An Inter domain Adaptive Management architecture for Internet Service Providers (ISPs)

2 authors:

Ahmad Kamal Ramli
University of Leeds

Karim Djemame
University of Leeds

An Inter domain Adaptive Management architecture for Internet Service Providers (ISPs)

Ahmad Kamal Ramli and Karim Djemame*

Abstract

Internet Service Providers (ISPs) provide Internet access to their subscribers with agreed terms and conditions. Quality of Service (QOS) is the mechanism to appraise subscribers satisfaction on their provided services. The current business model between ISPs has increased competition on the bandwidth prices, while the negotiations between them are exclusive among themselves and are inaccessible to the public knowledge. Users are becoming active subscribers in line with attractive offers from available suppliers. To mitigate this situation, a Service Level Agreement (SLA) is a contract signed embedded as the legal element within the QOS framework to monitor the fulfillment and violation of terms of running services. The novel contribution of this paper is an adaptive QoS provision and monitoring feedback inter - ISPs with the support of SLAs, bandwidth management and user profiling using an autonomic computing ecosystem. Early experiments show an improvement in terms of throughput, Internet Protocol (IP) traffic drop, and application response time in the autonomous environment as compared to a non-autonomous environment. These outcomes are an example of substantial performance of enterprise routing, client-server application and application profiles throughout inter ISPs architecture.

1 Introduction

Internet access is the vital catalyst for online users, and the number of mobile subscribers is predicted to grow from 6.7 Billion in Q2 2013 to 9.3 Billion by the year 2019 [1]. To ensure demand is within the bandwidth capacity of current Internet Service Providers (ISPs), a mechanism is needed to ensure user satisfaction for their services. An ISP has the opportunity of getting more revenue by imposing extra cost for services through peering inter domain networks such as metro Ethernet, Enhanced Interior Gateway Routing Protocol (EIGRP) and Border Gateway Protocol (BGP). However, ISPs have their own limitations such as tiers, available bandwidth and business models to serve current and potential end users and corporate customers. This scenario leads to an ongoing market price issue and at present there is no concrete solution to undertake that effectively. To streamline the existing architecture running on private or

*School of Computing, University of Leeds, scakr@leeds.ac.uk , K.Djemame@leeds.ac.uk

public networks [2], an adaptive solution regarding the policies of getting the right agreement and negotiation in decision making must be available within the ISPs neighborhood or inter domain networks. An adaptive architecture inspired by autonomic computing will ensure the process is transparent between autonomic elements in inter-domain operations. The key of this architecture is the extension of self - * capabilities [9] designed to have self-management over user behavior, available network resources and interactions with neighboring ISPs [6]. This enterprise feature is considered, to some extent, in organic computing, autonomous Software Defined Networking, Software Defined Networking and will address the problem statement between inter ISPs services. A Service Level Agreement (SLA), is the utmost legal catalyst to monitor any contract violation between both end users and ISPs and is embedded with Quality of Service (QoS). It will strengthen and advance the quality of control over the application and network resources and can be further stretched out by leveraging into ensuring permitted time in mission-critical applications, better user experience and manage the costs of the resources efficiently. A considerable amount of literature has been published on the development of autonomous approaches [13], [18] and inter domain architecture [7] [13]. However, little attentien is given to self-management features with the Monitor, Analyse, Plan and Execute (MAPE) Model [9] to support the services running through inter ISPs environments. Recently, an adaptive framework for link prices at the maximum of two ISPs and inter ISP connection using agents rather than autonomic elements was proposed. As for industrial environments, CISCO proposed Application Centric Architecture [22], a robust approach and limited to the local network and is famously known within Software Defined Networking (SDN). Lastly, Autonomic IT Management as a service for cloud computing is presented in [20] but left the inter domain architectures for further investigation.

Among the substantial input of this paper is to fill in this missing gap by providing a novel adaptive self-management architecture for ISP services. The core contributions are:

1. Introduce a novel adaptive architecture for managing global and local policies such as Service Level Agreements, Quality of Service, Bandwidth Management and User Profiling.

2. Introduce a novel autonomic element as a broker to identify a number of ISPs with their offers and proceed with comprehensive negotiation to perform service deployment between ISPs.

3. Introduce a novel negotiation element for inter ISPs to support service deployment that matches the established criteria, such as pricing, routing distance, and category service quality.

The computing context will impact the achievement of the fully autonomous system. It requires ISPs negotiation as the continuous element to ensure ability to exercise any definite impact between the parties. In the same way, the usage context reflects end-users and external systems that connect with autonomous system and places where the interaction will be executed. A combination of computing and usage context is the key of outlining the entire architecture. Through early experiments, we demonstrate the capability of an autonomous environment in handling network routing, client-server applications, and user profiles with different regions using Border Gateway Protocol (BGP) or non-BGP routing. Three core metrics are used for evaluation; throughput, IP traffic dropped , and Application Response Time which are a combination of elements in the environmental context an administration in the computing environment [21]. The remaining of this paper is structured as follows: the related work is presented in Section 2, whereas section 3 discusses research challenges and methods to address the research problem. In section 4, we present the proposed architecture for this work, details of negotiation, brokerage and autonomic elements. The simulation and early experiment findings are discussed in section 5 and finally, in section 6, we draw the conclusion and future work.

