User Analysis for Effective Resource Planning in Hybrid Computer Networks

Melanie Delport, Magdalena J. Grobler and Henri Marais
School of Electrical, Electronic and Computer Engineering
North-West University, Potchefstroom Campus
Tel: +27 18 299 1978, Fax: +27 18 299 1977
Email: {20554044, leenta.grobler, henri.marais}@nwu.ac.za

Abstract—Increased popularity and user demand for networking and resource sharing calls for effective provisioning of network resources. By deriving user requirements with respect to network resources a resource provisioning scheme may be developed to incorporate these requirements. User analysis is introduced as a method of determining the inferred user requirements for the development of such a scheme to more effectively plan network resources in hybrid computer networks.

Index Terms—Behavioural analysis, Hybrid computer networks, Network resource management, User analysis.

I. INTRODUCTION

Hybrid computer networks are networks implementing two or more communication standards for example Ethernet and Wi-Fi. This implies many obstacles for effective resource provisioning as most resource management schemes implement static rules that do not cater for dynamic user requirements. According to Cai et al. in [1] understanding the structure and dynamics of behaviour in networks is a key to modelling and managing networks. This paper proposes user analysis for the effective planning of network resources.

The remainder of this paper is arranged as follows: In section II, we give background on hybrid computer networks, network resource planning and user analysis. In section III, the proposed research and methodology will be discussed. A conclusion will be drawn in section IV.

II. BACKGROUND

A. Hybrid Computer Networks (HCN)

Hybrid networks connect network-enabled devices by the use of hybrid hubs, switches and routers. Resource provisioning in HCNs need to utilize management schemes with features to monitor or control both the wired and wireless extensions of the network. This along with the multiplicity of users and shared resource inhibits the effectiveness of resource provisioning in HCNs.

B. Network Resource Planning (NRP)

Network resource planning is vital to quality of service (QoS) management and includes the planning, scheduling and control of a computer network. This entails network diagramming, analysis of traffic, application behaviour and demand, procedures for failsafe and disaster recovery, forecasting requirements and redesign. NRP schemes can be placed in two categories:

1) Static resource management

This type of resource management scheme is based on reserving resources for a specific connection. The problem with this approach is that network resources cannot be fully utilized and the planning and re-configuration of static schemes are troublesome and time-consuming. This was overcome with the introduction of dynamic resource management schemes.

2) Dynamic resource management

Dynamic schemes allow for automatic management of network resources. In [2], Vilà et al. indicate that this requires a type of hierarchical reservation scheme or the ability to establish a logical network layer over the physical network. Network resources can then be modified according to demand by dynamically configuring this logical network. The main issues when considering dynamic management schemes is the setup latency and necessity of user login to establish connections via the logical network layer. This scheme dynamically allocates network resources and plans for future requirements but is unable to predict resource requirements. Furthermore current NRP schemes do not address performance affecting factors caused by the user population. In [3] Nishiyama et al. state that performance of typical HCN environments degrade not only because of user demand but also because of wireless mobility. Unexpected demand spikes can occur when wireless users are roaming between access points, directly affecting the availability of resources. Highly variable user requests for on-demand content, resource type and popularity all present many problems for resource management in hybrid computer networks.

This can be found in typical campus networks where the wireless access network is used mostly for accessing content like webinar or web-pages. If a lecturer instructs students to access YouTube videos as part of an interactive learning experience, this will be seen as an anomaly and the needed resource might not be allocated because this was not a “popular” resource request. This will greatly affect the QoS of the delivered content and the availability of all resources mapped to that wireless access point. Furthermore the majority of the available resources might be allocated only to the “popular” demand. The issue of relevance is that most resource management schemes make use of static rules to provision network resources; these rules are unable to predict or interpret specific user demand.

C. User Analysis

User analysis is said to be a crucial aspect of user-centred systems design and requires the identification of user characteristics from the user population, grouping of the population into communities and determining their inferred requirements [4]. Techniques are applied in [5] to extract user requirements from visited HTML pages. The
information is mined from server log files where the requirements are found by analyzing and grouping users by means of the text presented in the HTML page titles and keywords. The generated model is able to determine the requirements of a specific user or the usage patterns of a specific resource. User behaviour modelling and traffic analysis of instant messaging service (IMS) presence servers are described in [6]. Here user login and logout actions are analyzed during specified time intervals as to predict traffic load during the specific period. Statistical methods are implemented to calculate a user’s online probability, thereafter a discrete-time Markov chain is used to model the state change of a user during daytime or at night.

According to Cai et al. in [1] network user behaviour better determines the layout of the virtual network topology than the physical network connections. In this study web traffic of bipartite networks were analyzed according to user behaviour to determine community structures. The theory states that vertices in a group have a higher density of edges than found among groups and users that access the same server at the same time can imply clustering communities. Communities were identified by implementing methods such as the maximization of modularity function and the Newman-Girvan modularity to develop a community finding algorithm (Eq 2). The modularity $M(p)$ of a partition $p$ of a network into modules is:

$$M(p) = \sum_{i=1}^{N_M} \left( \frac{d_i}{L} - \frac{(d_i/2L)\sum_{a=1}^{N_M} m_{ai}}{(\sum_{a=1}^{N_M} m_{ai})^2} \right)^2$$  \hspace{1cm} (1)

Where $N_M$ is the number of modules, $L$ the number of links, $d_i$ the number of links between nodes in modules $s$, and $d_i$ the sum of the degrees of the nodes in module $s$. Then $l_i/L$ is the fraction of links inside module $s$, and $(d_i/2L)$ an approximation to the fraction of links inside a module. Roger Guimera defined a new modularity $M_B(p)$ that can be applied to identify modules in bipartite networks.

$$M_B(p) = \sum_{i=1}^{N_M} \left( \sum_{a=1}^{N_M} \frac{c_{ij}}{m_{ai}(m_{ai}-1)-\sum_{a=1}^{N_M} m_{ai}(m_{ai}-1)\sum_{a=1}^{N_M} m_{ai}} \right)$$ \hspace{1cm} (2)

Equation (2) defines the bipartite modularity as the cumulative deviation from the random expectation. Where $c_{ij}$ is the actual number of server in which $i$ and $j$ are together. The results found in [1] were refined with a simulated annealing approach using the heat-bath algorithm.

**PROPOSED RESEARCH**

By analyzing the user population of a HCN certain user requirements and resource usage patterns may be derived. As seen in Figure 1 the proposed research aims to code and model these requirements and patterns as “soft rules” for resource management. An optimal selection of rules can be derived and implemented to achieve the desired result of user-driven resource provisioning. This will be used for the development of a more effective resource planning scheme for HCNs. The relevant user requirements will be derived using similar approaches as indicated in section II C. This will then be used to construct a conceptual model of the user-driven NRP scheme and will be simulated in a typical HCN environment by the use of simulation software such as Matlab. The performance results will be verified and validated by use of techniques as proposed by Sargent in [7] and the model optimized for efficiency.

**III. CONCLUSION**

In this paper, the idea of implementing user analysis to derive user requirements was suggested to construct “soft rules” for dynamic NRP. Relevant background on user analysis and network resource planning was provided. The proposed research and methodology was discussed. Future work entails the extraction of user requirements from server log file data gathered from a typical campus HCN, the transformation of these requirements to rules and the incorporation thereof into a NRP model. A NRP tool may also be developed.

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**REFERENCES**


