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Evaluation Test Cases for Interactive Real-Time Media over Wireless 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 LTE networks and Wi-Fi networks. It is aimed that the proposed solutions should be evaluated using the test cases defined in this document to select most optimal solutions.

Status of This Memo

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1. Introduction

Wireless networks (both cellular and Wi-Fi [IEEE802.11] local area network) are an integral part of the Internet. Mobile devices connected to the wireless networks produces huge amount of media traffic in the Internet. They covers the scenarios of having a video call in the bus to media consumption sitting on a couch in a living room. It is a well known fact that the characteristic and challenges for offering service over wireless network are very different than providing the same over a wired network. Even though RMCAT basic test cases defines number of test cases that covers lots of effects of the impairments visible in the wireless networks but there are characteristics and dynamics those are unique to particular wireless environment. For example, in the LTE the base station maintains queues per radio bearer per user hence it gives different interaction when all traffic from user share the same queue. Again, the user mobility in a cellular network is different than the user mobility in a Wi-Fi network. Thus, It is important to evaluate the performance

of the proposed RMCAT candidates separately in the cellular mobile networks and Wi-Fi local networks (IEEE 802.11xx protocol family).

RMCAT evaluation criteria [I-D.ietf-rmcat-eval-criteria] document provides the guideline to perform the evaluation on candidate algorithms and recognizes wireless 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 and Wi-Fi local 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

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 -

- 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.

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

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

- 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.

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

- 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.

- 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.

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, for example-NS-3 LTE simulator [LTE-simulator].

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.

```
                          uplink
   ++)))        +---------------------------->
   ++-+      ((o))
   |  |       / \     +--------+    +-------+   +----+
   +---+     /   \----+       +------+     +-----+   |
            /     \   +--------+    +-------+   +----+
    UE         BS        EPC        Internet    fixed
                <---------------------------+
                         downlink
```

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.ietf-rmcat-eval-test]. The desired simulation setup as follows-

1. Radio environment

   A. Deployment and propagation model : 3GPP case 1[Deployment]

   B. Antenna: Multiple-Input and Multiple-Output (MIMO), [2D, 3D]

   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 intercity : {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.ietf-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)

* Unlink 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 and propagation model : 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

3.3. Desired Evaluation Metrics for cellular test cases

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.

4. Wi-Fi Networks Specific Test Cases

TBD

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

[Deployment]
TS 25.814, 3GPP., "Physical layer aspects for evolved Universal Terrestrial Radio Access (UTRA)", October 2006, <http://www.3gpp.org/ftp/specs/archive/25_series/25.814/25814-710.zip>.

[HO-def-3GPP]
TR 21.905, 3GPP., "Vocabulary for 3GPP Specifications", December 2009, <http://www.3gpp.org/ftp/specs/archive/21_series/21.905/21905-940.zip>.

[HO-LTE-3GPP]
TS 36.331, 3GPP., "E-UTRA- Radio Resource Control (RRC); Protocol specification", December 2011, <http://www.3gpp.org/ftp/specs/archive/36_series/36.331/36331-990.zip>.

[HO-UMTS-3GPP]
TS 25.331, 3GPP., "Radio Resource Control (RRC); Protocol specification", December 2011, <http://www.3gpp.org/ftp/specs/archive/25_series/25.331/25331-990.zip>.

[I-D.ietf-rmcat-eval-criteria]
Singh, V. and J. Ott, "Evaluating Congestion Control for Interactive Real-time Media", draft-ietf-rmcat-eval-criteria-03 (work in progress), March 2015.

[QoS-3GPP]
TS 23.203, 3GPP., "Policy and charging control architecture", June 2011, <http://www.3gpp.org/ftp/specs/archive/23_series/23.203/23203-990.zip>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

9.2. Informative References

[I-D.ietf-rmcat-cc-requirements]
Jesup, R. and Z. Sarker, "Congestion Control Requirements for Interactive Real-Time Media", draft-ietf-rmcat-cc-requirements-09 (work in progress), December 2014.

[I-D.ietf-rmcat-eval-test]
Sarker, Z., Singh, V., Zhu, X., and M. Ramalho, "Test Cases for Evaluating RMCAT Proposals", draft-ietf-rmcat-eval-test-01 (work in progress), March 2015.

[IEEE802.11]
"Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications", 2012.

[LTE-simulator]
"NS-3, A discrete-Event Network Simulator", <https://www.nsnam.org/docs/release/3.23/manual/html/index.html>.

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