2 Related Work

In the perspective of bandwidth management allocation, the research in [7] focuses on the implementation of bandwidth management in the intra domain environments. Autonomic management is the key to this exercise to ensure the availability of the bandwidth with sufficient justification between network resources. Although the result grants that it can control bandwidth allocation from one edge router to another end within the small network, further research should examine the large scale of networks with various routing protocols. The Reason is to ensure the autonomic management with robust enhancement can operate all the differences in routing technologies. Alcaraz et al [15] explored another method for supporting bandwidth reservation. Four main elements are highlighted: Primary Network (PN), Secondary Network (SN), Primary Users (PU), and lastly Secondary Users (SU) as the perimeter that will be the input into the Markov Reward Model. A bandwidth reservation scheme is proposed by which the PN keeps a set of adjacent channels free of PU transmissions. These retained channels merely accommodate PU traffic when all the non-reserved channels are used, and the SU simply occupies the available channel within the engaged spectrum. In this theory, secondary users are not limited to persons; this can be extended to appliances, running algorithms such as Bayesian and multichannel access. The results show that, in non-congested PN with activity coming from Secondary Users, the interference reduction capability of Bandwidth Reservation increases the comprehensive capacity of the PN compared to not using Bandwidth Reservation. In the latest development by Peter Vrancx et al, [19] the research differs in terms of contributions and extensive approaches using autonomic computing rather than partial reinforcement learning to manage the major issues which are identically addressed in the introduction to this paper. Research on the subject has been mostly restricted to the limited comparison such as; One ISP learns in a stationary environment; One ISP learns in a nonstationary environment, and Two ISPs learn simultaneously. Instead of autonomic computing self-features, the approaches applied to this research are based on Learning Automata (LAs) to understand and adapt the best link prices to associate with. The assessment of the work done by Valancius and Lumezanu [16] is different on the tiered pricing with the transit market issues. A recent and thorough review made in [8] shows that adaptation in techniques with MAPE architecture are widely implemented in various applications and among are the real time applications. It is a strong argument how this solution within this proposal can be forecast in terms of future development ecosystems and support from different types of applications.

3 Research Challenge

The Internet is the combination of various tier inter networks, which supply bandwidth as their core services among the ISPs. Globally, there are connected from different regions and identified by a unique autonomous system controlled by the ISPs using their core routers, this architecture available in figure 1. The router can be a single or a group of autonomous systems depending on the setup and architecture of each ISP. In this research, the core challenge is to have an adaptation mechanism to react on the available resources that cross over inter-domain connections between ISPs. Four issues are identified and require research and assessment to be incorporated into the enterprise approach using autonomic computing, which are;

- Quality of Service
- Service Level Agreement
- Bandwidth Management
- User Profiling

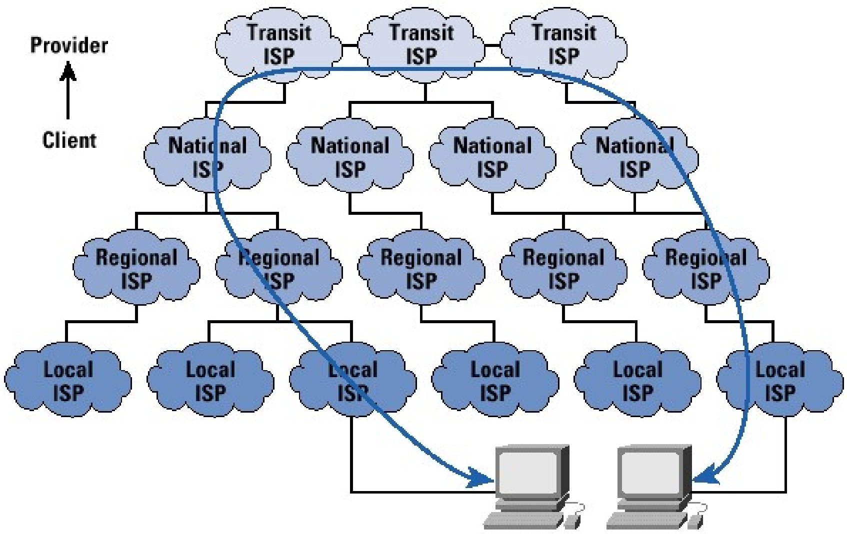

Figure 1: ISPs Tiers Architecture.

QoS is the standard mechanism in the networking connection to assess how well the network establishment from one point to another with designated metrics. QoS is commonly deployed when network bandwidth is limited and is sometimes needed to review network performance in the event of congestion. The concept of QoS itself can perform classification, marking, shaping, policing and queuing. In the ISP environment, the steps for QoS execution are engineered as below;

- Recognize Application Traffic (Classification and Marking)
- Prioritize (Queuing and Shaping)
- Buffer Tuning
- Throttle Traffic (Policing and Weighted Random Early Detection)

Corporate customers are equipped with software or devices such as traffic shaper or bandwidth management to monitor and configure provided services from an ISP. However, the solution is limited to the enterprise, and these are not applicable to the entire ISPs ecosystem. An inter-domain ISPs connection has different costs and depends upon the connection types. At this stage, ISPs are motivated by their business model to choose which offers match which their requirements. Furthermore, prices of the routing are different for ISPs, depending on the tiers and quality. There are three core categories available such as gold, silver or bronze. On the other hand, end users always aim for the low-cost price and good service quality. As per this model, some ISPs with an overloaded network will have problems in meeting their end-users satisfaction, whereas ISPs with the low load network will offer better prices to attract the active customers, this situation will be continuous and jeopardize the transit market price. SLA is the key to bind all the terms and agreement between ISPs and end-users. However, with the conventional process, the adaptive model in observing negotiation and monitoring on the violation of the SLA via brokerage activities is not present and requires an urgent attention with the growing number of ISPs. A successful model will enhance the way of controlling bandwidth and performing user profiling to ensure all bandwidth activities are well presented to the end users to satisfy Service Level Objectives (SLO). Table 1 summarizes the research challenges and relations to current ISPs operation.

3.1 Method

Adaptation has attracted considerable research interests in various disciplines, including computing with a focus on self-Adaptation [8]. The adaptation control can be classified into three core areas such as approach, adaptation decision criteria and degree of decentralization. Figure 2 shows the information about the self-adaptation taxonomy.

