**Possible ways of determining the characteristics of network traffic for identification of required external connection line rate for a specific object**

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Today, various areas of activity in the context of globalization and digitalization require connection to telecommunications networks of various scales - regional, national and global. Reliable and stable network access is a must for modern business activity, but there are countries in the world where broadband coverage is still insufficient, and many households remain unconnected [1]. Thus, it is obvious that the tasks associated with providing broadband Internet access are actual.

There are many difference methods to calculate necessary bandwidth external connection line [2]. An important factor in this task is the trade-off between the cost of the connection and the basic information characteristics (Quality-Defined Bitrate, latency), which allows more efficient use of the network resource and ensure the required level of quality of service. Internet (or data) traffic is generated by different users using different type of devices that usually are sharing the same communication environment (local area network of a school or a hospital, access network of a locality, etc.). This combination of users and devices creates a wide combination of services (video conferences, web-surfing, playing online games etc.) with different level of intensity of using.

Taking into account the variety of software, applications and tasks that are solved by connecting to a global information network, it seems important to determine the parameters of the quality of service that are supposedly necessary to provide for the user with maximum consideration of the activity specifics. In [3] was proposed the method to calculate necessary bandwidth that base on the connectivity traffic profiles. The traffic profiles contain a list of quality of services and intensity of sessions characteristics, representing the extent to which some user groups use various Internet services. The proposed methodology is based on the classical teletraffic theory when assuming the nature of the sessions creation requests’ flow (flow of requests to create new sessions follows a Poisson distribution). Erlang formula B is used as a core of the calculations.

The aggregated traffic generated by all the users usually less than sum of separate traffic flows that is generated by each user individually. It explained by the irregularity of the traffic sessions and by the statistical multiplexing that is used in the modern IP networks. To calculate the required external line rate of such external channels it is necessary to identify the number of simultaneous sessions that could be served by the channel without decreasing Quality of Experience (QoE) level. At the same time, it is also necessary to identify the level of the workload of each session on the channel, considering that for the different services, the length of the sessions (in seconds) and data transfer rates are different. In overall the methodology described in [3] to estimate the required bandwidth, it is necessary to take into account such parameters as: latency, Quality-Defined Bitrate (bit-rate), intensity of using service (for one user) and amount of Data per session for a service.

The goal of paper is considered possible ways of determining these characteristics of network traffic that are used to calculate the required bandwidth.

There are various methods and approaches can be used to determine the values of these parameters. Some characteristics, such as latency, are determined in the normative documents of the ICT industry regulators [2]. Unlike latency and data bit rates, such traffic parameters as the intensity and volume of data per session are not standardized by regulatory documents. To determine these traffic characteristics, there are can be applied the following approaches:

1. Direct traffic measurement. This approach involves measuring the characteristics of traffic on real objects (home, hospital, school, farm, etc.), with its subsequent analysis. The advantages of this approach are obtaining objective traffic characteristics and ease of implementation. The disadvantages include the fact that it is rather difficult to get access to the traffic of the object. Also, the measurement results reflect an objective picture only for the measured object or objects from one sphere (for example, the results of measuring traffic parameters to schools can be used for universities, colleges). For other type of objects, the results will be somewhat subjective - for example, there are may be used other types of services.

2. Marketing research. This approach involves collecting traffic parameters by polling users. The advantages of this method are ease of implementation, the formation of an objective user model in the context of the use of network services. The disadvantages of the method are relatively low accuracy (users find it difficult to indicate the exact values of different characteristics), high labor intensity and duration of implementation (it is necessary to develop check list, organize the survey process, conduct a survey).

3. Analysis of statistical data. This approach involves the analysis of statistical data on traffic parameters that are published in the public domain by various analytical agencies, international organizations that exercise control and regulation in the field of telecommunications. The advantage of this approach is the relative simplicity of realization, the possibility of applying the results to objects of any type. The disadvantages of the method include its high labor intensity - to obtain a result, it is necessary to analyze a large amount of static data.

In our work, to determine the traffic parameters, we used the methods of direct measurement and the method of analyzing statistical data. The final value for traffic parameters for or different traffic profiles, that we got after apply these methods are showed in table 1.

