CONE – CONVERGENT HETEROGENEOUS NETWORKS QOS EVALUATION TOOL

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ABSTRACT

This paper presents CONE - the Convergent Heterogeneous Networks Evaluation Tool. CONE was designed to help Instinct Project network analysts, business modelers and consumers to evaluate convergent services when running over heterogeneous networks with real traffic, considering the need of a cheap setup. CONE is comprised of a series of network emulators in virtual machines. It does not have the overhead of simulating complex networks, receiving data from external simulators instead, so it can emulate fast networks. CONE has the ability to emulate the entire heterogeneous networks environment (content delivery and return channel system), when or where it is not available. It emulates the "real world" inserted into the data path of a prototype of such environment and gives its user the ability to evaluate the results from the customer's point of view. CONE emulates both the delivery path and the return channel, allowing for service interactivity. It is based in existing tools like the *Linux iproute2* architecture and *VNUML*. We also provide virtual networks jitter measurements for scalability purposes. At the presentation it will be demonstrated how video content delivery is affected by network conditions under heavy duty.

INTRODUCTION

The rapid advances recently in mobile devices, wireless networking, and messaging technologies have given mobile users an excess of choices to access service contents (9). Unfortunately, all these devices and protocols, such as Palm PDAs, cell phones with Wireless Application Protocol (WAP) or Short Message Service (SMS) and Digital Video Broadcast (DVB) do not communicate with each other easily. For example, the nature of wireless Internet, or the traditional Internet is very different from Digital Video Broadcast.

In other words, new communication systems proposed for heterogeneous environments use many of the existing network communication systems to perform convergent services over heterogeneous networks.

Heterogeneous networks project management has to coordinate multiple technologies, interfaces, vendors and materials. These characteristics make the infrastructure and business model design more difficult. Quality of Service (QoS) validation is also very hard to perform (8). In most cases, mock-ups (a usually full-sized scale model of a structure, used for demonstration, study, or testing) do not present real applications (audio and video) and network performance requirements (delay, jitter, bandwidth) to network, application or business analysts (7).

In this case, we need a tool that will allow the evaluation of QoS parameters of the various networks and services in the mobile environment (5,2,1). This tool should help to manage technical influences on the system, including other system parameters, equipment, models, terminals and middleware. When used with mock-ups of the services, it allows the consumer/user to evaluate real applications and services. The tool also provides guidelines about user behaviour, expectations and acceptability of mobile applications.

This paper is organized as follows. In next section we describe the environment where we focus our work; in section Service Design and Quality Assessment we examine the issues about evaluating end-to-end convergent services over heterogeneous networks and in section CONE we present the tool. Finally, in the last section, we draw some conclusions.

ENVIRONMENT

The main downstream path of convergent heterogeneous services, mainly video streaming with a high content of data, meta-data and interactivity possibilities, comes through Digital TV system DVB, named DVB-T (Terrestrial) and DVB-H (for handhelds) (6). The reason for this choice is its huge capability for transmitting digital content downstream. There is, of course, an IP-HEADEND to provide IP content to be transmitted over the DVB channel. The receiver itself has some capabilities for reception of various sources. Hybrid receivers will be receiving data from the DTV channel but can, if it is not available, receive data from the mobile network. In this case, enough bandwidth must be granted but, above all, the transition from one channel to the other must occur without notice, or with minor consequences for the consumer. When moving the mobile receiver there is a channel switch, named handover, which is called horizontal if done from one cell to another of the same technology and vertical if from one technology to another; the handover must happen without the participation of the consumer, for whom it must be transparent.

When watching a TV program or gaming, the consumer would interact with the service and there should be a return channel, a channel for the interaction information. This return channel, usually created over the mobile network because of its unique UNICAST capability, will play an important role when the services need quick answers from the service provider. The connection capability, the time to connect and the service provider reach ability over the various networks through which the information needs to travel and, on the other hand, the time that the consumer feels that the action has taken, are some of the parameters of quality of service - QoS.

Each network will be playing its own role on the overall service delivery. The Internet will be used many times in this path, from any service provider, service creator, video streaming, return channel and so on. A model for this environment is shown in Figure 1.

A new era of communication has begun, not only for the communication processes themselves but also mainly for the new consumers that the market brings to business every day. This new environment is creating solutions for problems not even imaginable a couple of years ago.