The central question for the adaptation time is how long it can tailor to the situation. It is actually the input from user's perspective to evaluate and justify the adaptation with regards to all the arguments connected to their situations. This approach can be realistic with the usage of MAPE (Monitoring, Analysis, Planning and Execute) [9]. In the early phase, there are two processes , which are monitor and execute. This is due to human interference playing a major role [14]. Once the adaptive architecture is developed , analysis and planning will be the next. Human interference will take place to develop a knowledge foundation on the frequent decision making. By causing this, the adaptive system, with an outstanding knowledge base will be guided by growing artificial knowledge.

This research will establish autonomic elements that will be contained within the adaptable management architecture. The elements will be the policy exchanges between the local and global autonomic managers, whereby the overall management will be controlled by enterprise adaptive architecture. Inter-

Table 1: Comparison of QoS Research Contributions and Relation to Provision.

Activity	Current Research Problem	Proposed Novel Solution	Benefit after completion of research activity
Inter-ISPs QOS provision	No back to back agreements exists with tier issues in ISPs	Architecture of Adaptive Enterprise Management to incorporate the elements of ISPs provision	• Transparent agreements and terms of the end-users • Better network Management • A system able to react adaptively to the available resources
QOS load balancing	The load balancing feature available for intra domain	Inter domains, load balancing resource management	• Load balancing in using available resources between ISPs
QOS Services	Issues of Integrated services and differentiated services.	Adaptive Service Level Agreements mechanism to ensure end-users satisfaction	• Transparent Service Level Agreements between users and ISPs. Users are allowed to have adaptive terms in the best effort and guaranteed services
QOS performance	Issues with an uncertainty of network performance either in intra networks or entire networks.	Bandwidth Management supported through usage based module on the profiling basis	• Transparent billing over the convergence of ISPs network with the ability to place their preferences on the usage of applications

connection latency as a QOS provision element will support the bandwidth management framework.

4 Proposed Architecture

A QOS Broker is introduced to keep the successful negotiation, document or known as Service Level Agreement to be appraised by the Local Autonomic Manager within the same tier on the cost-saving, effective routing that concludes as the latency issue and will access by the enterprise autonomic manager for the result and the governance of the autonomic computing ecosystem within this high level architecture.

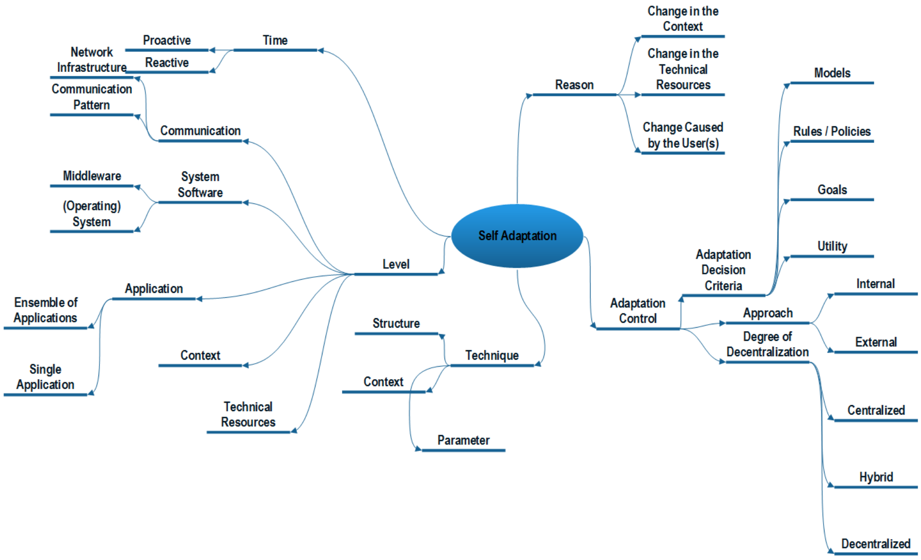

Figure 2: Self-Adaptation taxonomy.

The connection between the local autonomic manager and the enterprise autonomic manager over autonomic computing main architecture is addressed in figure 4. This enterprise autonomic manager and the local autonomic manager consist of the same K-MAPE model design for autonomic computing. With the abilities to minimize expert's intervention by providing managed elements , it will then develop betterment of the knowledge base which runs recursively in the iteration procedure. Within this architecture, K-MAPE will evaluate the exchanging elements either from local and enterprise process as well as system response. The system will have four core functions, which are monitor, analyze, plan and execute to ensure the environments are running smoothly and intelligently updated with every new alert.

The QoS Broker as per figure 5, contains two more sub-elements, which are the vital to this operation. First, one is the trailing of user profile between brokers, and secondly the negotiation over the terms and services with other ISPs. User Profiles model solver inherits three main databases such as user profile metadata, SLA commitments and Internet Service Providers Metadata. By having databases, it will develop concrete user profiles and will carry credential data to be further evaluated during the negotiation process. The technical decision of the bandwidth management model solver is in the response to the information supplied by QOS negotiators through the negotiation process. As discussed earlier, the key for valuation is bandwidth, and will focus heavily on the latency issues. Offers from the Internet Service Provider will ensure the establishment of a connection between ISPs with the support of autonomic computing ecosystem.

The final proposed architecture sub-component is the Meta negotiation architecture as illustrated in Figure 6. This is component inspired by the one proposed in [18] and is divided into six negotiation layers.

