

A method to determine the network performance objectives for IPv4 transport in the UMTS Terrestrial Radio Access Network

K A Knaggs†

† University College London

Abstract: In the 3GPP standards for Release 6 of the Universal Mobile Telecommunications System (UMTS) IPv4 transport is introduced between the Radio Network Controller (RNC) and Node-B to convey the radio network layer's user and control protocols. This paper gives an overview of a test model to help evaluate the QoS objectives needed to dimension the UMTS IPv4 transport network layer.

1 Introduction.

UMTS mobile operators in their hunt for capital and operational cost savings nowadays seek a choice whether IP or ATM is used as the transport network layer (TNL) to carry the various types of traffic (e.g. audio, video and data) from the circuit and packet domains. In the 3GPP UMTS Terrestrial Radio Access Network (UTRAN) standards for Release 99 & 4 [1] only ATM was specified for the TNL; however, in Release 5 and beyond IP is introduced as an alternative transport mechanism to satiate the operators' demands.

Whilst the ATM TNL QoS performance objectives (e.g. delay, jitter, loss etc.) are defined and their impact on a mobile users perception of telephony services understood; this is not the case, at present, with the proposed IPv4 TNL. A useful framework to gauge the requisite IPv4 QoS objectives is provided by ITU-T Recommendation Y.1541 which specifies public network performance objectives for an international end-to-end IP network path. However, within the Y.1541 Recommendation it was not intended that radio would function as the IP layers physical link; due to the extended transmission delays induced by the difficult propagation environment of air – the round-trip time can vary between a few hundred milliseconds and one second [2]. Accordingly mobile operators will require more stringent performance commitments from their network service provider (NSP) than the ITU-T Rec. Y.1541 defined network QoS Classes. In this regard mobile operators and vendors are pursuing several avenues to determine the bounds of a new mobile centric provisional class to facilitate IPv4 becoming a viable UTRAN TNL. There follows an overview of a suggested test model to help settle the requisite IPv4 TNL performance values.

2. Test Model Overview.

While it is possible to characterise the mobile radio network layer (RNL), for example, purely in terms of packet arrival time and throughput it is not easy to comprehend, nor readily express, what the effect of this is on the mobile user's experience? Hence the methodology adopted for the test model is to determine the TNL IPv4 transfer delay, delay variation, error ratio, loss ratio and packet reordering ratio [3] based on the Quality of Experience (QoE) as perceived by the mobile user. The advantage of this approach is that changes to network performance parameters, such as packet loss and transmission rate, do not always mirror the actual user's perception of the underlying TNL; ergo an opportunity exists to focus on those tunable QoS performance factors that unduly shape the users views. For example, a user's opinion of web-browsing download speed will be favourable for a slower rate, but reliable, TNL as opposed to a faster rate, but lossy, TNL; due to the latter TNL's throughput reductions resulting from TCP retransmissions and window size re-adjustment to overcome underlying network losses. By correlating QoE evaluations with actual measurement of the mobile's IP user plane data performance, in terms of throughput, packet loss, one-way delay and delay variation, an understanding of those IP factors that influence QoE can be gained; for example, the significance of TNL IP Datagram Size on overall performance can be seen when a reduction in the QoE MOS can be associated with a simultaneous jump in IP delay experienced on the mobile.

Concerning the IPv4 TNL, to overcome the cost implications of building a routed IPv4 network and the resultant difficulties fine tuning such a network's performance parameters, the UTRAN will

encompass the IP WAN impairment emulator (WIE) as shown in Figure 1. Rather than relying on the dialled up configuration parameters of the WIE, the performance envelope of the IPv4 TNL data delivery service will be resolved via a working implementation of the IETF WG IP Performance Metrics (IPPM) standards [4] that itself bounds the WIE. A secondary advantage of this approach is the near universal adoption of this set of metrics, the Reportable Metrics Set [5], allows the mobile operator to communicate verbatim those findings, as revealed by the test model, to be the NSP IPv4 TNL optimum network state.