These new services and their potential consumers are not well known, or not known at all, to the potentials vendors, service providers, etc. The sets of stakeholders (4), infrastructure, equipments, possible contents and so on are too complex and too expensive to be experimented in laboratories.

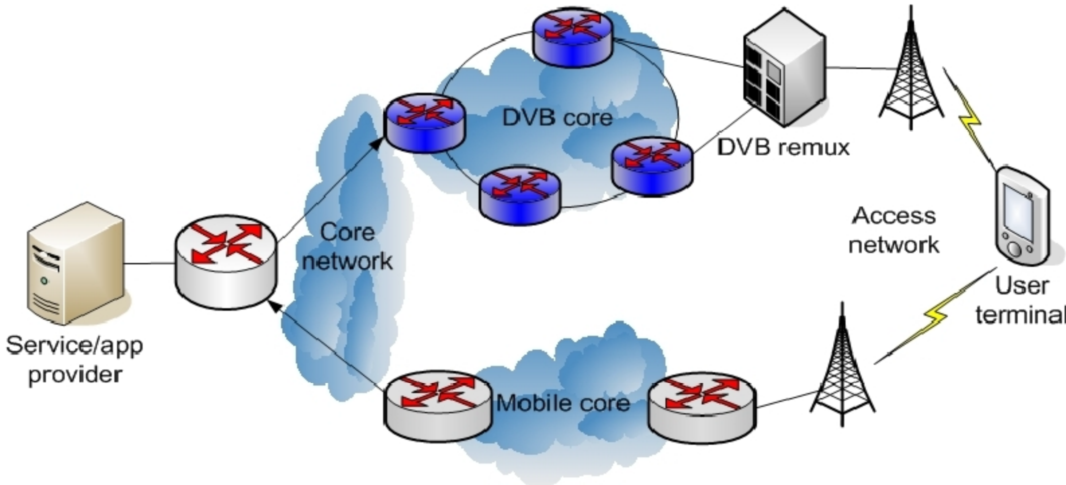

Figure 1: Environment Model

In this environment, with so many variables, there must be a way to learn before doing any mistakes. The way one can find is to simulate, to emulate, to create a way to learn what the consumer will like and, if possible, how much he would pay for a set of services with a given quality.

The environment where various networks serve as the infrastructure for streaming data, news information, video and TV content, interactivity and mobility need to be integrated with the end-to-end quality perception. End-to-end in its real meaning, not from one border to another of a single network; the complete set of internal network QoS parameters have to be integrated and the consumer must be the main end.

The end that will pay the bill will decide when a service is worth it. This quality perception has to be measured against that promised when the service was sold. There is an agreement - the Service Level Agreement (SLA) - where quality in its many ways will be confronted to the expectations of the client. The human factor study is, in this sense, the better returning investment in the project. Whoever knows better what to sell to who, will be in business for a much longer time.

An Evaluation tool that can bring some *"reality"* to the test environment will bring light to the consumer needs and expectations on whatever service one could imagine. Prototyping the service in a local area network is far cheaper than the real implementation, even in a restricted area or lab. Using mobile equipment, the consumer will feel like the service is real providing that the evaluation tool can bring even the technical QoS problems to the service. The Evaluation Tool concept is in Figure 2.

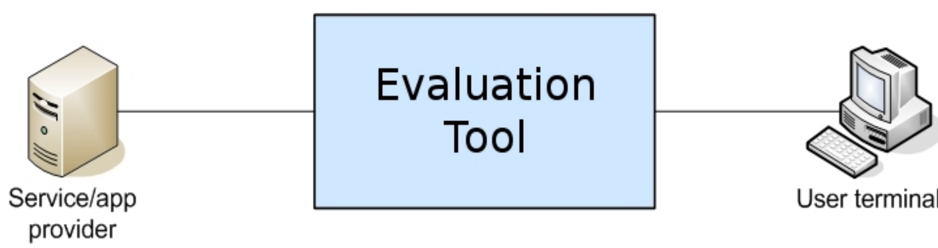

Figure 2: Evaluation Tool Concept.

The concept is to give to the evaluation tool the real, measured or simulated, QoS parameters and get, at the consumer end, the quality results to be evaluated by the consumer point of view.