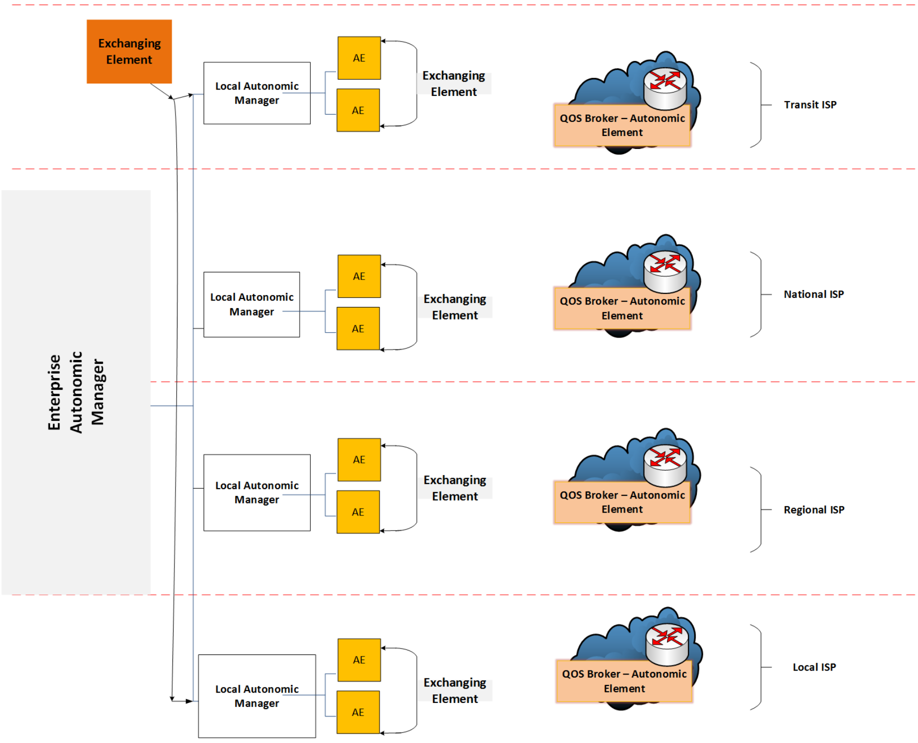

Figure 3: High Level Design of the proposed architecture.

5 Early Evaluation

The main aim of this early assessment is to have a model of autonomous environment evaluated through simulation. Self-properties are the ultimate metrics to ensure the MAPE model is able to simulate the considered scenarios. The OPNET software [23] selected to ensure inter ISPs environment with various backbones routing protocols can be seamlessly executed with three major metrics as addressed earlier.

5.1 Objectives of the experiments

There are four main objectives, which have been identified for this evaluation;

- To demonstrate that Border Gateway Protocol (BGP) with autonomous system is relevant to the high-level architecture described in Figures 3 and 4.
- To justify the transmission of digital data applicable and measurable in the autonomous environment.
- To ensure the autonomic elements as per Figure 6 are available for the BGP connection.
- Following this early experiment to drive future research activities in autonomic computing environments.

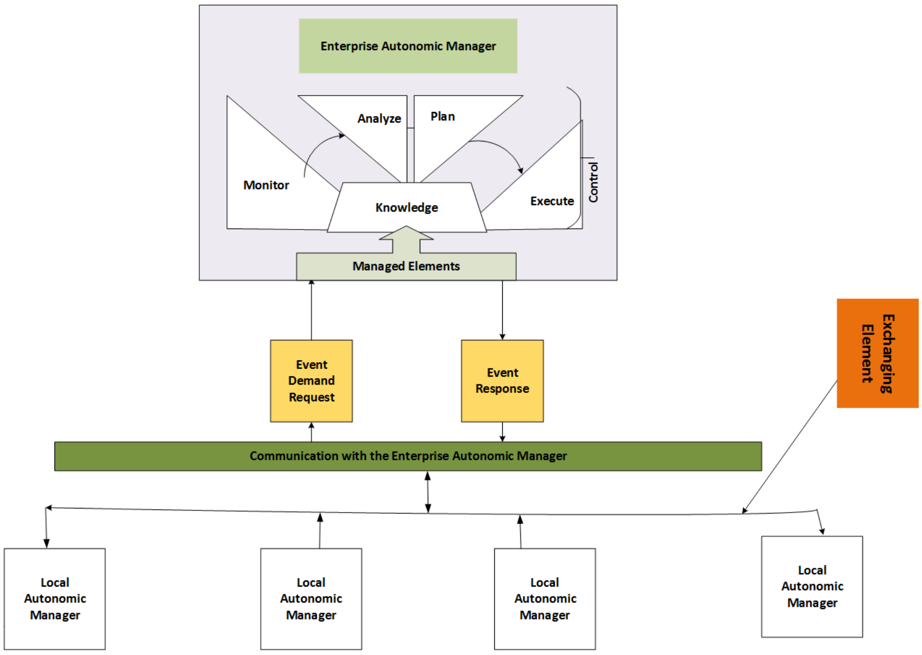

Figure 4: Adaptive autonomic computing between Local Autonomic Manager and Enterprise Autonomic Manager.

5.2 Setup

In this experiment, there are two scenarios, one with without Border Gateway Protocol (GBP) and another one with BGP environment. Border Gateway Protocol chosen as the protocol to justify the autonomous concept unoccupied in the autonomous system uniquely present for each server and how later it can connect within the same autonomous system number to create a group of neighbourhood ISPs or with different neighboring routers. The following Table 2 show the scenario information.

5.3 Results

The evaluation will be based on three metrics which are throughput, delay and response time. Below are the criteria for the assessment;

i. Throughput.
   As for this part, it will have two logical subnets from each region as per Figures 7 and 8; each of them is an individual scenario. In the case of the scenario without BGP, the output will be straight forward because it will be measured from one region to another region through one ISP. Whereas, for the next scenario, the environment will be in the BGP mode and the connection from one region to the Internet connection will be based on the dedicated autonomous system and neighborhood concept. All of this assessment will be for the outgoing packets rather than incoming packets. The outgoing packets will ensure the connectivity from one point

