Chapter 4 of Network Performance and Quality of Service: Basic Calculation of the Network's Availability and Reliability

1. Availability Measurement Principle

One of the basic indicators of the performance of telecommunications networks is availability, then here is given the important parameters of the availability of measurement:

1) Mean Time between failure (MTBF) : average time between two failure. This is vendor warranty for the availability of the Telecommunication mobile network operator.
2) Mean Time To Repair (MTTR) : average time for repair and testing. This is internal assurance for the availability of the Telecommunication mobile network operator, especially the Network Operation and Maintenance division and Internal Quality Division. Sometime, this is the guarantees of "Maintenance Partner" to the Telecommunication mobile network operator.

1.1. Formula

The formula for calculates the availability is written as follows:

- Availability = (1 - (1/total down time)) * 100%

  Where: Down Time = Time to repair + Testing time + Waiting, Movement & Coordination time.

1.2. Some important things:

Here are important points to remember:

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- 1 year is = 365 days = 8760 hours = 525,600 minutes = 31,536,000 seconds.
- Downtime = 1 day then the availability = 99.726027% (two nine)
- Downtime = 1 hour then the availability = 99.988584% (three nine)
- Downtime = 1 minute then the availability = 99.999810% (five nine)
- Downtime = 1 second then the availability = 99.999997% (seven nine).

1.3. Calculation Examples:

1.3.1. Basic Network Availability Calculation

On a mobile operator, data failure of a particular service in October 2017 is as follows: The first failure occurred on October 2, 2017 at 12:05:10 in 1 minute 38 seconds. The second failure occurred on 15 October 2017 at 21:33:20 in 2 minutes 3 seconds, and the third failure occurred on 24 October 2017, at 10:07:29 in 15 minutes 17 seconds.

Calculate: MTTR, MTBF and service availability

Solution:

1) In this problem, we assumes that the MTTR (Mean Time to repair) is the average time of Down time, since no information about the time to repair, testing time and waiting, movement and coordination time, then MTTR = ratio between total time of downtime and number of failure.

   Total time of down time = 1 minute 38 seconds + 2 minutes 3 seconds + 15 minutes 17 seconds = 18 minutes 58 seconds

   Then MTTR = (18 minutes 58 seconds)/3 = 6 min 19.3 sec

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2) In this problem, we assumes that the MTBF (Mean Time Between Failure) is the Mean Time Between Down Time, since no information about the time to repair, testing time and waiting, movement and coordination time, then MTBF = average of time between down time, since there are any 3 failures, then there are any two TBFs (time between failure).T

   TBF1 (time between failure 1 and failure 2) = time between (October 2, 2017 at 12:05:10) and (15 October 2017 at 21:33:20) = 321 hours 26 minutes 32 seconds.

   TBF2 (time between failure 2 and failure 3) = time between (15 October 2017 at 21:33:20) and 24 October 2017, at 10:07:29 = 205 hours 32 minutes 5 seconds.

   Then MTBF = (TBF1 + TBF2)/2 = 263 hours 29 minutes 19 seconds

3) Measurement period = October 2017 = 31 days = 31*24*60*60 seconds = 2,678,400 seconds.

   Total time to repair, in this problem is total time of down time = 18 minutes 58 seconds = 1138 seconds.

   Then the Availability = {(measurement period – total time to repair)/measurement period} * 100 % = {(2,678,400 seconds - 1138 seconds)/ 2,678,400 seconds} * 100 % = 99, 96 %%

1.3.2. Availability Calculation of The Intermittent Service

Assume that:

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Data Records of The Operation and Maintenance Division on an Intermittent Service, Period: January 1, 2017 through December 31, 2017			
Customers know that the connection is broken		**Connection is established by the network operator**	
Dates	**Time**	**Dates**	**Time**
12 Jan	10.00 am	12 Jan	06.00 pm
14 Feb	06.30 am	15 Feb	09.30 am
20 May	11.30 am	20 May	12.45 am
18 Jun	01.30 pm	18 Jun	09.30 pm
17 Nov	08.00 am	17 Nov	09.00 pm
28 Dec	09.00 am	28 Dec	09.30 am
Outage known by provider technicians provider		**Completed repairs and testings**	
Dates	**Time**	**Dates**	**Time**
12 Jan	10.00 am	12 Jan	06.00 pm
20 Jan	09.00 am	20 Jan	11.00 am
14 Feb	05.30 am	15 Feb	09.30 am
20 May	00.30 pm	20 May	09.00 pm
18 Jun	08.00 am	18 Jun	09.00 pm
17 Nov	09.00 am	17 Nov	09.30 am
28 Dec	09.00 am	28 Dec	09.30 am

Calculate:

1. Calculate on the customer side:
    a. number of failure
    b. period of observation
    c. total interruption period
    d. average accessibility
    e. overall mean time between outage = MTBO
    f. the mean time to restore (MTTR)
    g. Graph of the operating characteristic curve for operational service interruption (= mean time between service interruption vs. interruption duration).
2. Calculate on the service provider side:
    a. number of outage
    b. period of observation
    c. the total outage period

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d. average of connection availability

e. outage lasting

f. overall mean time between outage = MTBO

g. mean time to repair (MTTR)

h. Indicate when (a) The duration of the service outage = service interruption (b) The duration of the service outage much longer than the perceived service interruption (c) The perceived duration of the service interruption much longer than the actual service outage (d) A service outage not result in an operational service interruption at all.

