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Determination of tariffs on telecommunication services based on modeling the cost of their providing: methodological and practical aspects of application

Abstract. The article deals with the main methodological and practical aspects of determination and application tariffs on telecommunication services by using the method developed by the authors. Its core is a model of service delivery (conceptual model), which allows to exclude from the calculation those elements of the existing provider's network which, for various reasons, are not involved in the implementation of the planned range and volume of services provided to the estimated tariff duration (the evolution of the network as a result of equipment modernisation, a change of nomenclature and structure of the provided services, etc.) and based on a simulation model of determination of operating costs volume.
The content of the article is the answer to a series of questions and suggestions that arise from employees and economic services telecommunication operators dealing with the tariffs determination, as well as regulators in different countries, during the discussion of the proposed method. These include a detailed description of key provisions of the construction and usage of the conceptual and simulation models, composition and characteristics of the initial data used in the construction of models, description of the principal advantages of the proposed method when compared to other existing methods and the most common analogues used in the current time, namely**:** the costs determined by the LRIC method and related to the semi-fixed costs were 2.25 times lower than the determined actual costs; the proposed method of determination of tariffs on telecommunication services enables us to exclude from our calculation those elements in the provider's existing network which, due to various factors, are not involved in the implementation of the planned range and volume of services for the intended tariff period; the proposed method takes into account investment costs for the development of networks and/or services for the planned period and profit; it enables us to avoid the separate cost accounting method and to eliminate the deficiencies of the Historical Costs and Long-Run Incremental Cost, which allows significantly reducing the amount of work required for tariff determination and increasing their validity.

Keywords: Telecommunications Services; Tariffs; Costs; Method; Simulation Model; Conceptual Model.
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Визначення тарифів на телекомунікаційні послуги на основі імітаційного моделювання витрат на їх надання

Анотація. Розглядаються основні аспекти застосування розробленого авторами і опублікованого раніше методу визначення тарифів на телекомунікаційні послуги.
Зміст статті є відповіддю на низку питань та побажань, які виникли у співробітників економічних служб операторів телекомунікацій, що займаються питаннями визначення тарифів, а також представників регуляторних органів різних країн, у процесі обговорення запропонованого методу. До них відносяться: більш докладний опис ключових положень побудови та використання еталонної та імітаційної моделей; склад та характеристика вихідних даних, які використовуються при побудові моделей; опис принципових переваг методу, що пропонується, порівняно з іншими моделями та найбільш розповсюдженими аналогами, що використовуються сьогодні.

Ключові слова: телекомунікаційні послуги; тарифи; витрати; метод; імітаційна модель; еталонна модель.

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Метод определения тарифов на телекоммуникационные услуги на основе моделирования затрат на их предоставление: методические и практические аспекты применения

Аннотация. Рассматриваются основные методические и практические аспекты применения разработанного авторами и опубликованного ранее метода определения тарифов на телекоммуникационные услуги.
Содержание статьи является ответом на ряд вопросов и пожеланий, возникших у сотрудников экономических служб операторов телекоммуникаций, занимающихся вопросами определения тарифов, а также представителей регуляторных органов различных стран в процессе обсуждения предложенного метода. К ним относятся: более подробное описание ключевых положений построения и использования эталонной и имитационной моделей; состав и характеристика исходных данных, используемых при построении моделей; описание принципиальных преимуществ предлагаемого метода, по сравнению с другими, наиболее распространенными аналогами, используемыми в настоящее время.
Ключевые слова: телекоммуникационные услуги; тарифы; затраты; метод; имитационная модель, эталонная модель.

1. Introduction. One of the key conditions of humanity's transition to an information society is the development of infocommunication infrastructure and the provision of effective management of the modern infocommunication services sector. Under these conditions, one of the most important areas of development of economic science is the development of effective methods of tariff formation in the infocommunication area that can best satisfy consumer demand for telecommunication services and promote favourable conditions to attract investments, maximise revenues and profits for operators and providers, etc [1–7].

The present research related to the problem of tariff determination relevant to telecommunication services has enabled the authors to develop and propose a method for tariff determination based on cost modeling of service providing [8–10], which exemplifies new approaches to the formation of tariffs on telecommunication services.

Not repeating the guidelines method proposed in [8–10], we note the following.

The method is based on the construction and usage of a conceptual model of service providing process, as well as a simulation model for the volume of operational costs determination.

The construction of the conceptual model takes into account only those network elements that are involved in service provision. This is achieved by modeling the process of telecommunication traffic which passes between corresponding network elements using the minimal necessary and sufficient route. The construction of the conceptual model allows to eliminate from the calculation those elements in the existing operator's network which, due to a range of factors, do not take part in the implementation of the planned nomenclature and volume of provided services for the intended tariff period (evolution of the network as a result of equipment modernisation, changes in the nomenclature and structure of services, etc.).

