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Policy Refinement for Traffic Management in Home Area Networks: Problem Statement

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Policy Refinement for Traffic Management in Home Area Networks – Problem Statement

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Abstract

Traditional home area network (HAN) equipment is usually unmanaged and network traffic is served in best effort fashion. This type of unmanaged network sometimes causes quality-of-service issues in the HAN, for example loss of quality in streamed video or audio content. Traffic management rules using policies to prioritise certain types of traffic according to user requirements and to assign bandwidth limits to other traffic types. However very little work has been done yet addressing the specification of these requirements, how they would be communicated to the gateway device using policies, and how the policies would be refined into device level configurations to effectively implement the user requirements. In this paper we briefly discuss this as a research problem, placing it within the context of the research goals and an initial research methodology in the area of policy refinement for policy-based traffic management in home area networks (HANs).

Keywords: Policy, Policy-based traffic management, Policy refinement, Home area network, Autonomic networks.

1 Problem Statement

In a traditional home area network (HAN), there can be several types of network traffic e.g. VoIP, audio & video on demand, web, large file downloads and uploads. Usually the HAN Internet Protocol (IP) traffic works in a best effort fashion where quality-of-service (QoS) is not guaranteed. Therefore the quality can deteriorate when some bursty traffic e.g. UDP based download or upload, tries to consume the maximum available bandwidth. This can cause bandwidth unavailability for other traffic types, such as streaming audio or video, that are very sensitive to QoS. This leads the network into a state of congestion, which blocks other traffic flows (usually though packets being delayed or dropped due to the congestion) and results in poor quality of network applications. One solution to resolve congestion issues is to assign more bandwidth for the network, but logically this can only alleviates the issue rather than providing a long lasting remedy for better traffic management. In addition, in many HANs, customers have a maximum potential bandwidth set by the service provider's infrastructure; in ADSL this is often a lower maximum for upload compared to download. The general problem with adding more bandwidth as a solution is that greedy network applications simply attempt to consume more of the bandwidth, and risk here is that the actual congestion remains.

In a HAN most user generated traffic has equal priority with no bandwidth constraints; this means the packets are queued on the gateway device in a first-in first-out (FIFO) queue (depending on default configuration). When two UDP traffic flows (e.g. VoIP and Video streaming) of equal priority compete for bandwidth, their quality can suffer because of varying bandwidth availability, which can result in great packet loss and unwanted packet delays. We know that policies can be used to manage QoS requirements, therefore by separating the VoIP and streaming traffic into two different priority queues, with optimal flow rates, this can potentially improve the quality both traffic flows. It works best where one is clearly a lower priority than the other.

Policy-based network management (PBNM) provides a flexible and robust mechanism to allocate bandwidth and to prioritise the network traffic. This approach has been used extensively in larger telecommunication networks, but potentially is also a good approach to meet HAN requirements, if this type of solution can be designed so that it can be easily managed by end users. The best advantage of using PBNM is that policies can be changed at run time without affecting underlying working model. This means that traffic management policies can be changed dynamically; this is a basic requirement in managing network traffic as user requirements can change over time (e.g. new devices, new services, changing priorities). To cater for this issue, autonomic policy refinement can play a very important role in establishing a policy-based traffic management system on residential gateway device. The quality of network traffic is measured in terms of QoS parameters -i.e. packet loss and delay, our research questions are:

(1) How can QoS requirements for a traffic flow or aggregate flows be communicated to a gateway device using policies?
(2) How can a comprehensive policy framework can be devised from the user requirements and then refined into configuration rules, which also contains desired QoS settings?

As currently formulated, these are not easy to evaluate or measure, and will they will require further refinement. The aim is to focus in on the knowledge representation issues in a suitable policy representation, but to deploy a working prototype that demonstrates that it can be effective in a real HAN deployment. Additionally, issues such as the usability of the resulting systems by end users are important, but may lead the research towards a more social science methodology, that the author would rather avoid. Thus the aim is to design the questions so that they can be evaluated through an empirical experimental design or simulation, whilst ensuring that the results have some real validity and are not merely artefacts of simulation.