Answer:

Calculation Table		
Interruptions in service perceived by customers		
Dates	**Periods (minutes)**	**Summary**
12 Jan	480	
14 Feb	1,620	
20 May	75	
18 Jun	480	
17 Nov	780	
28 Dec	30	
Total	3,465	= Total Interruption period
	577.5	= average interruption period
	527,040	Observation period (1 year)
Outage known by the provider		
Dates	**Periods (minutes)**	**Summary**
12 Jan	480	
20 Jan	120	
14 Feb	1,680	
20 May	60	
18 Jun	510	
17 Nov	780	
28 Dec	30	
Total	3,660	= Total outage period
	522.86	= Average outage period

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Then:

Service outage duration (minutes)	**number of outage where the duration time ≥ its outage duration or more**	**Mean Time Between Interruption = ration between observation time and number of interruption**
30	1	75,291
75	2	87,840
120	3	105,408
480	4	131,760
780	6	263,520
1,620	7	527,040

1. Calculation on the customer side:
    a. number of failure = 6
    b. period of observation = 527,040 minutes
    c. total of interruption period = 3,465 minutes
    d. accessibility = (period of observation – total of interruption period) / period of observation = 0.993425546 = 99.34 % (= two nine).
    e. overall mean time between interruption = MTBO = (period of observation – total of interruption period) / number of interruption = 87,262.5 minutes
    f. the mean time to restore (MTTR) = total of interruption time / number of interruption = 577.5 minutes
    g. Figure 2 is the operating characteristic curve for operational service interruption graph.
2. Calculation on the service provider side:
    a. Number of outage = 7 (so the Provider know that the outage occurred is more than the interruptions perceived by the customer, indicating that there is an outage that does not cause an interruptions in service.

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b. period of observation = 527,040 minutes
c. the total outage period = 3,660 minutes
d. average of connection availability = (period of observation - total of outage periods) / period of observation = 0,993055556 = 99.31 % (= two nine). In this problem, the availability of providers is smaller than that accessibility is perceived by customers.
e. outage lasting = (1-availability) day = (1-availability)* 24 * 60 minute = 10 minutes
f. overall mean time between outage = MTBO = (period of observation – total of outage period) / number of outage = 74,768.57 minutes
g. the mean time to restore (MTTR) = total of outage period / number of outage = 522.86 minutes
h. Indication when (a) The duration of the service outage = service interruption: 12 January and 28 December, (b) The duration of the service outage much longer than the perceived service interruption: 14 january and 18 June, (c) The perceived duration of the service interruption much longer than the actual service outage: 20 May,(d) A service outage not result in an operational service interruption at all: 20 January.

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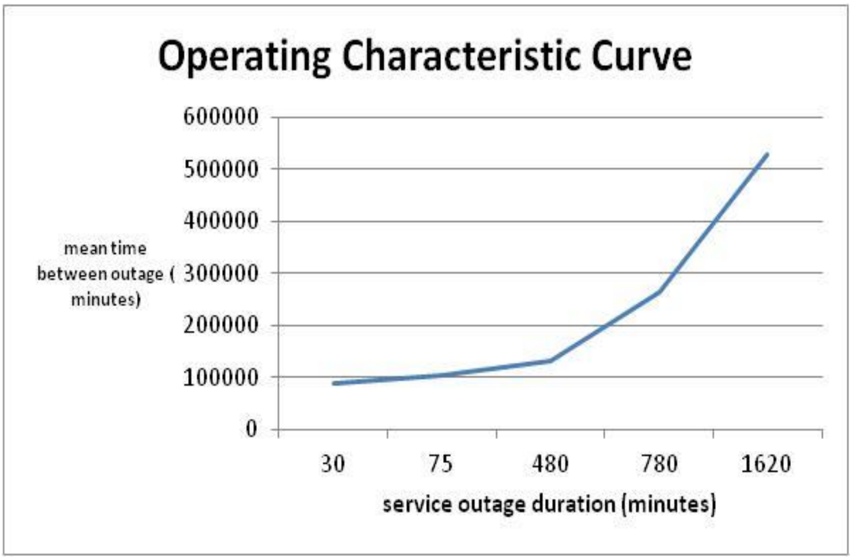

1.3.3. Network Availability Calculation of Continous Service

Data Records of the operation and maintenance division on a continuous service which has an average capacity = 768 kbps.

Calculate:

a. the OEC (effective operational capacity) on the day of measurement, when the data transfer is 5 Gbyte per customer
b. the OEC (effective operational capacity) where the availability of providers = 99.67%
c. the throughput efficiency, if the probability that each transmission unit will retransmit = 0.0005 and the probability that any information exchange unit will retransmission = 0.005
d. handling overhead if the ratio between the number of transmission units of information exchange unit and the number of transmission used exclusively for handling traffic on each unit = 0.05

Calculation:

a. the OEC (effective operational capacity) on the day of measurement:
   Provider capacity in a day = 24 * 3600 * 768 kbps = 66.3552 Gbit per customer.

