       Evaluation Test Cases for Interactive Real-Time Media over Cellular
                                  Networks
                draft-sarker-rmcat-cellular-eval-test-cases-00

Abstract

   It is evident that to ensure seamless and robust user experience
   across all type of access networks multimedia communication suits
   should adapt to the changing network conditions. There is an ongoing
   effort in IETF RMCAT working group to standardize rate adaptive
   algorithm(s) to be used in the real-time interactive communication.
   In this document test cases are described to evaluate the
   performances of the proposed endpoint adaptation solutions in a
   cellular network such as LTE network. It is aimed that the proposed
   solutions should be evaluated using the test cases defines in this
   document to select most optimal solutions.

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1. Introduction

Cellular networks are an integral part of the Internet. Mobile
devices connected to the cellular networks produces huge amount of
media traffic in the Internet. It is important to evaluate the
performance of the proposed RMCAT candidates in the cellular network.

A cellular environment is more complicated than a wireline ditto
since it seeks to provide services in the context of variable
available bandwidth, location dependencies and user mobilities at
different speeds. In a cellular network the user may reach the cell
edge which may lead to a significant amount of retransmissions to
deliver the data from the base station to the destination and vice
versa. These network links or radio links will often act as a
bottleneck for the rest of the network which will eventually lead to
excessive delays or packet drops. An efficient retransmission or
link adaptation mechanism can reduce the packet loss probability but
there will still be some packet losses and delay variations.
Moreover, with increased cell load or handover to a congested cell,
transport network level congestion will become even worse. Besides,

there are certain characteristics which make the cellular network
different and challenging than other types of access network such as
Wi-Fi and wired network. In a cellular network -

o The bottleneck is often a shared link with relatively few users.

   * The cost per bit over the shared link varies over time and is
      different for different users.

   * Left over/ unused resource can be grabbed by other greedy
      users.

o Queues are always per radio bearer hence each user can have many
   of such queues.

o Users can experience both Inter and Intra Radio Access Technology
   (RAT) handovers ("handover" definition in [HO-def-3GPP]).

o Handover between cells, or change of serving cells (see in
   [HO-LTE-3GPP] and [HO-UMTS-3GPP]) might cause user plane
   interruptions which can lead to bursts of packet losses, delay and
   /or jitter. The exact behavior depends on the type of radio
   bearer. Typically, the default best effort bearers do not
   generate packet loss, instead packets are queued up and
   transmitted once the handover is completed.

o The network part decides how much the user can transmit.

o The cellular network has variable link capacity per user

   * Can vary as fast as a period of milliseconds.

   * Depends on lots of facts (such as distance, speed,
      interference, different flows).

   * Uses complex and smart link adaptation which makes the link
      behavior ever more dynamic.

   * The scheduling priority depends on the estimated throughput.

o Both Quality of Service (QoS) and non-QoS radio bearers can be
   used.

Hence, a real-time communication application operating in such a
cellular network need to cope with shared bottleneck link and
variable link capacity, event likes handover, non-congestion related
loss, abrupt change in bandwidth (both short term and long term) due
to handover, network load and bad radio coverage. Even though 3GPP

define QoS bearers [QoS-3GPP] to ensure high quality user experience,
adaptive real-time applications are desired.

Different mobile operators deploy their own cellular network with
their own set of network functionalities and policies. Usually, a
mobile operator network includes 2G, EDGE, 3G and 4G radio access
technologies. Looking at the specifications of such radio
technologies it is evident that only 3G and 4G radio technologies can
support the high bandwidth requirements from real-time interactive
video applications. The future real-time interactive application
will impose even greater demand on cellular network performance which
makes 4G (and beyond radio technologies) more suitable access
technology for such genre of application.

RMCAT evaluation criteria [I-D.ietf-rmcat-eval-criteria] document
provides the guideline to perform the evaluation on candidate
algorithms and recognize cellular networks to be important access
link, however, it does not provides particular test cases to evaluate
the performance of the candidate algorithm. In this document we
device test cases specifically targeting cellular networks such as
LTE networks.

2. Terminologies

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in RFC2119 [RFC2119]

3. Cellular Network Specific Test Cases

The key factors to define test cases for cellular network are

o Shared and varying link capacity

o Mobility

o Handover

However, for cellular network it is very hard to separate such events
from one another as these events are heavily related. Hence instead
of devising separate test cases for all those important events we
have divided the test case in two categories. It should be noted
that in the following test cases the goal is to evaluate the
performance of candidate algorithms over radio interface of the
cellular network. Hence it is assumed that the radio interface is
the bottleneck link between the communicating peers and that the core
network does not add any extra congestion in the path. Also the
combination of multiple access technologies such as one user has LTE

connection and another has Wi-Fi connection is kept out of the scope
of this document. However, later those additional scenarios can also
be added in this list of test cases. While defining the test cases
we assumed a typical real-time telephony scenario over cellular
networks where one real-time session consists of one voice stream and
one video stream. We recommend that an LTE network simulator is used
for the test cases defined in this document.

3.1. Varying Network Load

The goal of this test is to evaluate the performance of candidate
congestion control algorithm under varying network load. The network
load variation is created by adding and removing network users a.k.a.
User Equipments (UEs) during the simulation. In this test case each
of the user/UE in the media session is an RMCAT compliant endpoint.
The arrival of users follows a Poisson distribution, which is
proportional to the length of the call, so that the number of users
per cell is kept fairly constant during the evaluation period. At
the beginning of the simulation there should be enough amount of time
to warm-up the network. This is to avoid running the evaluation in
an empty network where network nodes are having empty buffers, low
interference at the beginning of the simulation. This network
initialization period is therefore excluded from the evaluation
period.

