S. Maskara, Application of bayesian belief networks for context extraction from wireless sensors data, in: ICACT, 14th International Conference on, 2012, pp. 410 –415.
10. SIPp: Test Tool Traffic Generator for the SIP Protocol; http://sipp.sourceforge.net.
11. F. E. Goncalves: Building Telephony Systems with OpenSIPS 1.6; 2010.
12. C. Hwang, K. Yoon, Multiple Attribute Decision Making Methods and Applications, Springer Verlag, New York, 1981.
13. T. Saaty, The Analytical Hierarchy Process (1980).
14. AUTOI, Autonomic Internet, EU FP7 IST Project ((http://ist-autoi.eu/autoi)).
15. K. Odagiri, S. Shimizu, N. Ishii, M. Takizawa, Theoretical suggestion of policy-based wide area network management system (wdacs system part-i), in: NBiS, 15th International Conference on, 2012, pp. 268–275. doi:10.1109/NBIS.2012.11.
16. G. Xiao, X. lin Ji, R. qing Zhang, Research on semantic expression methods of management policy in multi-agent based nms, in: ICCM, 8th International Conference on, Vol. 1, 2012, pp. 361–365.
17. H. Pervaz, A multi-criteria decision making (mcdm) network selection model providing enhanced qos differentiation to customers, in: MCIT, International Conference on, 2010, pp. 49 –52. doi:10.1109/MCIT.2010.5444854.
18. W.-T. Tsai, Q. Shao, Role-based access-control using reference ontology in clouds, in: ISADS, 10th International Symposium on, 2011, pp. 121 –128. doi:10.1109/ISADS.2011.21.
19. V. Dostal, MISSION TO MARS, MIT USA (Spring 2003).
20. K. Odagiri, S. Shimizu, M. Takizawa, N. Ishii, Concept of policy-based wide area network management system, in: ICIS, IEEE/ACIS 11th International Conference on, 2012, pp. 253–258. doi:10.1109/ICIS.2012.38.
21. F. Salardini, An AHP-GRA method for asset allocation: A case study of investment firms on Tehran Stock Exchange, Decision Science Letters ISSN 1929-5804 4 (2013) 275.