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Then OEC = 5 Gbyte / 66.3552 Gbit = 5*8 Gbit / 66.3552 = 60.3 %

b. Where the availability of providers = 99.67%, then the provider capacity = 0.9967* 66.3552 Gbit = 66.1362 Gbit per day.

   Then OEC = 5 Gbyte/66.1362 Gbit = 5*8 Gbit / 66.1362 = 60.48 %

c. The throughput efficiency = TE = 1 / ((1 +0.0005) * (1 +0.005)) = 99.45 %

d. Handling overhead = HO = 0.05 / (1-0.05) = 5.263%

2. Routing Reliability Calculation

Routing realibility is the portion of the transmitted packets reach the proper destination node

Calculation Example:

Calculate the realibility, assume that the measurement results for internet services

a. The number of services per second = 100,000; successful services = 80,000; number of services to the proper destination address = 79,000
b. The number of packets received = 1,000,000,000; packet loss = 200,000; packets sent to the right address = 999,000,000
c. compare the results of the calculation of a and b

Answer

a. QoS perceived by the customer:

   Routing reliability of the service = (79,000/100,000) = 79 %

b. QoSD (QoS Delivered by the Service Provider):

   Packet loss = 20,000/1,000,000,000 = 0.02 %.

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Routing reliability of the packets = (999,000,000/(1,000,000,000 – 200,000) = 99.92 % (3 nine)

c. Conclusion: QoSD is better than QoE (quality of experience)

3. Data Connection Quality Evaluation

The evaluation of the connection function is to calculate the transaction time, so the lower transaction time the higher connection quality.

Calculation technique is use the following formulas:

$$Handling\_Overhead = HO = \frac{(\sum H_i)}{[(\sum T_i) - (\sum H_i)]} \quad [17]$$

$$\text{ThroughputEfficiency} = TE = \frac{1}{[(1 + R_{tu}) * (1 + R_{iu})]}$$

$$Transaction\ Time\ (T_t) = \frac{[b * (1 + HO) * (1 + EO)]}{(d * TE)}$$

Calculation example:

a. Calculate the average transaction times at a Fixed Speed Protocols if assume that the probability that a transmission unit will be retransmitted = 0.001; the probability that an information exchange unit will have to be retransmitted = 0.002; the ratio of the number of transmission units, bits, or characters used to specify handling in the ith exchange unit sampled and the corresponding total number of transmission units, bits, or characters in the ith information exchange unit = 0.08; Transmission use the ARQ error handling techniques with the addition of one bit per message block size of 99 bits; the fixed transmission speed = 0.7 Mbps; and injected a data bit = 1 Gbyte

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b. By using the data as on problem a, calculate transaction time of the Variable Speed Protocols when the average transmission speed = 0.8 Mbps.

Answer:

Basic calculation for problem a and b:

- Handling overhead = HO = 0.08/(1-0.08) = 0.08696
- Encoding Overhead = EO = total bits for encoding purposes / total bits in a message after encoding = 1 / (99 +1) = 0.01
- Throughput Efficiency = TE = 1 / ((1 +0.001) * (1 +0.002)) = 0.997

a. $Transaction\ Time\ (T_t) = \frac{[b*(1+HO)*(1+EO)]}{(d*TE)} =$

(1,000,000,000*8*(1+0.08696)*(1+0.01))/(700,000*0.997) = 12.58 seconds

b. $Transaction\ Time\ (T_t) = \frac{[b*(1+HO)*(1+EO)]}{(d*TE)} =$

(1,000,000,000*8*(1+0.08696)*(1+0.01))/(800,000*0.997) = 11.01 seconds

4. Continuity Connection

Evaluation of the continuity connection perform in the calculation of spontaneous disconnect, disconnect report rate, and abnormal disconnect rate.

The formulas are:

a. P [d | x] = the probability that a transaction, once initiated, will be interrupted by a spontaneous disconnect = ration between spontaneous disconnect and the total number of transactions

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b. Disconnect report rate (DRR) = Nd / Nb; Where Nd is the number of complaints of disconnects registeredand Nb is the number of billable service

c. Abnormal disconnect rate (ADR) = 1 – (tc/ts); Where Tc is the observed number of the transactions that were initiated and completed without interruption ts is the total number of transactions sampled.

Calculation example:

Evaluate the continuity connection of the following data: the spontaneous disconnect = 10,000; the number of complaints of disconnects registered = 1000; the number of billable service = 100 million; the observed number of the initiated transactions that were completed without interruption = 124 million; the total number of transactions sampled = 125 million

Answer:

d. P [d | x] = 10,000/125,000,000 = 0.00008

e. Disconnect report rate (DRR) = 1,000/100,000,000 = 0.00001

f. Abnormal disconnect rate (ADR) = 1 - (124.000.000/125000000) = 0,008

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