NREN Network Access - Evaluating Value for money

1. Introduction

One of the comments sometimes made about NREN networks is that their access charges can appear expensive where compared with 'equivalent' commercial offerings. This document looks in more detail at the basis for evaluating value for money in terms of Network Access. It shows that the simple access pricing mechanisms, generally used in providing service, bear very little relationship to value for money offered. In order to determine true value for money it is necessary to look much more closely at the way a network is constructed and dimensioned. Only by doing so, is it possible to understand what capacity is available for use. This document considers the way a network is built and describes the different elements to be evaluated when analysing the network capacity, available to an individual customer, to determine true value for money.

2. Background

The cost of an Internet connection is generally expressed in terms of the speed of operation of the access Interface. Thus, as an example, an interface might have an annual price for 622 Mbps of access. Whilst this is a very simple measure, and 'easily understood,' it is also an extremely inaccurate way of defining value for money. The access speed of operation is one limited factor in determining performance. More important parameters are the information transfer capacity that an interface is capable of providing, particularly when network usage is high, and the quality of the capacity expressed in terms of error rate, stability of network created delay etc. These parameters are described in more detail in Annex 1. The values of these factors are defined by the overall capacity, which the associated network provides to carry the traffic. They represent much more relevant measures of value.

Network performance is a real-time quantity. As a network carries increasing amounts of traffic its performance declines. There is a strong analogy with the performance of a motorway during times of high traffic. In the case of a motorway traffic slows and ultimately stops. In the case of a network performance degrades and data is lost as packets are discarded because they cannot be delivered. A particular concern is the delay introduced as a network becomes more loaded. Delay reduces bandwidth available and leads to packet-loss, which destroys bandwidth.

The relationship between network load and network capacity is generally well understood. It can be modeled by an M/M/1 queue. Particularly at the access to a network, where multiple independent sources of traffic converge, it can be assumed that traffic arrival will be a Poisson distribution. These assumptions allow a model of performance to be made. The results of this model are shown in Figure which (i) describes the relationship between network delay experienced by traffic crossing the network compared with the percentage loading of the network. It can be seen that there is a strong relationship between delay and network loading so that, as network load increases, so to does network delay but at an increasing rate. Once the load exceeds about 60% of capacity performance can be further degraded by packet loss caused by congestion.