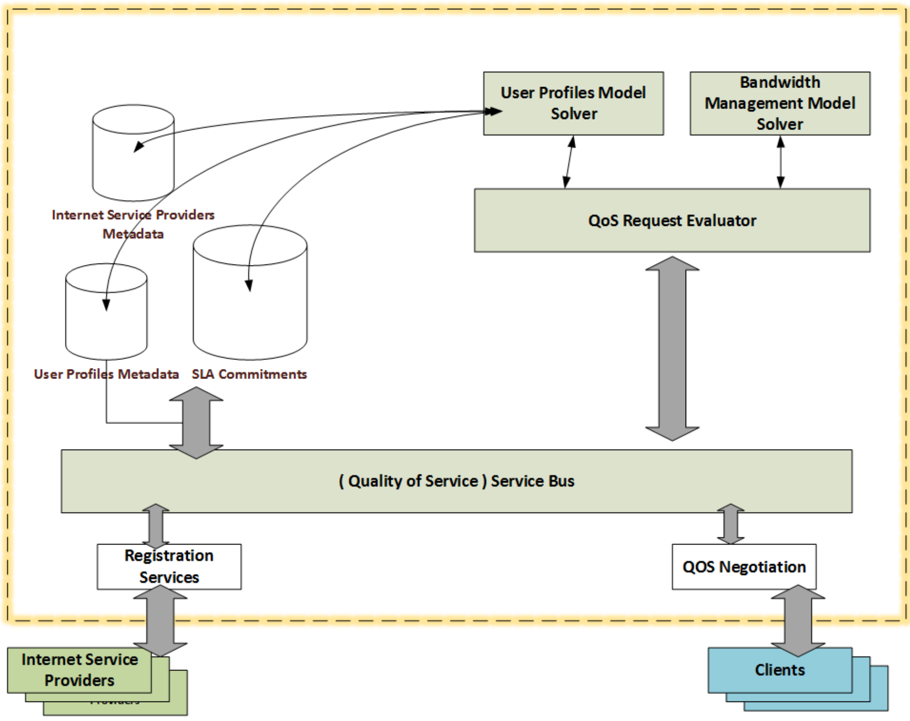

Figure 5: QoS Broker architecture.

Table 2: Scenario Parameters for Simulation Exercises.

No	Description	Quantity
1	Internet Service Providers	2 (Non BGP) and 3 for BGP
2	Country within ISP	One Country with two regions
3	Logical Subnet	Two Subnets
4	Router	2 (for Non BGP) and 10 for BGP
5	Number of Nodes	One group of workstation for both subnets. Three servers located within one of the logical subnet
6	Cloud Connection	Using Cloud32. It is worldwide internet connection and connected via PPP DS3. It is also known as T3 line and the signal transmission up to 45 MB per seconds.
7	Application Supported Profiles	Using two Application Servers , Email and Streaming. Every workstation will have profiles that identical to both of the application server and with additional http browsing activities

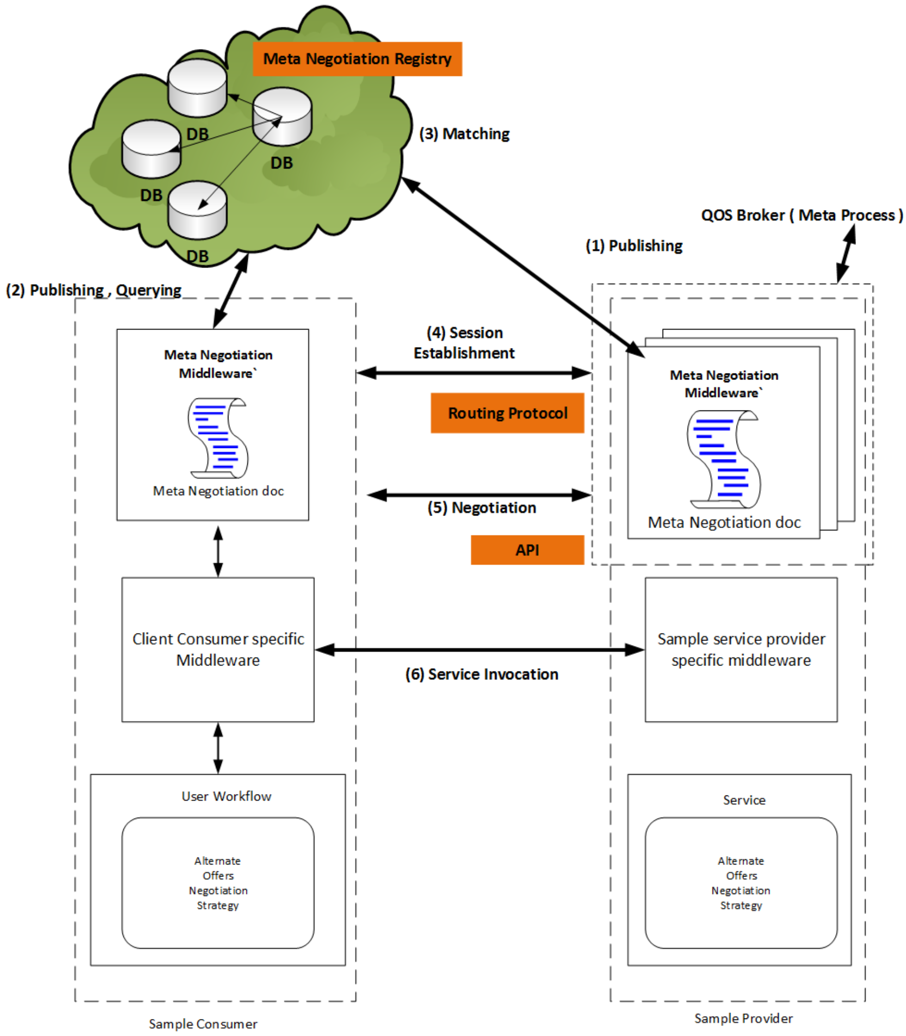

Figure 6: Meta Negotiation Architecture with multiple brokers.