This test case also includes user mobility and competing traffic.
The competing traffics includes both same kind of flows (with same
adaptation algorithms) and different kind of flows (with different
service and congestion control). The investigated congestion control
algorithms should show maximum possible network utilization and
stability in terms of rate variations, lowest possible end to end
frame latency, network latency and Packet Loss Rate (PLR) at
different cell load level.

3.1.1. Network Connection

Each mobile user is connected to a fixed user. The connection
between the mobile user and fixed user consists of a LTE radio
access, an Evolved Packet Core (EPC) and an Internet connection. The
mobile user is connected to the EPC using LTE radio access technology
which is further connected to the Internet. The fixed user is
connected to the Internet via wired connection with no bottleneck
(practically infinite bandwidth). The Internet and wired connection
in this setup does not add any network impairments to the test, it
only adds 10ms of one-way transport propagation delay.

3.1.2. **Simulation Setup**

   The desired simulation setup as follows-

   1. Radio environment

       A. Deployment : 3GPP case 1[Deployment]

       B. Antenna: Multiple-Input and Multiple-Output (MIMO)

       C. Mobility: [3km/h, 30km/h]

       D. Transmission bandwidth: 10Mhz

       E. Number of cells: multi cell deployment (3 Cells per Base
           Station (BS) * 7 BS) = 21 cells

       F. Cell radius: 166.666 Meters

       G. Scheduler: Proportional fair with no priority

       H. Bearer: Default bearer for all traffic.

       I. Active Queue Management (AQM) settings: AQM [on,off]

   2. End to end Round Trip Time (RTT): on avg. {40ms,....,150ms}

   3. User arrival model: Poisson arrival model

   4. User intensity = {0.7,.....,10.5}

   5. Simulation duration: 91s

   6. Evaluation period : 30s-60s

   7. Media traffic model

       1. Media Type: Video

           a. Number of Media source per user: One (1)

           b. Media direction: [Uplink, Downlink]

           c. Media duration per user: 30s

           d. Media codec : Variable BitRate (VBR)

           e. Bitrate :

          - Maximum bitrate: nominal 1.5 Mbps

          - Minimum bitrate: nominal 150kbps

       f. Adaptation:

          - Bitrate: 150kbps-1.5mbps

          - Resolution: 144p-720p(1080p)

          - Framerate: 10fps-30fps

    2. Media Type : Voice

       a. Number of Media source per user: One (1)

       b. Media direction: {Uplink, Downlink}

       c. Media duration per user: 30s

       d. Media codec: Constant BitRate (CBR)

       e. Bitrate :

          - Maximum bitrate: 20 kbps

       f. Adaptation: off

  8. Other traffic model: Maximum of 2Mbps/cell (web browsing or FTP
     traffic)

3.2. Bad Radio Coverage

The goal of this test is to evaluate the performance of candidate
congestion control algorithm when users visit part of the network
with bad radio coverage. The scenario is created by using larger
cell radius than previous test case. In this test case each of the
user/UE in the media session is an RMCAT compliant endpoint. The
arrival of users follows a Poisson distribution, which is
proportional to the length of the call, so that the number of users
per cell is kept fairly constant during the evaluation period. At
the beginning of the simulation there should be enough amount of time
to warm-up the network. This is to avoid running the evaluation in
an empty network where network nodes are having empty buffers, low
interference at the beginning of the simulation. This network
initialization period is therefore excluded from the evaluation
period.

This test case also includes user mobility and competing traffic.
The competing traffics includes same kind of flows (with same
adaptation algorithms) . The investigated congestion control
algorithms should show maximum possible network utilization and
stability in terms of rate variations, lowest possible end to end
frame latency, network latency and Packet Loss Rate (PLR) at
different cell load level.

3.2.1. Network connection

Same as defined in Section 3.1.1

3.2.2. Simulation Setup

The desired simulation setup is same as Varying Network Load test
case defined in Section 3.1 except following changes-

1. Radio environment : Same as defined in Section 3.1.2 except
    followings

    A. Deployment : 3GPP case 3[Deployment]

    B. Cell radius: 577.3333 Meters

2. User intensity = {0.7,.....,7.0}

3. Media traffic model: Same as defined in Section 3.1.2

4. Other traffic model: None

4. Desired Evaluation Metrics

RMCAT evaluation criteria document [I-D.ietf-rmcat-eval-criteria]
defines metrics to be used to evaluate candidate algorithms.
However, looking at the nature and distinction of cellular networks
we recommend at minimum following metrics to be used to evaluate the
performance of the candidate algorithms for the test cases defined in
this document.

The desired metrics are-

o Average cell throughput (for all cells), shows cell utilizations

o Application sending and receiving bitrate, goodput

o Packet Loss Rate (PLR)

o End to end Media frame delay

o Transport delay

o Algorithm stability in terms of rate variation

[Editor's note: This document needs to define the metrics clearly (or
provide references to the respective definition) and the procedure of
measuring those.]

5. Conclusion

This document defines two test cases that are considered important
for cellular networks. Moreover, this document also provides a
framework to define more additional test cases for cellular network.

6. Acknowledgements

We would like to thank Tomas Frankkila, Magnus Westerlund, Kristofer
Kristofer Sandlund for their valuable comments while writing this
draft.

7. IANA Considerations

This memo includes no request to IANA.

8. Security Considerations

Security issues have not been discussed in this memo.

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