Contribution to Improving the Quality of Traffic in Mobile Networks

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Authors' contributions

This work was carried out in collaboration among all authors. Author OTA designed the study and wrote the first version. Author RD wrote the second version and performed the tests supervised by author AV and made some corrective remarks and all authors contributed to the overall achievement. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Today, mobile networks are faced with congestion which results in regular slowness given the variation in the actual speed of the network, that is to say the time required to transmit all of the data from a point to another. In third and fourth generation mobile networks, actual throughput is not directly measurable, it actually consists of three separate indicators, latency, jitter and loss rate. Many studies have shown that these parameters have a particular influence on congestion problems. In practice, the effective speed on the network is inversely proportional to the latency. However, the bit rate is four times the latency. Next, jitter is the variation of latency over time, impacting the flow by influencing latency. In this article, we have examined the analysis of traffic congestion in third and fourth generation networks in order to make a comparative study of the congestion rate for good decision-making.

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1. INTRODUCTION

Congestion causes saturation of nodes in a network and thus disrupts data processing, which leads to either a significant delay in routing, or loss of data. Faced with this problem, a mechanism must be put in place to control congestion [1-3]. Cellular networks have grown exponentially and their technologies have evolved rapidly in recent decades. Given the high demand for mobile data connectivity worldwide, the data rates of mobile networks have been constantly improved [4,5]. Today, there are many technologies that aim to connect users to each other and allow them to access the Internet from almost anywhere in the world [6,7]. But sometimes they are known for their great variability in terms of performance [8,9,4]. As a result, users often experience low data rates and high transmission delays. We note that congestion is one of the main causes of this situation [10,11]. The research that has been carried out to date has not been able to fully control congestion [12-14]. The resurgence of flows and traffic creates permanent challenges in Congestion research [15-17]. The purpose of this research is to study all the causes of congestion and to set up realistic methods to improve the quality of traffic in mobile networks. In this article, we are interested in the analysis of traffic congestion in third and fourth generation networks.

2. STAND-ALONE DEDICATED CONTROL CHANNEL CONGESTION

2.1 Definition

The Stand-alone Dedicated Control Channel (SDCCH) is one of the important counters that indicate accessibility in circuit service. It is the ratio of Failed SDCCH Seizures to the total no of SDCCH attempts. If all the SDCCH Resources are busy and not available for assignment then it is called SDCCH Congestion.

2.2 Formula

The formula of SDCCH Congestion is:

$$\text{SDCCH Congestion} = (\text{CCONGS}/\text{CCALLS}) * 100 \tag{2.1}$$

CCONGS is the Failed SDCCH Seizures and CCALLS is the Channel Allocation attempt on SDCCH.

2.3 Reasons for Degradation and Solution

There are multiple reasons for degradation. It is SDCCH Availability, Hardware Issue, SDCCH Dimensioning, Improper Lac Planning, High Volume of SMS, Immediate Assignment on TCH, Congestion Caused by interference, Spillage, SCHO, Incorrect Timer Settings and the High SDCCH Mean holding Time.

2.3.1 SDCCH availability

To start we must check SDCCH Availability and if it is marginally less than 100% then it will come under Low Availability and will impact on SDCCH Congestion.

$$\text{SDCCH Availability} = (\text{CAVAACC}/(\text{CAVASCAN} * \text{CNUCHCNT}))*100 \tag{2.2}$$

CAVAACC: AVAILABLE CHANNEL ACCUM

CAVASCAN: NOF ACCUM OF AVAIL CHANNELS CNT

CNUCHCNT: NOF DEFINED CHANNELS

2.3.2 Hardware issue

In the hardware issue it is important to check for RBS fault and any Hardware Alarm that will impact the SDCCH. Alarm check can be done in 3 ways.

- In Command prompt (By MML Commands)
- Alarm List Viewer (Current Alarm & History of Cells & BSC also).
- Base Station Management (Error Log).

The faults on BTS, BSC and A-bis interface, such as broken LAPD link, cause the SDCCH congestion. The alarm "Excessive Loss of E1/T1 Signals in an Hour" also causes the SDCCH congestion.

2.3.3 SDCCH dimensioning

To do the SDCCH Dimensioning we have the steps below:

- Calculate the SDCCH Traffic by taking 0.5% as Grade of service for SDCCH.