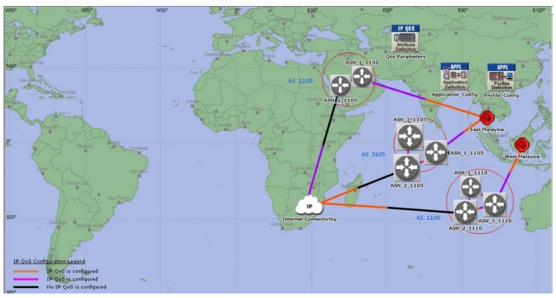

Figure 7: OPNET Academic Modeller BGP Environment Design.

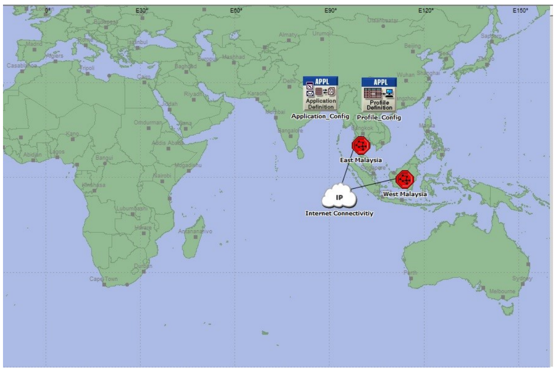

Figure 8: OPNET Academic Modeller Non BGP Environment Design.

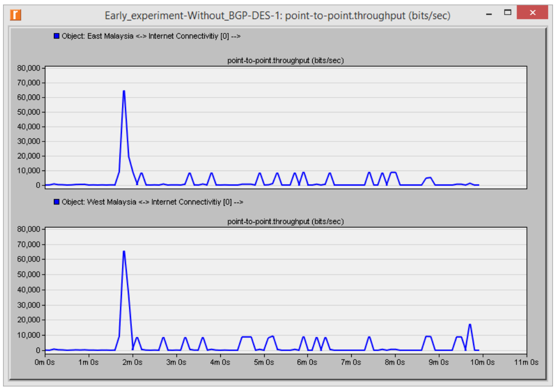

Figure 9: Point to point throughput East and West Malaysia.

to another from distinctive routers will be carefully measured to produce the designated finding.

- Results of the simulation software

  In Figure 9, the outcome based on the normal network connectivity using non BGP environment from one region to another is shown, whereas for Figure 10, it is a BGP environment with a dedicated autonomous number from one router to another. Figures 11 and 12 are the results of connection from one region with multiple BGP and it is within multiple BGP neighborhoods. Results are measured by quantum of 10 minutes and evaluates in the number of bits per seconds. In Figure 8, it took slightly a duration of two minutes before the performance reaches the 62,000 bits per second and the amount of packets, and this graph is really much different with BGP environments as presented in Figures 10-12, whereas the increments for a bits per second rocketed at 0.5 minutes. In this early feedback, we can conclude by using non BGP environment, the throughput will be efficient at the start of the simulation after 4 minutes, whereas using BGP, network performance is better as seen in Figures 11 and 12.

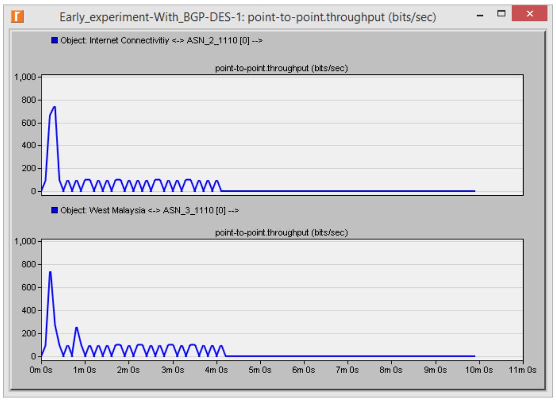

Figure 10: Point to point throughput West Malaysia using BGP

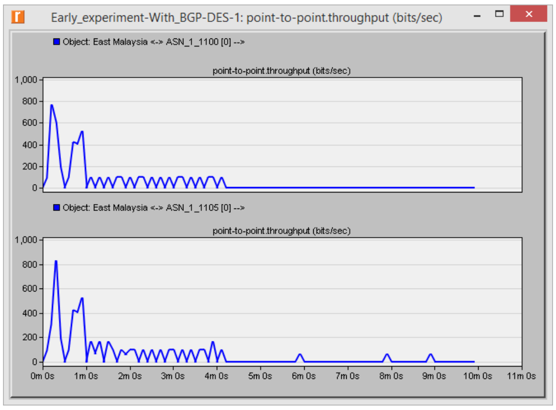

Figure 11: Point to point throughput West Malaysia uses multiple BGP (A).

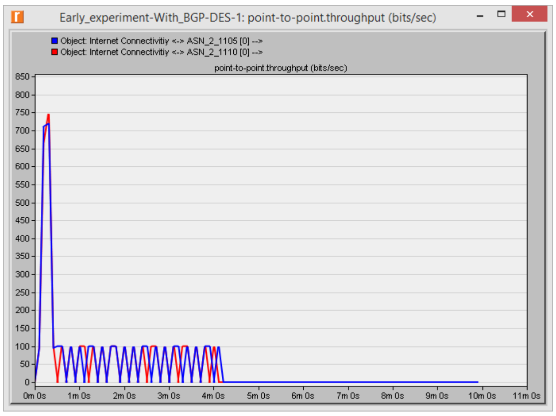

Figure 12: Point to point throughput West Malaysia uses multiple BGP (B).