The construction of the models is based on two components – the transport network and service implementation.

The end result of the modeling at the conceptual model construction stage is the identification of the base elements (cost drivers) of the network (ATE ports, connecting links, radio channels, conditional router ports, subscriber radio stations and so on) that take part in the providing one service or another, and the determination of a numerical consumption equivalent for each element in respect of the transport component and the service providing component.

The development of simulation models entails the determination of current (operational) costs that are essential for ensuring the continuous operation of all network infrastructure elements that ensure operation of one subsystem (the transport network, ATE, mobile operator's base station subsystems etc.) or another. This is achieved by modeling of the operation of the same (in terms of the scale) hypothetical subsystem using initial data corresponding to the current state of the market and current legislation, as well as by taking into account the particularities of the subsystem's operation under the conditions of a specific provider. Modeling at this stage determines the reduced costs to one base network element (driver).

Based on the numerical consumption equivalent for each element in respect of each service, as determined by the conceptual model, and the costs for one element, obtained from the simulation modeling, the tariff on a service is determined.

A number of questions related to the application of the proposed method were raised in the in the course of discussions about the published works [8-11]. The analysis has shown that publicity among who, as a rule, are employees providing economic services, working for telecommunication service providers and dealing with the determination of tariffs, as well as representatives of regulatory authorities of various countries are interested in defining:

- a more detailed description of key principles of construction and usage of conceptual and simulation models;
- what data are initial, who submits them, and in what form they have to be submitted;
- what is the main advantage of the proposed method, if compared to other methods currently used, for example, the widely-known Long-Run Incremental Cost (LRIC);
- why it is desirable to introduce a relatively simple example to illustrate the process of tariff calculation.

3. The purpose of this article is to provide answers to some of the raised questions.

4. Results. While constructing the conceptual model, we used initial data and information which, arising out of the network topology, reflect the current state of the network. They are the composition and nature of the provided services, the number of communication nodes in the network; the number of used data transmission systems types; the number of constructed communication channels and their bandwidth; the length of communication channels; the distance between the sites, etc.

For the purpose of clarity, we have considered the key provisions of the construction and usage of the conceptual and simulation models as an example of telephone communication and data transmission.

As it has been noted, the end result of modeling at the conceptual model construction stage is the determination of the numerical consumption equivalent for each element (cost driver) of the network in terms of the transport component and the implementation component for each service. We have used the conditional connecting line (CCL) and the conditional trunk connecting line (CTCL) as base elements of the transport network.

The basis for determining of the numerical consumption equivalent for each element in terms of the transport component is the common resource of the transport network. In this case, the channel-kilometer is used as a unit of measurement.

This resource is defined as the sum of products of communication lines length in each section of network over the number of conditional digital channels with a bandwidth of 64 Kbit/s for each constructed element within the sections.

In order to determine the average resource capacity of one conditional connecting line (in channel-kilometer) it is necessary to:

- select all types of data transmission systems which are used to transport traffic for a given set of services in the framework of the transport network;
- calculate the average distance between two units of equipment (half-sets) and the general number of conditional digital channels which were organised by using this equipment for each type of data transmission system;
- calculate the average length of CCL as an average weighted value for all types of used data transmission system.

The average resource capacity of one CTCL is calculated as a product of the average resource capacity of one CCL on the average distance between connection nodes.

To determine of the average distance between communication nodes, it is necessary to:

- construct an adjacency matrix, which shows any existing direct links between all possible pairs of communication nodes in the transport network;
- calculate a matrix of least distances between nodes (e.g. using Dijkstra's algorithm [12]);
- determine the average distance between nodes on the basis of the sum quantity of all the least distances (it is necessary to use automation computing for large tables).

As indicated in the description of the proposed method [8], all services that envisage the usage of the transport network can be conditionally divided into two groups: services of an unshared consumption and services of sharing (adjacent) resource consumption of the transport network.

The determination of numerical consumption equivalent for the usage of the transport network resource by service of an unshared consumption (for example, a service which provides the usage (rent) of digital communication channel which involves a fixed reservation of transport network bandwidth in all sectors from one end point to another) is determined by simple estimation of the number of CCL (or CTCL) for the organisation of the guaranteed traffic transfer through the channel with a bandwidth equivalent to the necessary number of digital communication channels. For example, if service provision presupposes continuous usage of a virtual data transmission channel with bandwidth of 2 Mbit/s between the two neighbouring network nodes, than the numerical consumption equivalent for the usage of the transport network resource by this service will be 30 CCL (2 bit/s divided by 64 kbit/s). Thus, the distance between these nodes is taken into account in the determination of the resource capacity of the CCL in channel-kilometers, which allows starting using virtual channels abstracted from specific units of equipment and characterised with regard to their bandwidth only.