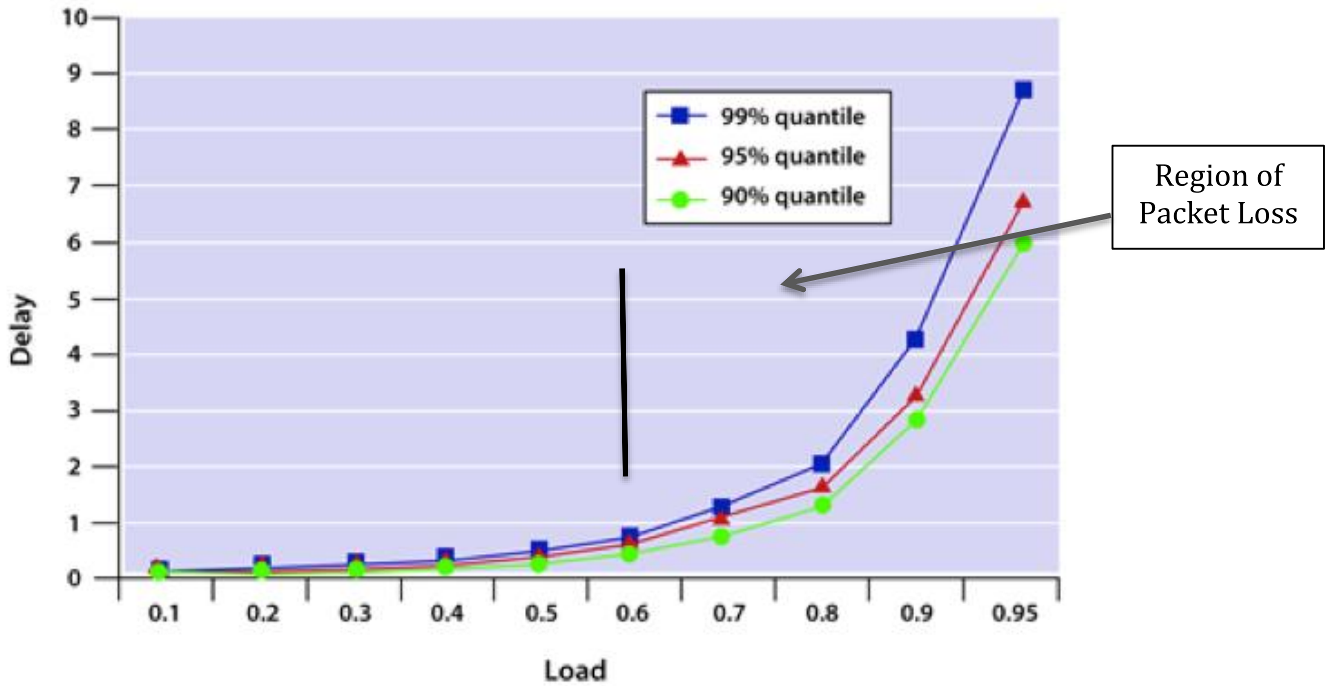

Figure (i) Relationship between Network Delay and Loading

3. Network Design

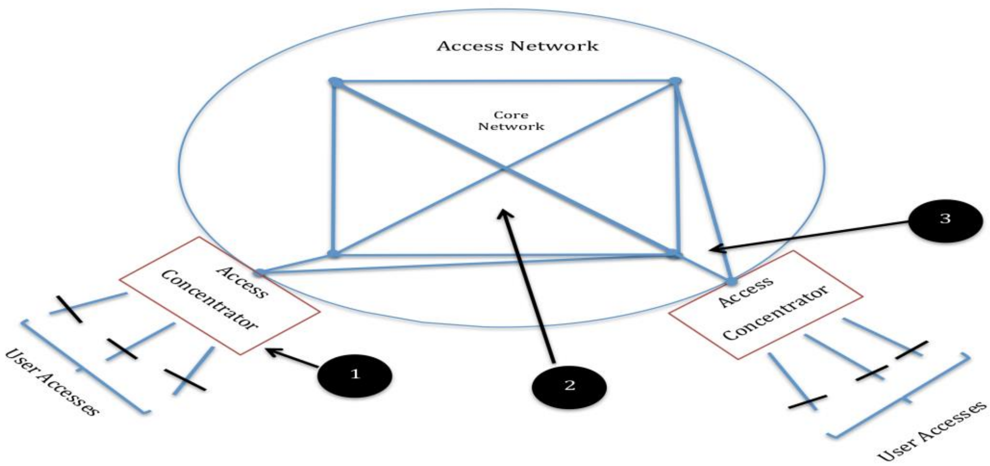

Figure (ii) Block Schematic of Network Elements

Figure (ii) above shows the elements that make up a wide area network. It is the combination of these elements that define network performance. From a user perspective it is the end-to-end capacity that is available from an access interface that is the important quality parameter. The access interface itself defines the maximum potential value of this capacity. It is the network design, dimensioning and network loading that will define what is actually achievable. They way in which the individual elements contribute to performance degradation is discussed below.

3.1 Access Concentration (1)

In commercial networks individual access points are normally connected to the network via a concentrator function. The purpose of the concentrator is to share a single connection to the access network among a number of user interfaces. As an example, ten 622 Mbps user interfaces might be connected to a single Gigabit Ethernet access. The ratio between the sum of the user interface capacity and the network access is known as the contention ratio. Access concentration works on the assumption that not all user interfaces will be used simultaneously. Nevertheless, when network demand is highest, there will be insufficient capacity to handle the traffic offered. It is well modeled by the analysis presented in section 2. Access Concentration has two negative effects on performance:-

i. When accesses are busy it is impossible to utilize the subscribed access interface capacity, as there is insufficient network capacity to support the offered traffic.
ii. The concentration function leads to a higher offered load and, as a consequence more delay and poorer service quality.

3.2 Core Network (2)

The core network consists of the main backbone links that carry traffic across the geographic footprint. The performance of the core network is defined by the capacity of the trunk connections that form the core relative to the traffic offered to it. The utilization factor, which is the ratio of traffic offered to system capacity, is a key ratio in determining the network performance experienced by a user. As the utilization factor increases, so to does delay, and the possibility of degraded performance through packet loss. Figure (i) above describes this relationship. As noted, this is not a linear effect. At 50% loading the delay is approximately twice that of an unloaded system but at 80% loading the delay is nearly five times that of an unloaded system.

There is another factor relating to core network performance. Many commercial operators will use the same backbone links for time-sensitive traffic such as voice as well as Internet traffic. They will do this by operating a priority queue for voice traffic. The effect of the priority queue is to further degrade the performance of Internet traffic.

3.3 Access Network (3)

The performance considerations relating to the Access Network are very similar to those for the core network. The capacity provided in the access network related to the traffic offered will be the primary factor affecting performance. An additional factor that needs to be considered is the amount of resilience built into the access network. Core networks are generally built with a reasonable degree of resilience but this is often not the case for access networks. The lack of resilience will only affect performance until failure conditions but it can lead to very serious performance degradation.

4. Conclusions

Comparing value for money between NREN and Commercial networks is not simply a matter of comparing access prices. Commercial networks generally use a 'headline' access price as their competitive selling factor. In contrast NREN networks are generally optimized for performance. They seldom, if ever, use Access Concentrators and are usually dimensioned to carry the expected traffic without loss. In order to properly evaluate value for money it is really necessary to understand the dimensioning and construction of the network that will carry the traffic and the user requirements for performance.

Annex 1 – Description of Network Performance parameters

There are a number of parameters that are use to define Network performance. The principal ones are:-

- Bandwidth Available. This represents the actual bandwidth that is available between two end-points on a network. It is determined by the overall loading of the network. The available bandwidth will obviously be constrained by the user interface. In practice, depending on network dimensioning and loading, the available bandwidth may be much less than that which is theoretically available at the user interface.

- Packet delay variation. Packet delay variation, often known as 'jitter,' is particularly an issue for real-time services such as voice or video where a human user is involved. High packet delay variation can lead to these services being unusable. Although it is possible to 'smooth out' jitter, This adds to overall end-to-end delay which is itself a key quality parameter for real-time services

- Packet Loss. The purpose of a network is to correctly deliver the packets to a destination that are input from the source. By definition packet loss is an indication of failure to achieve this. Packet loss represents in-efficiency. It is most generally associated with a network that is overloaded. Some types of traffic are seriously affected by packet loss. Data transmission is the obvious example. In order to mitigate the effects of packet loss, TCP employs a re-transmission mechanism which, whilst protecting data integrity. This causes further network load.