- Check for the SDCCH Congestion for couple of days form BBH Stats and check the SDCCH attempts and no of SDCCH/8 Timeslot defined in that cell.
- If required then increase the No of SDCCH/8 TS in that cell but it is recommended not to define more than 2 SDCCH/8 TS in one TRX this is to keep the signaling load on E1 and CP load on BSC below Congestion.
- If Sudden Increase in SDCCH Attempt and Traffic Observed then check for any special event(Festival) in that area, HW Issue in Neighbor cell and outages in Neighbor cell also.

SDCCH Traffic = CTRALACC/CNSCAN (2.3)

Apart from SDCCH Increase one feature can be implemented called ACLC.

ACLC: Adaptive Configuration of Logical Channels

- The purpose of the feature is to minimize the risk of SDCCH congestion by automatically converting TCH Timeslots to SDCCH Timeslots when there is high requirement for SDCCH and reconfiguring SDCCH to TCH after some defined time.

2.3.4 Improper LAC planning

- If the cell is having high Location update attempts then it will increase load on SDCCH and which impacts SDCCH Congestion.
- Change the Lac boundary away from this cell to the cell which carries less traffic by migrating sites from one BSC to other BSC.

Tuning Periodic location update timer can also bring down the Load on SDCCH.

3. TRAFFIC CHANNEL CONGESTION

3.1 Definition

It is the proportion of Traffic channel (TCH) assignment failures to the no of TCH seizure request.

3.2 Formula

The TCH Congestion = ((CNRELCONG+ TFNRELCONG+THNRELCONG) / TASSALL) *100   (3.1)

- TCASSALL is the Assignment complete for all MS power classes.
- TASSALL is the No of Assignment attempts for all MS power classes. Successful attempts are counted in the target cell and failed attempts are counted in the serving cell.
- CNRELCONG is the Released Connections on SDCCH due to Radio Resource Congestion counters are incremented when a connection on SDCCH is released due to radio resource congestion that is when there is congestion on TCH or congestion on transcoder resources.
- TFNRELCONG is the released connections (in full rate in UL) due to radio resource congestion. Counters are incremented when a TCH connection used for signaling and allocated as a result of immediate assignment is released due to radio resource congestion that is when there is congestion on transcoder resources.
- THNRELCONG is the released connections (in Half rate due in UL) to radio resource congestion counters are incremented when a TCH connection used for signaling and allocated as a result of immediate assignment is released due to radio resource congestion, that is when there is congestion on transcoder resources.
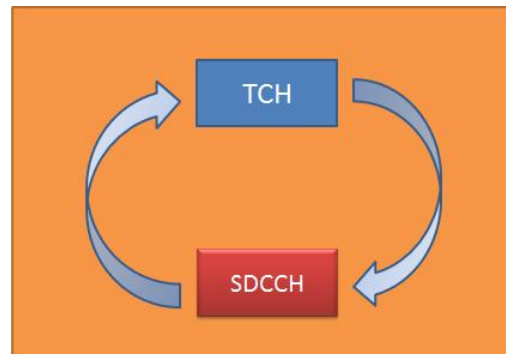

Fig. 1. Adaptive configurations of logical channels

3.3 Reason for Degradation and Solution

In the Traffic channel (TCH), the reason for degradation and solution is High Traffic (High Utilization), Low TCH Availability, Hardware Issue, Transcoder Congestion, ABIS Congestion.
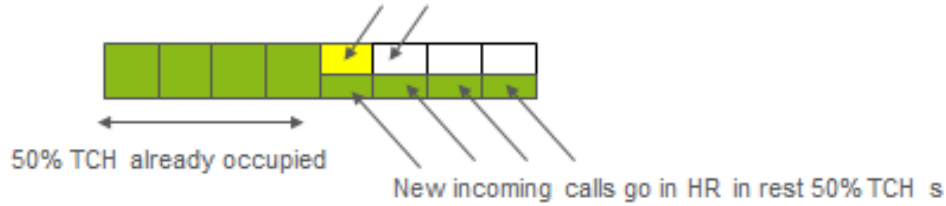
Fig. 2. Presentation of the traffic call rate

3.4 High Traffic (Highly Utilized Cell)

Calculate the TCH Traffic of the Cell(BBH Traffic) and by taking offered Traffic in to account Calculate the Utilization((Carried Traffic/Offered Traffic)*100) of that Cell. If the cell is carrying more Traffic than the designed/offered/Ideal Traffic and utilization of the cell is more than 100% then there are chances that congestion can occur.