In turn, the determination of the numerical equivalent of transport network resource consumption with services of sharing (adjacent) resource consumption (for example, telephone connection services, provision of which involves only temporary (not permanent) reservation for each communication channel subscriber in all the way passage of voice traffic) is carried out on the basis of quality, and the average intensity of load for each subscriber. For telephone communication services the numerical consumption equivalent of the transport network can be defined as a ratio of the required conditional digital channels, for all telephone subscribers to the number of subscribers. In turn, the necessary number of conditional digital channels can be determined by using a modified first Erlang formula [13] for a given level of losses and the specific load of subscriber line (SL) in the busy hour (BH). For example, taking the average number of subscribers served by one automatic telephone exchange (ATE) for 1000, and the specific load in the BH for SL of 0.1 Erlang (at the level of losses 0,005) can be easily determined; thus, to ensure all specified telephone subscribers with a given level of quality it is necessary to reserve at least 121 virtual digital channels with a bandwidth of 64 Kbit/s. Therefore, if we assume that 100% of the telecommunication traffic is concentrated across the provider's network (without any division into local and long-distance), the numerical consumption equivalent of the transport network of the service will be 0.121 CTCL (121 ÷ 1000).

In contrast to the transport component, indicators which characterise the resource of the describing component of the service implementation differ not only according to the type of consumption but also according to the nature of the service. For example, in the case of a fixed telephone connection such indicators are the average resource capacity of one conditional subscriber line (CSL) and an ATE port. Thus, the CSL encompasses any passive components (communication line, fragments of cross-connect equipment, switchgear cabinets and so on).

The average resource capacity of CSL in channel kilometers is determined by dividing of the general length of the subscriber lines by the number of ATE ports in the telephone connection network.

Figure 1 shows an example of a graphical image of the telephone communication services conceptual model in three different versions: 1 – local telephone services without access to the public switched telephone network (PSTN), 2 – local telephone services with access to the PSTN and 3 – the intercity telephone service without exit to the PSTN.

Analysing of presented model, it is easy to determine that in order to provide Service 1 (local telephone services without access to PSTN) the following two types of all basic elements (cost drivers) are used. They are two units of CSL (one for each subscriber) and two ATE ports (one for each subscriber). The transport network resource to maintain subtypes of the mentioned service is not involved and thus it does not influence the determination of its tariff according to the proposed method.

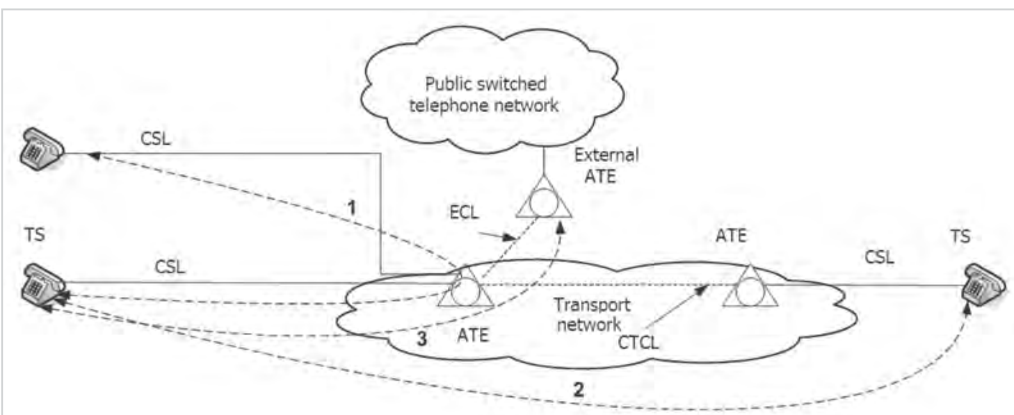

Fig. 1: **An example of the conceptual model graphic of telephone communication services**
Source: Designed by the authors

In turn, only one CSL which refers to the operator network and one ATE port are used to provide Service 2 (local telephone service with access to the PSTN). At the same time, an external connecting line (ECL) is an additional base element, which provides a connection to an operator`s ATE with external ATE of another operator that provides access to the PSTN. It should be noted that the tariff will include only that part of the service that provides voice traffic transmission to the external exchange and does not include the services of its transmission through the PSTN itself.

To provide Service 3 (intercity telephone service without access to the PSTN), we need to use two CSL and two ATE ports (one set for each subscriber). In this case, we also engage resources of CTCL (in the amount sufficient to organise and maintain of a communication channel for a period of a telephone conversation), taking into account a certain quality, and the average intensity of the load for each subscriber.