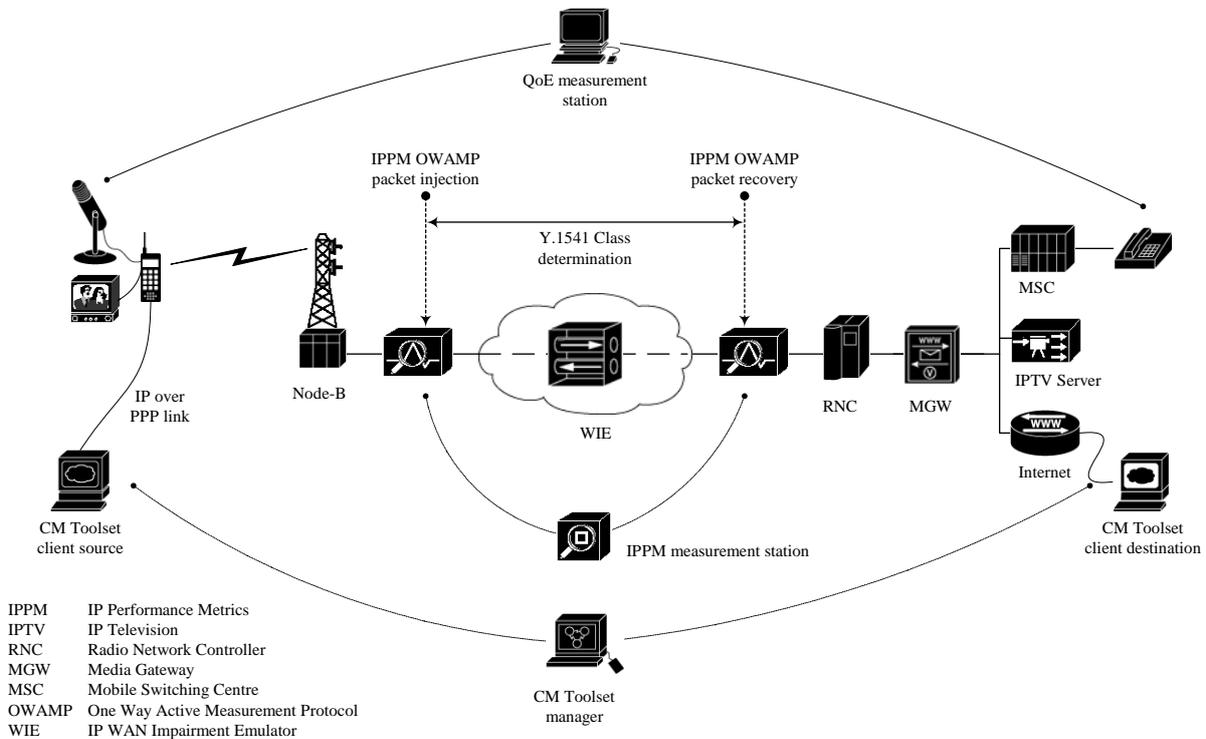


Figure 1. Test network architecture.

3. Test Model Components.

3.1 QoE Measurement.

The QoE measurement station shall provide an objective measurement of the perceptual quality for multimedia services such as telephony, videoconference, web browsing, etc. By this we mean an algorithm that compares an original multimedia signal $X(t)$ with a degraded multimedia signal $Y(t)$ that is the result of passing $X(t)$ through the WIE communications system. The output of the algorithm is a prediction of the perceived quality, based on a five-point category-judgement scale (Excellent = 5; Good = 4; Fair = 3; Poor = 2; Bad = 1), that would be given to $Y(t)$ by subjects in a subjective listening, watching, and interacting test. Perceptual models for the objective measurement of audio quality and video quality are now at a reasonably advanced stage within the ITU. ITU-T Recommendation P.862 is in place for narrowband voice audio quality measurement and the Video Quality Experts Group (VQEG), which reports to ITU-T Study Group 9, has provided input on objective video quality measurement algorithms. Current ITU-T Recommendations that will form the basis for the development of the multimedia model are ITU-T Recs P.910, P.911, P.920 and P.931. Further, a number of companies have proposed draft ITU standards based on existing product offerings that are expected to be released as recommendations; for example Opticom's Perceptual Evaluation of Download Quality algorithm that assesses web-browsing access quality from a user's point of view [6].

