

# Application of the Theory of Complex Networks in Analysis of Tourist Infrastructure

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**Abstract** – One of the most dynamically developing sectors of the service sector, which has a significant impact on the socio-economic development of a region, is tourism. Its characteristic feature is a significant multiplicative effect that generates incomes in related sectors of the economy and gives impetus to their development. National tourism should play a key role in the development of the territories, since it is, tourism which is the main source of financial income from tourist activities. In the regions of our country, national tourism is poorly developed, which is explained by the underdeveloped infrastructure of the industry, the discrepancy between prices for tourist products and their quality, as well as the lack of qualified personnel. It is obvious, however, that it is the infrastructural component that most influences the tourist attractiveness of a region. At the same time, at the moment, the following factors contribute to the popularity of national (domestic) tourism: the turbulent geopolitical situation in many countries, the growth of the exchange rate, the restrictions on Russian travel to popular foreign resorts etc. Under these conditions, the studies that analyze the existing infrastructure of a region, including using the theory of complex networks, become the most relevant.

**Keywords** – tourism industry, social interactions, actor-networks, complex networks, components of network structures

## I. INTRODUCTION

In the theory of social networks, the distance is the number of different intermediaries between two actors. In particular, in the work of researchers from the University of Colombia [1], it is said that geographic location is of primary importance in the formation of a relationship between individuals. Researchers identify network elements such as «hubs» - network elements that have the greatest number of connections, and elements such

as «intermediate centrality» that connect different communities, i.e. use their position as an intermediary [1]. As an example, border areas can be given, which, despite having fewer connections than central areas, have their advantages by providing a channel connecting other regions.

Following the developments of M. Granovetter, it is necessary to pay special attention to «weak» connections, serving as «bridges» for circulating, sharing and updating information with the outside world, because with "strong" connections, community members possess almost the same information [2].

In particular, M. Granovetter demonstrated the influence of social networks on such economic indicators as employment, pricing, productivity and innovation. The example of «strong» ties is an isolated community. Due to the study of such «weak» connections, it is possible to expand the research of local communities beyond only traditional and rural ones.

Speaking about the geography of social networks, sociologists talk about the movements of people over time and their consequent construction of networks (frequency of connections) and in space (far / near, by phone / over the Internet) using various means (visits, meetings, telephone conversations, electronic communications). Continuing the division of social ties into strong and weak, proposed by M. Granovetter, they insist that, due to the development of technology and mobility, nowadays it is possible to maintain even strong connections at a distance, subject to regular visits. Moreover, with an increase in the availability of various forms of communication at a distance, the authors suggest that the number of reasons for meetings is also increasing. To study the socio-economic components of network structures,

an actor-network approach (ANA) is used, which focuses on the work on building networks of actors of various origins and assessing the sustainability of certain relationships and organizing priorities in network formation [3].

## II. MATERIALS AND METHODS

If traditionally the issues of the functioning of actor-networks were studied directly in dense urban conditions, then in the Baikal region there is an opportunity to focus on those areas where such networks have the lowest density. This perspective allows more detailed consideration of the influence of each network participant individually, due to their sparseness, studying the significance and strength of certain network connections, and on the basis of their analysis, considering the territorial patterns of the formation of socio-economic associations.

Characteristically, the ANA describes any relationship that is materialized. Participants in relationships can be both people and other entities that, also endowed with the subjectivity of activity, becoming actants. The information obtained from the analysis of actor-networks allows developing research on the integrated network platform in future. This approach is partly based on integrated research devoted to the study of sustainable development of tourism [4, 5].

In the Baikal region, complex studies are presented in the works [6, 7] and et al. In their paper Danilenko N. N. and Rubtsova N.V. [6] calculated the performance assessment of the sphere of recreation and tourism using indicators of socio-economic efficiency on the basis of official statistical data from Irkutskstat and Buryatstat. However, the issue of commensurability of various factors affecting sustainable development remains unresolved. In addition, the generalization of tourism as a general set of quantitative characteristics leaves eliminates focus on the diversity and the role of various actors involved in this area.