TCH Traffic = (TFTRALACC/TFNSCAN) + (THTRALACC/THNSCAN) → (Hourly)   (3.2)

TCH Traffic = (TFTRALACC+THTRALACC) /360→(24hr Traffic)   (3.3)

The resolution of (3.2) and (3.3) is composed of Half Rate and Dynamic Half Rate Allocation (DHA). We have two features for half rate implementation that is Dynamic Half Rate Allocation (DHA) and Dynamic adaptation (DYMA). The dynamic Half Rate Allocation

- This feature when activated allocates new incoming calls in HR for Dual Rate MSs when cell load is high.
- Main controlling parameters are DTHAMR and DTHNAMR.

3.5 DTHAMR

- Let its value is x. It indicates when x% of the total no of available TCH s are idle, the new incoming calls will go in HR.
- **An example:**
- Let total no of TCH is 8, and DTHAMR=50
- When 50% TCH (=4 TCH) will be idle the new incoming calls will go in HR and fill the idle 4 TCHs.
- **Formula:** How to calculate the exact DTHAMR Value with help of No of TCH & the Carried Traffic.

Total effective TCH Traffic=No of TCH* (1+DTHAMR Value/100)

4. TCH CONGESTION

4.1 Definition

The TCH Congestion is the proportion of TCH assignment failures to the no of TCH request.

4.2 Formula

The formula is:

TCH Congestion = ((CNRELCONG+ TFNRELCONG+THNRELCONG)/TASSALL) *100   (4.1)

where,

CNRELCONG is the Released Connections on SDCCH due to Radio Resource Congestion counters are incremented when a connection on SDCCH is released due to radio resource congestion that is when there is congestion on TCH or congestion on transcoder resources.

TFNRELCONG is the released connections (in full rate in UL) due to radio resource congestion. Counters are incremented when a TCH connection used for signaling and allocated as a result of immediate assignment is released due to radio resource congestion that is when there is congestion on transcoder resources.

THNRELCONG is the released connections (in Half rate due in UL) to radio resource congestion counters are incremented when a TCH connection used for signaling and allocated as a result of immediate assignment is released due to radio resource congestion, that is when there is congestion on transcoder resources.

TASSALL is No of Assignment attempts for all MS power classes. Successful attempts are counted in the target cell and failed attempts are counted in the serving cell.

4.3 Reason for Degradation and Solution

The reason for degradation and solution concern High Traffic (High Utilization), Low TCH Availability, Hardware Issue, transcoder Congestion, ABIS Congestion.

4.3.1 High traffic (Highly utilized solution)

To calculate the TCH Traffic of the Cell (BBH Traffic) and by taking offered Traffic in to account Calculate the Utilization((Carried Traffic/Offered Traffic)*100) of that Cell. If the cell is carrying more Traffic than the designed/offered/Ideal Traffic and utilization of the cell is more than 100% then there are chances that congestion can occur.

$$TCH\ Traffic = (TFTRALACC/TFNSCAN) + (THTRALACC/THNSCAN) \rightarrow (Hourly) \quad (4.2)$$

$$TCH\ Traffic = (TFTRALACC+THTRALACC)/ 360 \rightarrow (24hr\ Traffic) \quad (4.3)$$

4.3.2 Low TCH availability

For Low TCH availability, find out the Cell Availability (Hourly) and it must be 100% (equivalent to 100%) otherwise there is availability issue in that cell. Confirm the same by checking the Cell down time.

$$Availability = 100*(TAVAACC/ (TAVASCAN* TNUCHCNT)), \quad (4.4)$$

where TAVAACC is the AVAILABLE CHANNELS ACCUMULATOR, TAVASCAN is NO OF ACCUMULATION OF AVAILABLE CHANNELS COUNT and TNUCHCNT is the NUMBER OF DEFINED CHANNELS

Object Type: CLTCH

NUMREQBPC Check: Sometimes Availability decreases due to incorrect parameter setting NUMREQBPC