When constructing the simulation model, we applied initial data related to the results of the conceptual model construction (the number of CSL, CCL and CTCL, ATE ports, etc.), the operator’s reporting according to the cost of items (the cost of hardware and communication lines, industrial facilities and so on), as well as the regulatory standards applied in defining the cost of items (the number of personnel, amortisation rates, electricity tariffs, etc.). In the case of unavailability of such standards the average indicators for each sector can be used instead of them.

The model is presented in the form of a matrix in which the rows indicate the list and the number of base elements which characterise a given subsystem and the columns show all the cost items which are necessary for the subsystem operation. The intersections of matrix rows and columns indicate only those cost items which are associated with the subsystem operation.

Costs attributable to a given base element are determined by dividing the sum of all costs used to ensure the operation of the corresponding subsystems with the required level of quality by the number of base elements (cost drivers) of a given type.

The cost of one base element (driver), as well as the numerical consumption equivalents for each element in terms of the transport component and the component of implementation for each service determine the cost of each service.

The main advantages of the proposed method, in comparison to other methods currently in use, are such that the well-known Long-Run Incremental Cost (LRIC) method, include the following.

1. It is well known that the LRIC method and its variants (LRAIC, FL LRIC, TELRIC) is better able to determine universal service costs in the context of the level of losses associated with the given services and to compensate to providers of such services. The results of their using to tariffs determination for services are rather conditional (approximate), since they do not take into account a certain portion of semi-fixed costs (costs that are not distributed) which should be attributed to one service or another. The fact that ignoring the semi-fixed costs can distort the real situation is reflected in the research related to the relationship between the cost structure in mobile telephone networks and prices, which was carried out by Europe Economics [14]. The costs determined by the LRIC method and related to the semi-fixed costs were 2.25 times lower than the determined actual costs.

2. The concept of the proposed method is based on the usage of elements of the methods applied by providers working in a competitive environment: the current cost accounting (CCA) method which is based on data relevant to the cost of service production in current prices; the fully distributed costs (FDC) method, according to which all of the costs incurred by the operator in the manufacturing process (both direct and indirect) should be fully charged on all services or their components; the concepts of effective service costs, which involve the determination of costs on the condition that the provider uses advanced and most effective technologies and in view of effectively organised activities.

3. As already noted, the proposed method of determination of tariffs on telecommunication services enables us to exclude from our calculation those elements in the provider’s existing network which, due to various factors, are not involved in the implementation of the planned range and volume of services for the intended tariff period.

4. The proposed method takes into account investment costs for the development of networks and/or services for the planned period and profit. The justification of the method of tariff determination choice concerning the profitability of investments is given in [10].

5. The proposed method enables us to avoid the separate cost accounting method and to eliminate the deficiencies of the Historical Costs and Long-Run Incremental Cost, which allows significantly reducing the amount of work required for tariff determination and increasing their validity. This method is most effective in determining tariffs on telecommunication services under the conditions when the provider offers a broad range of services, as well as in calculating tariffs on new services.

For the purpose of clarity, the main results of the comparison of the proposed method and similar cost methods are presented in Table 1. The plus sign («+») indicates criteria which are fully met by the corresponding method, while the minus sign («-») indicates criteria which are not met by the corresponding method.

Tab. 1: **Comparison of the proposed method and its most popular analogues**

Comparison criteria	FDC	LRIC, LRAIC	Proposed method
Independence from historical data	-	+	+
Possibility of avoiding separate cost accounting	+	-	+
Cost accounting based on the principle of cause and effect chains	-	+	+
Accounting of only those elements that are essential to the uninterrupted operation of network infrastructure	-	+	+
Accounting of semi-fixed costs	+	-	+
Accounting of investment costs for network/service development	-	+	+
Possibility of formulating a long-term tariff policy	-	+	+
Possibility of rapid calculation/re-calculation of tariffs where necessary	-	-	+
Effectiveness in calculating tariffs for services subject to state regulation	-	+	+
Effectiveness in calculating tariffs for services not subject to state regulation	+	-	+
Possibility of independent calculation (estimation) of tariffs by a regulatory or anti-monopoly authority without using the provider’s confidential data	-	-	+

Source: Designed by the authors

5. Conclusions. These are some methodological and practical aspects of the proposed approach to the determination of tariffs for telecommunication services as contained in [8-10].

In our opinion, it is recommended to conduct further research in this area aimed at the identification and justification of the quantitative criteria of models’ adequacy, as well as the implementation of the assessment of the degree of the adequacy of the variables used in model construction. This, in turn, will allow examining the possibility of excluding inessential factors while constructing the models and simplify the modeling process without loss of representativeness of the data resulting from the calculations.

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