3.2 IPPM Measurement.

The IETF WG IP Performance Metrics (IPPM) has developed a set of standards that can quantify the performance and reliability of the test models WIE cloud. Of assistance in ascertaining the IPv4 TNL

QoS objectives are the One-way Delay Metrics [7], One-way Packet Loss Metrics [8], One-way Loss Pattern Sample Metrics [9], IP Packet Delay Variation Metric [10] and Packet Reordering Metric for IPPM [11]. Linux based demarcation devices, for example Brix Networks Brix Verifier [12], installed either side of the WIE using an implementation of the aforesaid standards and a prescribed evaluation interval of 1 minute can thus categorise the network based on ITU-T Recommendation Y.1540 and Y.1541 and assign a QoS class (0 though 5). Whilst the Communication Measurement Toolset (CM Toolset in Figure 1.) [13] or QosMetrics Netwarrior [14], for example, could provide the contextual performance information that helps an engineer make sense of the mobile users MOS score. In order to facilitate IPPM measurements using different vendor equipment at various points along the RNL / TNL link and still get meaningful results it is advisable to ensure the IPPM devices comply with the One-way Active Measurement Protocol [15]. An incidental benefit of placing IPPM probes at key junctures along the RNL / TNL path is the ability to calculate performance values attributable to various RNL / TNL component parts, i.e. Node-B, TNL, RNC etc.

An essential component that underpins IPPM measurements is the availability of an accurate time sources on all measuring nodes. A number of the metrics involve comparing times reported by two different clocks. For example, with the one-way packet delay metric, the time required for a packet to travel through the network is measured by comparing the time reported by clock C1 at one end of the packet's path, corresponding to when the packet first entered the network, with the time reported by clock C2 at the other end of the path, corresponding to when the packet finished traversing the network [16]. Whilst the hierarchy of the Network Time Protocol (NTP) typically provides accuracies within a millisecond on a LAN; if we compare clock C2's offset relative to C1 at a particular moment on disparate LAN's the difference in time reported by C2 and C1 could be a couple of milliseconds. This introduces a sizeable error "mask" that could, if not corrected or compensated for, undermine the accuracy of the IPv4 TNL measurements. As a result it is advisable that all clocks, and associated hardware buses, derive their time from an external source, preferably the global positioning system (GPS). Ideally in Ethernet environments the Precision Time Protocol IEEE 1588 should also be applied to achieve sub-microsecond timing accuracy [17].

4. Conclusions.

This paper has presented a high-level overview of a test model that can be used to help determine the UTRAN IPv4 TNL QoS objectives. It is not intended that this test model be considered a definitive solution to the aforementioned problem. Indeed early research indicates the test model needs to evolve to (1.) include a WIE that adjusts impairments in response to closed loop feedback from the IPPM measurement stations either side; (2.) allows for concatenating QoS performance values attributed to (a.) the processing delay introduced when a RNC experiences traffic overload and (b) the QoS performance values of the path to the right of the MGM in Figure 1. For example, in the case of the mean delay performance parameter, the end-to-end performance is the sum of the means contributed by each network section; that is to say, mobile operators must account for international call delays in their national IPv4 TNL delay budgets if they are not to block overseas calls.

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Appendices.

For the purposes of the present document, the following abbreviations apply:

ATM	Asynchronous Transfer Mode
GPS	Global Positioning System
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv4	Internet Protocol Version 4
ITU	International Telecommunications Union
LAN	Local Area Network
MOS	Mean Opinion Score – see ITU-T Recommendation P.800
Node B	Responsible for radio transmission / reception to/from the mobile phone
NSP	Network Service Provider
NTP	Network Time Protocol
QoE	Quality of Experience
QoS	Quality of Service
RFC	Request for Comments
RNC	Radio Network Controller
RNL	Radio Network Layer
TNL	Transport Network Layer
UMTS	Universal Mobile Telecommunications System – see ETSI 3GPP Project
UTRAN	Universal Terrestrial Radio Access Network
WAN	Wide Area Network
WG	Working Group