NUMREQBPC is the number of required basic physical channels (BPCs) in a channel group. Command is RLBDP

Default is SYSDEF: (System defined limit. The number of BPCs is defined by the number of frequencies in a channel group.

$$Cell\ Down\ Time = 100*(BDWNACC/ TDWNSCAN) +100*(TDWNACC/ TDWNSCAN) \quad (4.5)$$

where TDWNACC is the counter is stepped every tenth second if there are no TCHs in IDLE or BUSY state in the cell and the cell state is ACTIVE, TDWNSCAN is the counter is stepped every tenth second when the cell state is ACTIVE and BDWNACC is Accumulated number of scans of the cell where the BCCH was unavailable.

4.3.3 Hardware issue

Hardware issue consist to check for Hardware Alarms, RBS Faults, Faulty TRX (Block, NOOP, FAIL, SLIP), Faulty Timeslot (NOOP, SLIP). Three ways to check Alarms are:

a. Alarm List Viewer.
b. Command prompt
c. Base station Management.

4.3.4 Transcoder congestion

The transcoder congestion consist:

• To measure the released TCH signaling (during setup) due to transcoder congestion (despite the Availability of TCH); use the counter CNRELCONG, TFNRELCONG (for full rate) and THNRELCONG (half rate). If TCH is used for signaling then these two (TFNRELCONG, THNRELCONG) counters will be pegged.
• Sometimes sudden increase in CNRELONG observed in many cells of one BSC. If in that case you will not find any change in Traffic trend & Availability then you can check the Transcoder counters for Allocation & congestion. Counter information is given below.
• Basically it's a BSC Level Issue & Need to Check the Transcoder counters.

Object Type: TRAPEVENT

Counters:

• **TPACTTR:** Gives continuous information of the Active Transcoder Resources in the TRAPOOL. The counter is incremented at each allocation of transcoder resource & decrease at each release of resource.
• **TPAVTR:** TPAVTR shows the no. of idle & active transcoder resources in the transcoder pool.
• **TPALLOC:** TPALLOC is the allocation attempt counter. It is incremented in every attempt to seize a transcoder resource.

- **TPIDLTR:** TPIDLTR shows the no. of idle transcoder resources in TRAPOOL.
- **TPCONG:** TPCONG is incremented when an allocation attempt fails due to no idle resource in Transcoder Pool.
- **TPCTIME:** TPCTIME is the counter which tracks for how much time a particular call congestion remains.

4.3.5 ABIS congestion

- **OVERLOADREJCON:** No of TCH connections that are rejected due to Congestion in ABIS/ABIS Overload.
- We can check the TCH Rejection Ratio also by using the formula below.
- THC Rejection ratio = OVERLOADREJCON/(TFCALLS+ THCALLS)*100%   (4.6)
- **OVERLOADREJCON:** This counter counts the number of new CS connections that were rejected due to ABIS overload. The counter is stepped when an attempt to allocate an idle TCH fails, due to ABIS overload. The counter is valid for the features Packet ABIS over TDM and Packet ABIS over IP.
- **TFCALLS:** Number of channel allocation attempts for a TCH full rate channel.

- **THCALLS:** Number of channel allocation attempts for a TCH half rate channel.
- Object Type (CLTCH).

5. TCH ASSIGNMENT SUCCESS RATE

5.1 Definition

It is the ratio between the total no of TCH Assignment Success to the total no of TCH Assignment Attempt.

5.2 Formula

TCH Assignment Success Rate = 100* (TCASSALL / TASSALL)

