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**Evaluation Test Cases for Interactive Real-Time Media over Cellular
Networks
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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, congestion in transport network 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 the 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.

The path from the fixed user to mobile user is defines as "Downlink" and the path from mobile user to the fixed user is defined as

"Uplink". We assume that only uplink or downlink is congested for the mobile users. Hence, we recommend that the uplink and downlink simulations are run separately.

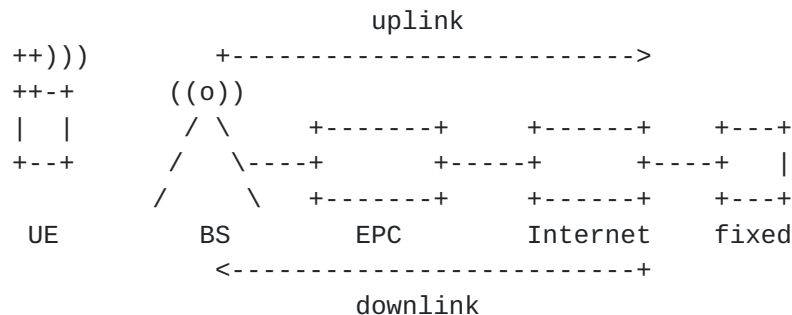


Figure 1: Simulation Topology

3.1.2. Simulation Setup

The values enclosed within " [] " for the following simulation attributes follow the notion set in [I.D.[draft-sarker-rmcat-eval-test](#)]. 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): [40, 150]
3. User arrival model: Poisson arrival model

4. User intensity:

- * Downlink user intensity: {0.7, 1.4, 2.1, 2.8, 3.5, 4.2, 4.9, 5.6, 6.3, 7.0, 7.7, 8.4, 9.1, 9.8, 10.5}
- * Uplink user intensity : {0.7, 1.4, 2.1, 2.8, 3.5, 4.2, 4.9, 5.6, 6.3, 7.0}

5. Simulation duration: 91s

6. Evaluation period : 30s-60s

7. Media traffic

1. Media type: Video

- a. Media direction: [Uplink, Downlink]
- b. Number of Media source per user: One (1)
- c. Media duration per user: 30s
- d. Media source: same as define in [section 4.3](#) of [I.D.[draft-sarker-rmcat-eval-test](#)]

2. Media Type : Audio

- a. Media direction: Uplink and Downlink
- b. Number of Media source per user: One (1)
- c. Media duration per user: 30s
- d. Media codec: Constant BitRate (CBR)
- e. Media bitrate : 20 Kbps
- f. Adaptation: off

8. Other traffic model:

- * Downlink simulation: Maximum of 4Mbps/cell (web browsing or FTP traffic)
- * Uplink simulation: 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
 - C. Mobility: 3km/h
2. User intensity = {0.7, 1.4, 2.1, 2.8, 3.5, 4.2, 4.9, 5.6, 6.3, 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. For video, this means the delay from capture to display.
- o Transport delay.
- o Algorithm stability in terms of rate variation.

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

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7. IANA Considerations

This memo includes no request to IANA.

8. Security Considerations

Security issues have not been discussed in this memo.

9. References

9.1. Normative References

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