SERVICE DESIGN AND QUALITY ASSESSMENT

All stakeholders in such a heterogeneous environment have their own QoS parameters and SLAs or contracts. The main problem is that the consumer does not need nor want to know who does what, who is the responsible for any lack of quality. A lack of quality in any part of the chain is equally responsible for the lack of quality of the overall service. The only SLA that really matters is the one seen by the consumer. Internal QoS parameters or any other problem with technical equipment, traffic problems, billing, etc are not to be addressed by or with the consumer.

The design of any new service must comply with the existing infrastructure and must be evaluated using, if possible, the real environment. Such type of evaluation is often not feasible or too expensive to be implemented. Considering this, the mere existence of an evaluation tool would be a necessity.

Using such tool, a consumer can try a complex service using a mock-up with the added quality problem that the given network infrastructure will have; this network infrastructure could even be one that does not exist or is still in planning. This way the consumer would have a *"real feeling"* of the services. It would be inexpensive to know the consumer in advance.

USING CONE

CONE provides the user with a testing environment composed of ten virtual networks (uml1,...,uml5) (Figure 3). Each one of these virtual networks can represent one of the real networks in the data path the user wants to study. The data path is divided in two groups: forward path and return path, each of them containing five virtual networks. The forward and return paths are serial sequences of networks that represent how the real networks are distributed between a specific server and a specific client.

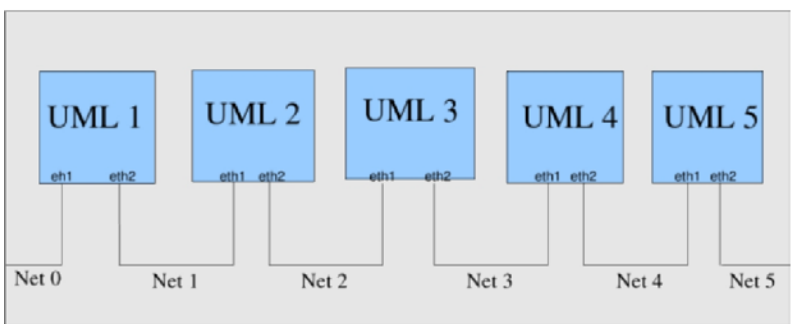

Figure 3: Virtual Networks: Host Linux Box

In order to configure the virtual networks, the tool provides five different types of network configurations. Each network configuration has a name (such as Broadcast Core Network, DVB Backbone, DVB Transmitter, Mobile Access Network and Telco Backbone Aspects) and an array of QoS parameters, and can be applied to any of the ten virtual network interfaces. As of now, the available QoS parameters are: packet delay (ms); packet delay jitter (ms); packet drop (%); packet duplication (%), and bandwidth.

When using the tool, the user has also to tell it who the two end machines are. The tool will have all - and only - the packets flowing between these two addresses routed through the virtual networks. These packets will then be affected by the parameters specified for each virtual network interface, representing the conditions of a real network. As a result, the user is able to see the effects of these networks on real traffic. This means that, instead of analyzing network simulation delay charts, the user can just play a video stream through CONE and see the effects on playback quality.

In order to completely configure the tool for usage, the user has to follow these steps: (i) define source and destination machines; (ii) configure parameters in all network configurations that will be used; (iii) apply network configurations to desired interfaces along the forward and return paths. The Evaluation Tool interface can be seen in Figure 4.