Table1 1 - The final values of the parameters that use to demonstrate the functionality of the ITU Bandwidth Calculator

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **#** | **Service Type** | **Service Name** | **Quality Parameters** | **Internsity Parameters** |
| **Link rate (bit-rate), Mbps** | **Maximum Delay, ms** | **Intensity of requests (per user), requests per hour** | **Amount of Data per session, MB** |
| **Low** | **Medium** | **High** | **Low** | **Medium** | **High** | **Low** | **Medium** | **High** | **Low** | **Medium** | **High** |
| 1 | Real-Time Services | Conversational voice e.g. telephony | 0.021 | 0.054 | 0.087 | 400 | 275 | 150 | 0.021 | 0.042 | 0.063 | 0.62 | 1.62 | 2.62 |
| 2 | High quality streaming audio | 0.016 | 0.780 | 0.128 | 10000 | 5000 | 2500 | 5.400 | 10.800 | 16.200 | 1.11 | 2.22 | 3.65 |
| 3 | Video conference | 0.384 | 2.192 | 4.000 | 400 | 200 | 100 | 0.021 | 0.042 | 0.063 | 188 | 1,463 | 1,950 |
| 4 | Broadcast | 0.500 | 9.000 | 30.000 | 10000 | 5000 | 2500 | 0.900 | 1.800 | 2.700 | 238 | 477 | 794 |
| 5 | Video streaming (CCTV. video blogs. video streams. etc.) | 1.500 | 3.000 | 5.000 | 1000 | 500 | 250 | 0.026 | 0.052 | 0.077 | 238.00 | 477.00 | 794.00 |
| 6 | Interactive games | 3.000 | 10.500 | 18.000 | 225 | 150 | 100 | 0.165 | 0.330 | 0.495 | 513.00 | 1,709.00 | 3,076.00 |
| 7 | Non-Real-Time Services | Web-browsing - HTML | 0.500 | 1.000 | 1.500 | 12000 | 8000 | 4000 | 0.014 | 0.027 | 0.041 | 41.13 | 82.50 | 123.40 |
| 8 | Data transfer/ retrieval | 0.500 | 1.000 | 1.500 | 60000 | 37500 | 15000 | 0.003 | 0.006 | 0.009 | 125.75 | 251.50 | 377.25 |
| 9 | Transaction services – high priority e.g. e-commerce. ATM | 0.500 | 1.000 | 1.500 | 4000 | 3000 | 2000 | 0.045 | 0.090 | 0.135 | 28.00 | 56.00 | 84.00 |
| 10 | Command/ control | 0.500 | 1.000 | 1.500 | 250 | 125 | 65 | 0.004 | 0.008 | 0.012 | 28.00 | 56.00 | 84.00 |
| 11 | Services for group work (virtual boards. online graphics. etc.) | 0.250 | 0.375 | 0.560 | 200 | 100 | 50 | 0.390 | 0.780 | 1.170 | 5.06 | 7.60 | 11.34 |
| 12 | Still image | 0.500 | 1.000 | 1.500 | 60000 | 37500 | 15000 | 0.038 | 0.075 | 0.113 | 22.00 | 44.00 | 88.00 |
| 13 | E-mail | 0.500 | 0.750 | 1.000 | 4000 | 3000 | 2000 | 1.260 | 2.520 | 3.780 | 0.05 | 0.10 | 0.15 |
| 14 | Client-server software (accounting. server. LIMS. etc.) | 0.500 | 1.000 | 1.500 | 200 | 100 | 50 | 1.260 | 2.520 | 3.780 | 0.05 | 0.10 | 0.15 |

The results obtained were used to create an automated bandwidth calculation tool ITU Bandwidth Calculator [12].

The paper describes possible ways to determine the values of the parameters required for calculating required bandwidth a line for connection object to the network. The analysis showed that the results obtained by different approaches may differ from each other. For example, the values of the intensity of using services obtained with help the direct measurement method differ from the results obtained using the analysis of statistical data. Obviously, in this situation, it is impossible to say unequivocally which approach is better. The approaches to determining the above parameters discussed in the paper are not final and are demonstrative in nature. If necessary, it can be use other approaches to obtain the to calculate the required bandwidth.

Further traffic estimation for proper profiles evaluation is necessary. Basic characteristics, that determine the quality of service that can be used for connectivity profiles, are defined in various regulatory documents of the ICT industry (standards), national standards of different countries, scientific and analytical research. A further direction in the development of the work is the organization of research aimed at clarifying the data obtained in the work. A promising direction will be the organization of direct traffic measurement on a global scale - traffic measurement at different specific objects in different countries.

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