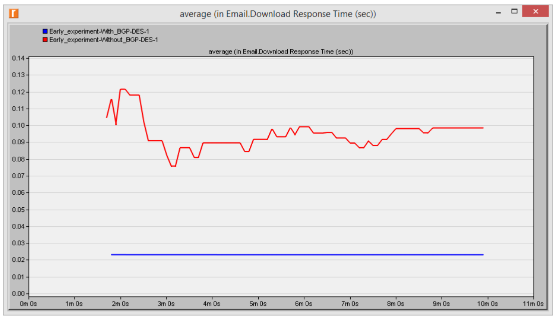

Figure 13: Average Response Time for Email Downloads

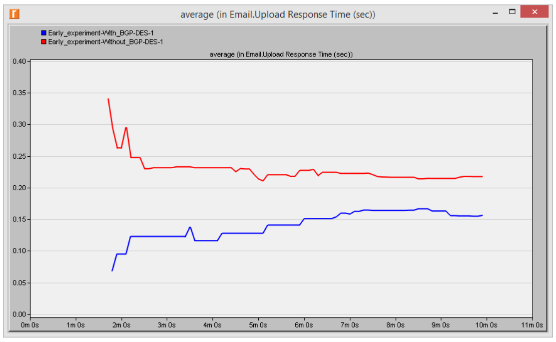

Figure 14: Average Response Time for Email Uploads

ii. Response Time (Application)
Upload response time and download response time will be the indicator for this simulation to measure the performance of both scenarios. It will simulate one email server with two groups of workstations from different regions running email activities. Each of the activities has been profiled using application profile feature within OPNET application.

- Results of the simulation software

  In Figure 13, we can see the performance of average response time for BGP environment is constantly at 0.024 seconds from beginning of 2 minutes simulation until end to the simulations time. This situation is different without BGP environment, and the results are inconsistent with high processing loads. On another note, the average of uploads response time for email activities in Figure 14 is slightly inverse from one to another between BGP and without BGP. Performance of BGP is better with the beginning of 0.07 seconds until the end simulation with 0.15 seconds. With this result , it shows in BGP environment, the application runs smoothly within the autonomous environment and is capable of sharing the load between ISPs neighborhoods.

iii. IP Traffic Dropped
The last indicator for this simulation will measure the quality of internet

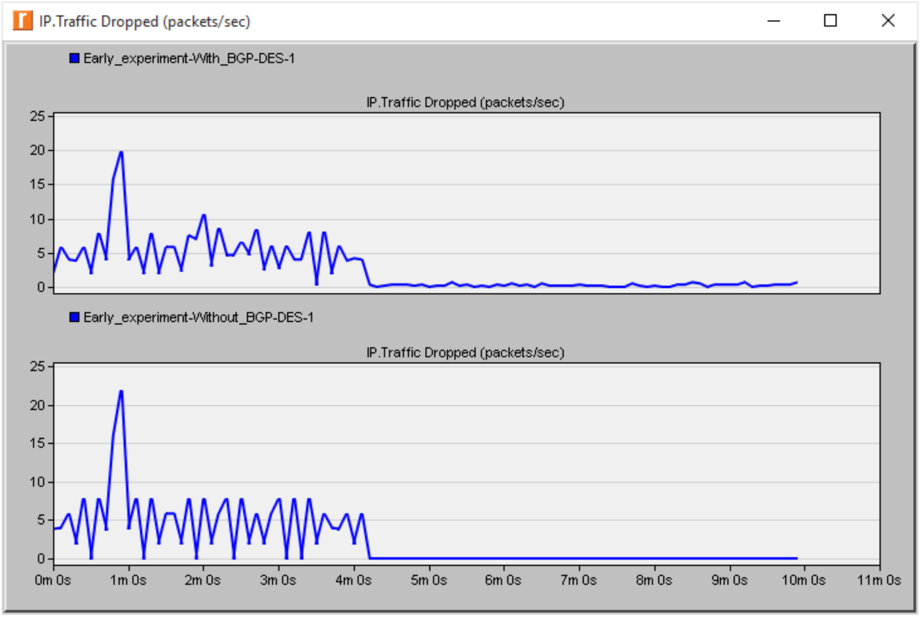

Figure 15: IP Traffic Dropped

protocol traffic dropped between subnets while executing different types of applications over the networks.

- Result of the simulation software

  Figure 15 shows the evaluation of IP traffic dropped while running all the applications and services with and without BGP. At the start of the simulation, BGP environment scored lower 1 packet per second dropped compared to non BGP and at minute 1, both reach the peak dropped, where the non BGP still have the highest number of dropped packets per second. This result remains consistent for BGP from minute 4 till the end of simulation, whereas a lower number of packets are dropped against non BGP.

6 Conclusion

This paper has proposed a novel ISPs architecture to provide QoS. The solution is designed for ISP architecture to integrate with additional elements of SLA, Bandwdith Management and User Profiling in the adaptive ecosystem of autonomic computing. Global and Local Autonomic Managers are the autonomic elements to manage ongoing negotiations between ISPs to ensure the establishement of services as per signed contract between agreed parties.

Preliminary simulation experiments show that the autonomic computing approach executed smoothly in the BGP environment, which is backed up with specific metrics to support this statement. To date, there have been continuous and promising algorithms available in binomial heaps, Bayesian network and reinforcement learning as suitable options for QoS provision. Figure 16 presents

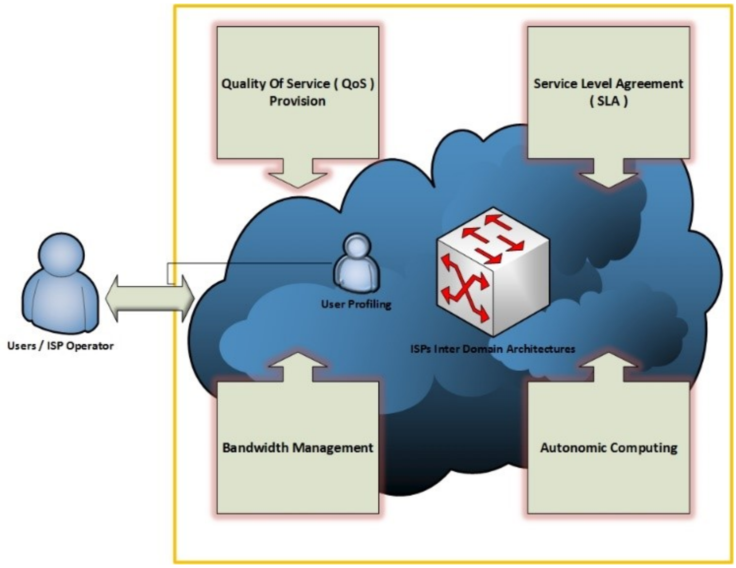

Figure 16: The layout of completed autonomic computing architecture from this paper

the plan of continuing research to enhance existing ISPs architecture.