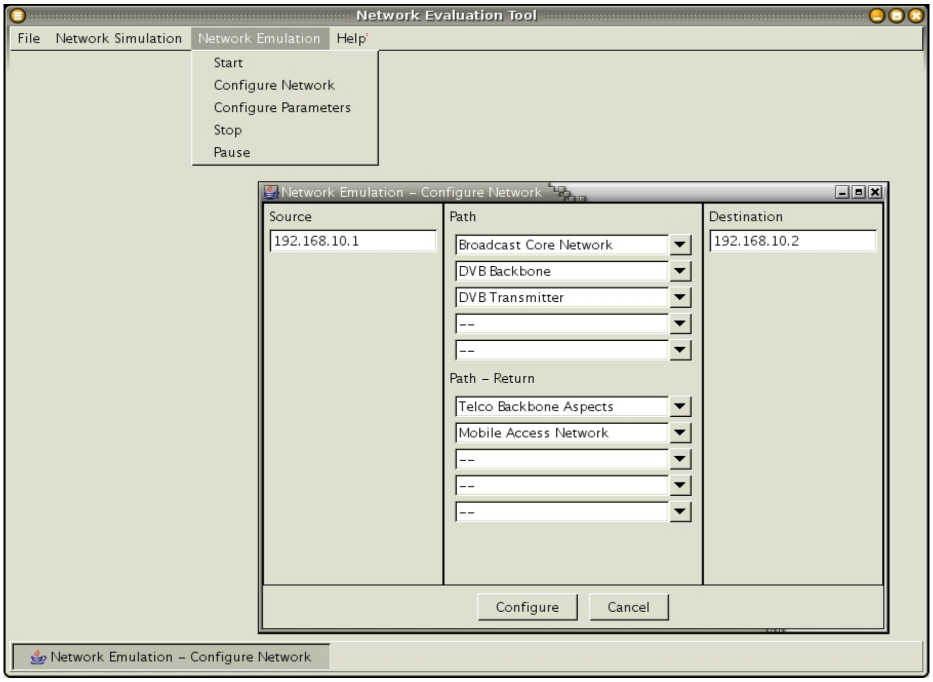

Figure 4: CONE Interface.

It is easy to see that configuring all five parameters for all five possible network configurations, and after that applying these configurations to all ten network interfaces can be a tedious job. For this reason, we have included an XML configuration file import facility. This file can be easily generated from network simulation environments, allowing for integration between QoS parameters generation (simulators) and their usage (CONE). For example, if a network design team wishes to test the performance of a new planned network, it generally uses a lot of simulation before deploying it. The data generated by simulation, however, is purely technical, composed of traffic delay numbers at certain nodes, queue sizes etc. For an end-to-end point of view with real data, the team could assemble an XML file with the technical data and upload it to CONE, which would show them the effects of that particular simulation run with real data passing through.

Another important feature of CONE is temporal variation. As this tool was designed for mobile environments testing, it has to be able simulate mobility features such as signal strength variation, losses of connectivity etc. These features can be translated into TCP/IP QoS parameters if their values can shift according to a predefined function over time.

Figure 5: Mpeg4, Drop = 0.1%, Delay = 1.5 ms and Jitter = 0.025 ms

We tested our tool using Mpeg2 and Mpeg4 video transmissions over Real Time Protocol (RTP) without any cache or buffering. We did not use any buffer at these tests because we really want to understand very well how the buffer size will affect this early results in QoS for video jitter and, on the other hand, how it will affect the time response for continued interaction with the consumer. In Figure 5 we can see the result of an Mpeg4 video transmission where the network packet drop was 0.1%, the delay was 1.5 ms and the jitter was 0.025 ms. In Figure 6 we can see an Mpeg2 video transmission result with the same drop, delay and jitter values.

Figure 6: Mpeg2, Drop = 0.1%, Delay = 1.5 ms and Jitter = 0.025 ms

PERFORMANCE MEASUREMENTS

During our experiments, we noted that sometimes the results were not as clean (video quality) as they should be with all parameters set to zero. This could be due to the introduction of several virtual networks along the data path. In an experiment to measure this interference, we sent approximately 4000 ICMP echo request (ping) packets to a neighbour host, measuring the total round-trip time until the ICMP echo reply came back. The experiment was repeated on four different setups: no virtual machine (the standalone Linux kernel), two, four and six virtual machines in the data path. The results are in Figure 7.

From Figure 7 we can see that there is no significant difference between delays of the two first setups, with zero or two virtual machines. There is, however, a significant increase in delay with four and six virtual machines, as long as an increase in delay variation, which can be interpreted as delay jitter. The consolidated data can be seen in Figure 8.