2 State of the Art

Significant work has been published relating to the management of QoS requirements in access and core networks using policy-based network management (PBNM). Different architectures are proposed in [2] for the control plane of a software router that integrates signalling protocols and control mechanisms for QoS and in [3] using PBNM. The paper [2] claims that the use of proposed architecture can meet the end-to-end QoS requirements for most the internet applications if applied on the access network routers. Traditional PBNM systems focus on the management of core networks and the internet in the broader sense. The access and the core networks use policies to meet service level agreements (SLAs) for different service users. However the concept of end-to-end QoS in the big picture would remain in a status-quo if QoS is not ensured at the edge networks. PBNM can play a significant role in managing home networks focusing on users' requirements. We purpose an intelligent gateway device to control and manage all outgoing and incoming traffic. The device can be configured according to user requirements through a policy manager; it would make HAN users' life much easier. The paper [4] proposes similar solution but it focuses more on intelligent control centre (ICC) to connect all other networks with in HAN e.g. power line network, PC network, wireless network, home automation network, and home gateway.

Policy refinement is an essential part of policy authoring but still it is a largely overlooked research domain. Some of the significant work has been discussed in [5] but most of the models used for policy refinement are not suitable for autonomic traffic management in HAN. Some of the common issues with policy refinement techniques are listed here:

- The human operator must have deep understanding of both the business level policy and domain specific knowledge such as security or network QoS;
- It is hard to check the accuracy and consistency of transformation carried out by the human operator;
- A policy author can only construct a policy by using accurate syntax in addition to having precise semantics;
- The human input must be compiled and interpreted to produce an output which is domain specific;
- There is no specific approach defined yet for autonomic policy creation and refinement from user requirements.

3 Goal Statement

The goal of our research is to provide solutions to HAN users to manage their networks effectively with minimal user intervention. And at the core, the research objective is to define efficient, robust and cost-effective autonomic policy refinement algorithms and policy-based traffic engineering techniques for quality of service user requirements in home area networks. This will enable prioritisation of different types of HAN traffic according to HAN user needs. We have simulated a HAN in our research lab, and our research experimental testbed has used the settings and configurations as discussed in research artefacts (the next section). We have successfully executed the experiments to observe the effect of policies in managing the home area network traffic and our next step is to use a formal policy refinement model to define policies from the user requirements.

4 Research Artefacts

Figure 1 shows the role of policy-based network management in HAN. The residential gateway device or the router is policy execution point to manage different types of traffic according to HAN users. Policy decision point (PDP) fetches the required policies from the repository and through policies are executed on the policy execution point (PEP). Policies can be managed through the management console.

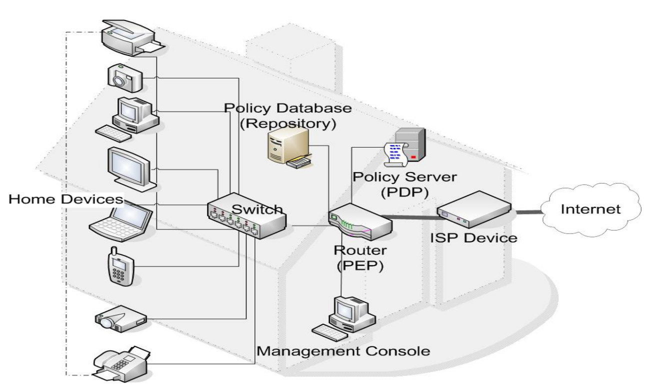

Figure 1: PBTM in HAN.

4.1 Equipment and Applications

We are using a Linux machine with Ubuntu Linux distribution as a gateway (software router) to simulate the HAN and its gateway device that represents a router between the HAN and the Internet Service Provider (ISP). We have used a traffic control (TC) application for setting up filters and queues on the router, this can generate different types of network traffic using shell scripts. The IPTables package is used for defining NAT, as commonly deployed in IPv4-based HANs. The TCPDump package is used for packet and queue analysis, the raw data dumps being processed by some perl scripts. The testbed will be further refined to allow investigation of PBNM. The interesting aspects of the testbed that we would be looking at in HAN traffic management are:

1. Use of policy continuum [6]
2. Formal policy specification language
3. Use of autonomic policy refinement techniques [1]
4. Building traffic management tool for HAN users

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5 Methodology

The aim is to use a set of research questions that can be empirically tested on the extended testbed. Thus the aim is to measure the effectiveness of a managed QoS network, compared to an unmanaged network, quantitatively. Some additional work will be done to measure the effective usability of the resulting PBNM system, but this usability will not be the main focus of the methodology. This may involve some user testing and questionnaires on a small sample set.

6 Conclusion

We have presented the key challenges being addressed in our research and outlined the major elements of ongoing research work in a number of inter-related network management fields that are relevant to policy-based traffic management, quality of service and policy refinement. The primary research methodology is an experimental one, potentially using elements of actual deployments of policy-based traffic management system that can be tested with real network traffic.

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