Adaptive technologies are promising research domains and have grown tremendously to academic and industrial disciplines. Future work on the adaptive architecture introduced in this paper includes:

- Synchronization of Software Defined Network (SDN) at the local and within an enterprise network with the ISPs architecture to produce robust services and automation of application, routing coming from every preferred layer within the networked environment.

- To streamline adaptive approaches with existing TCP/IP technologies. ISPs because they cannot proceed with the advancement of routing technologies due to limited resources in the hardware investment, such as appliance for IPv6, Metro Ethernet and Routing protocol. Due to these limitations, ISPs are using emulators to emulate various devices with different technologies to provide services as agreed with end-users.

References

[1] Douglas Gilstrap , Ericsson Mobility Report - November 2013, Ericsson, 2013

[2] Peering DB In Http://www.peeringdb.com

[3] F. W. K. - and T. J. , A Survey on QoS in Next Generation Networks, Advances in Information Sciences and Service Sciences Volume 2, Number 4, December 2010 ,pp. 91-102, 2010

[4] K. Kritikos, M. Carro, B. Pernici, P. Plebani, C. Cappiello, M. Comuzzi, S. Benrernou, I. Brandic, A. Kertsz, and M. Parkin , A survey on service quality description, ACM Comput. Surv., vol. 46, no. 1, pp. 158, Oct. 2013

[5] P. D. Ezhilchelvan and S. K. Shrivastava , A Model and a Design Approach to Building QoS Adaptive Systems, Chapter Architecting Dependable Systems II Volume 3069 of the series Lecture Notes in Computer Science pp 215-238, 2004

[6] Wei Dai and S. Jordan , How Do ISP Data Caps Affect Subscribers?, TPRC 41: The 41st Research Conference on Communication, Information and Internet Policy , pp. 120, 2013

[7] Anala M R and Dr. Shobha , Application of Autonomic Computing Principles in Virtualized Environment, First International Conference on Information Technology Convergence and Services (ITCS 2012),pp. 203208, 2012

[8] C. Krupitzer, F. Maximilian, S. Vansyckel, G. Schiele, and C. Becker , A survey on engineering approaches for self-adaptive systems, vol. 17, pp. 184206, 2015

[9] K. Ahuja and H. Dangey , Autonomic Computing: An emerging perspective and issues, 2014 Int. Conf. Issues Challenges Intell. Comput. Tech., pp. 471475, 2014

[10] T. O. Eze, R. J. Anthony, C. Walshaw, and A. Soper , Autonomic Computing in the First Decade: Trends and Direction, no. c, pp. 8085, 2012

[11] M. Femminella, R. Francescangeli, and G. Reali , An enabling platform for autonomic management of the future internet, Network, IEEE (Volume:25 , Issue: 6),pp. 24-32, 2011

[12] R. M. Bahati and M. a. Bauer , Towards adaptive policy-based management, 2010 IEEE Netw. Oper. Manag. Symp. - NOMS 2010, pp. 511518, 2010

[13] R. M. Bahati and M. a. Bauer , Adapting to Run-Time Changes in Policies Driving Autonomic Management, Fourth Int. Conf. Auton. Auton. Syst., pp. 8893, 2008

[14] a. Ouda, H. Lutfiyya, and M. Bauer , Towards Automating the Adaptation of Management Systems to Changes in Policies, 2006 IEEE/IFIP Netw. Oper. Manag. Symp. NOMS 2006, pp. 14, 2006

[15] Badis Tebbani and Issam Aib , GXLA a Language for the Specification of Service Level Agreements, IFIP International Federation for Information Processing 2006, LCNS 4195, pp. 201-214, 2006

[16] J. Elias , F. Martignon and A. Capone , An Efficient Dynamic Bandwidth Allocation Algorithm for Quality of Service Network*, IFIP International Federations for Information Processing 2006, LCNS 4195 , pp. 132-145, 2006

[17] Juan J. Alcaraz, Mario Lopez Martinez, Javier Vales Alonso and Joan Garcia Haro , Bandwidth Reservation as a Coexistence Strategy in Oppurtinistic Spectrum Access Environments, IEEE Journal On Selected Areas in Communications , Vol. 32, No. 3, 2014

[18] a. Kertesz, G. Kecskemeti, and I. Brandic , An interoperable and self-adaptive approach for SLA-based service virtualization in heterogeneous Cloud environments, Futur. Gener. Comput. Syst., vol. 32, pp. 5468, 2014

[19] P. Vrancx, P. Gurzi, and V. U. Brussel , A Reinforcement Learning Approach for Interdomain Routing with Link Prices, vol. 10, no. 1, pp. 126, 2015

[20] IPSoft Autonomous as Service . In http://www.ipsoft.com

[21] P.Lalanda and Julie McCain , Autonomic Computing : Principles Design and Implementation, Springer, 2013

[22] Cisco Application Centrix Architecture . In http://www.cisco.com/c/en/us/solutions/data-center-virtualization/application-centric-infrastructure/index.html

[23] Chen Jiongcong , Pan Wei , Hu Chunchao , Ma Kai , Cai Zexiang and Ouyang Jun , Research on networking strategy and optimization simulation of process level network in smart substation based on OPNET, Electricity Distribution (CICED), 2014 China International Conference on, pp. 700-705 , IEEE