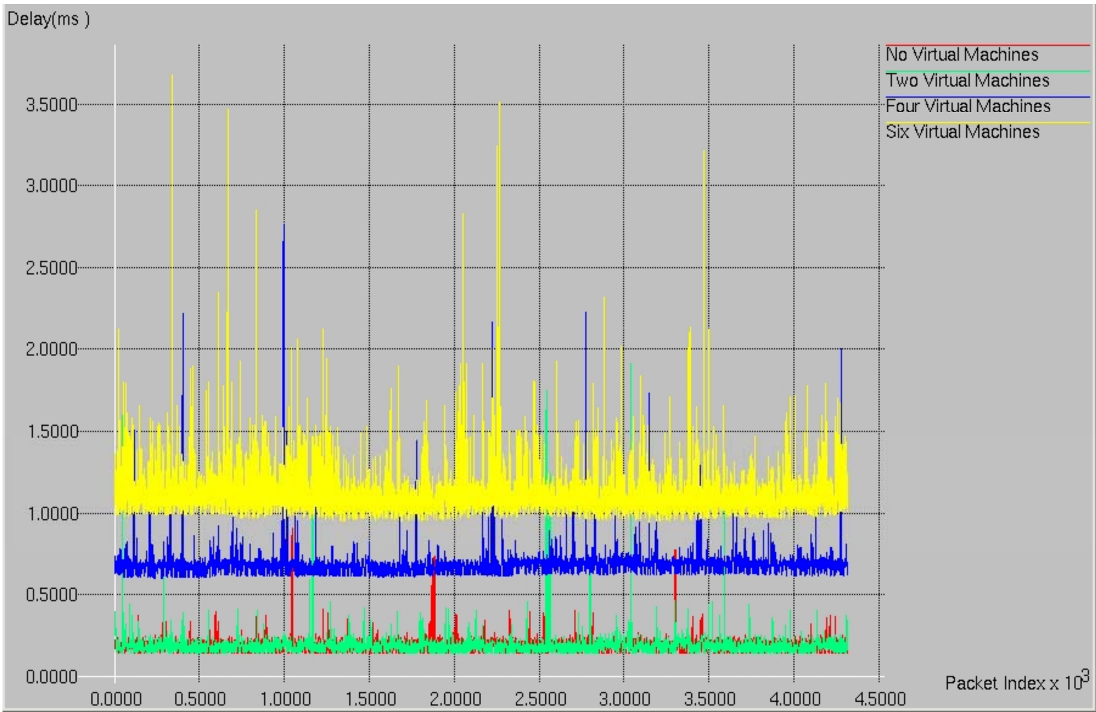

Figure 7: Measured round-trip time for ICMP echo packets

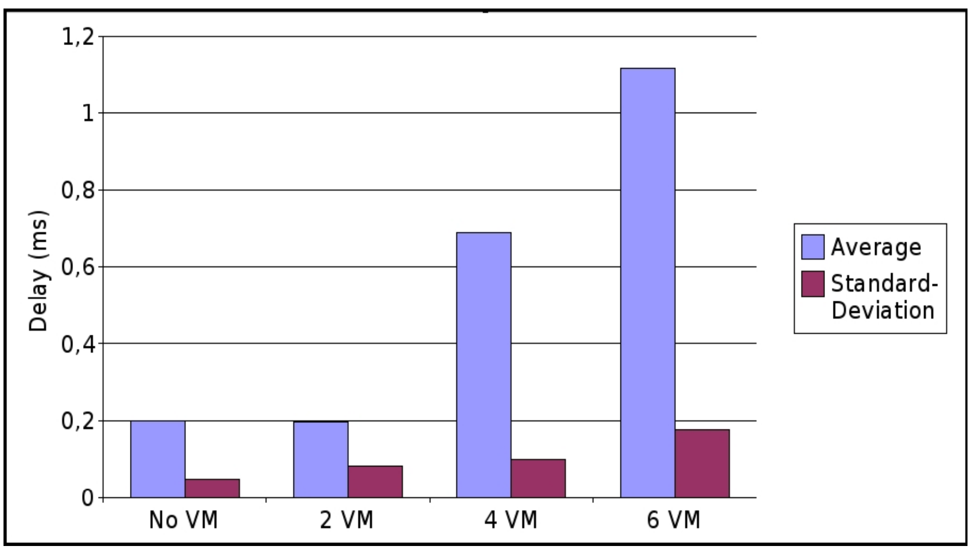

Figure 8: Average and Standard Deviation for Measured Packet Delay

CONCLUSIONS

The first attempts to get the consumer point of view evaluation for the overall QoS or, as we are calling it, the End-to-End QoS, were very stimulating. The next phase is to compare the simulated results against real ones, not available yet. The Human Factors for project INSTINCT (3) is one of the most important activities of its first phase. This Evaluation Tool will play an important role in phase two since services will be created and their evaluation could be made easier; determining network requirements will also be easier for regions where no real networks can be easily accessed for testing purposes.

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