5.3 Reason for Degradation and Solution

The reason and solution are High TCH Traffic/High Utilization/TCH Congestion, Low Availability, Hardware Faults, Transcoder Congestion, ABIS Congestion, Poor coverage, Check TACSR, Check Data Usage & FPDCH definition and TRX Performance check. All the points (1 to 5) are discussed in the TCH Congestion KPI so please refer the points explained above. Besides that some other factors are also there which may cause the Degradation of TASR.
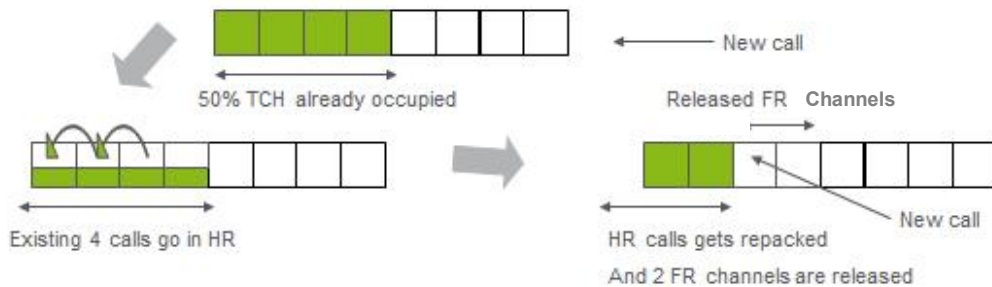

Fig. 3. Presentation of a series of call channels

5.3.1 Poor coverage

Due to the low coverage level caused by the poor coverage, the MS may fail to decode the assigned TCH properly. Thus, the TCH seizure failure occurs. This affects the TCH assignment success rate.

5.3.2 Check TACSR (TCH access success rate)

Sometimes we don't find any RBS Fault or any Hardware Alarm at site (Like Loose feeder cable, jumper cable connections, and faulty connectors) but it will impact on KPIs. So there is one KPI which indicates that the cell is having Hardware issues i.e. TACSR (TCH Access Success Rate).

- When an MS requests for a TCH, BSC orders the serving cell to activate a Traffic Channel. If the serving cell has free/idle channels available, it activates one of them and confirms the BSC about the channel activation. Then the BSC sends an assignment command to the MS which subsequently tries to access the specified TS and If MS was successful to access that then immediate assignment complete occurs. If there are no idle TCH channels available at serving cell then BSC sends assignment reject message.
- Sometimes BSC sends immediate assignment message to MS & MS tries to access the network by the TS which was assigned, during that time TACSR comes in to picture.
- Since TACSR is calculated after immediate assignment command received by MS hence TCH congestion (CNRELCONG, TNRELCONG) scenario is excluded from the calculation of TACSR. That's why TACSR points to the performance of the hardware as TCH Timeslot was free and allocated but due to some Hardware Issue in TRX MS was unable to use that.

TACSR = 100*TCASSALL / (TASSALL-CNRELCONG-TFNRELCONG THNRELCONG)

TASR = 100*(TCASSALL / TASSALL)

5.3.3 Check no of fixed PDCH defined

Check whether the cell is configured with too much fixed PDCHs (FPDCH) from the channel configuration (PS services). If the PS Traffic is relatively small, reduce the number of PDCHs properly.

Command: RLGSP: CELL=<CELL NAME>;
(To Check the No of FPDCH Defined)

5.3.4 TRX performance analysis check

- In Normal Scenarios we get Hardware Alarms & RBS Faults for the Sites where KPI degraded due to Hardware Issues But Sometimes we suspect KPI of the Site is degraded due to some Hardware Issue Like(Faulty TRX, Faulty Timeslots, Sleep Timeslots) but we didn't find any Hardware Alarm Neither form Alarm Viewer nor From the Command Prompt.

- In those cases we will observe an Abnormal Increase in Counter Values CONCNT & CONERRCNT on that corresponding Timeslot From that we can conclude that there is some Hardware issue at that Timeslot.
- In Ericsson For each Timeslot there are two counters containing the number of connection attempts and the number of abnormally terminated connections.

Counters: (CONCNT, CONERRCNT)

Object type = MOTS (Managed Object Time Slot)

- **CONCNT:** Connection set up attempts, Incremented each time a TCH or SDCCH is seized.
- **CONERRCNT:** Abnormally terminated connections, Incremented, for TCH and SDCCH when a connection is terminated abnormally.

6. CONCLUSION

The third and the fourth generation mobile networks consist mainly of three elements namely the user terminal, the radio access network and the core network. The numerous calculations based on the formulas made it possible to deduce a frequent occupation of the channels in the third and the fourth generation networks. The accumulation of packets on a network device, the speed of transmission over the bandwidth of a channel cause a strong and variable latency and are the cause of congestion in the third and the fourth generation networks. Finally we noted several algorithms and protocols for the management and control of congestion in mobile networks.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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