On the other hand, the developments in the study of only one factor (for example, only economic) are used. The examples of the study of individual factors are: assessment of recreational resources [8, 9]; ethno-recreational resources [7]; transport accessibility and seasonality [10]; spatial data infrastructure of the Baikal region [11].

Complementing the previous studies, the authors aim at detailing the various actors operating in the field of tourism and studying the interrelations and interdependencies between them using a combination of different methods: observation with the element of descriptiveness; historical; comparative; cartographic; analytical and statistical; expeditionary research; mathematical modeling; sociological [12].

The information obtained from the analysis of actor-networks will allow further development of research on the integrated network platform.

In contrast to the actor-network approach, the theory of complex networks (TCN), distinguishes between entities in accordance with their properties. TCN has attracted attention and has recommended itself as a reliable approach to solving complex multi-actor problems in systems of any nature [13, 14].

It is important to interpret the entire complexity of the systems as possible by a wide range of network representations, including the form of networks: temporal (dynamic) [15], multilayered (multiplexes) [16], interdependent [17], stem [18], combined [19], aggregated [20], as well as their generalizations - laces of unified networks (LUN) [21, 22].

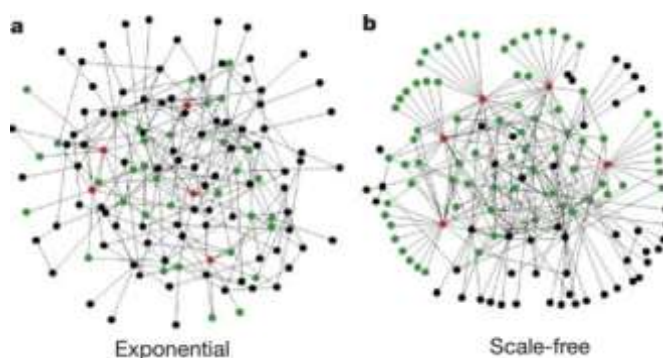


Fig. 1. Topologies of exponential and scale-free networks [23]

In addition, within the framework of TCN, the study of systems with a network structure and containing nodes in the number of millions and more was mastered [24]. This turned out to be available mainly due to the widespread use of the global Internet and the development of high-performance computing methods and technologies. Such networks are called «large», «large-scale» or «huge» [25] networks, with the terms «large», «large-scale» and «massive» [26] used in the English-language literature.

In the development of large-scale networks, a serious problem is the collection of practical data for research and subsequent analysis of the network picture. Significant financial and technical resources are required to build, for example, a social network or a technological communication network within a megacity or region. With the advent of tools on the global Internet, it became possible, for example, to select data for building a subnet based on social networks (Facebook etc.) using automated tools [27]. Distributed computing systems (high-performance clusters) and rapidly progressing information and communication technologies made it possible to store the obtained data arrays of a significant amount and to quickly process them (calculation of network metrics and visualization) [28, 29].

To sum up, the potential of TCN is powerfully and seriously realized in individual disciplines, but still not fully utilized in order to push time and conceptual boundaries and reliable approach and effective solutions to socio-economic and biosocial tasks of various scales in various subject areas.

The uniqueness of the geographical location (access to Lake Baikal), the heterogeneity and great aesthetic value of the landscapes of the Baikal natural territory: the golets, mountain taiga, foothill, as well as complex terrain and mountain rivers, good transport development and accessibility attract a huge number of tourists. During the recreational assessment of landscapes, the current natural conditions of the territory are assessed in terms of significance and sensitivity.

First, all-natural resources available in the given territory are considered, which determine the recreational use of the territory, as well as playing an important role in choosing a recreation and travel area. Rekreatants take into account the peculiarities of landscape and climate, the richness and diversity of flora and fauna, the natural possibilities for sports, hunting, fishing, etc. The organization of the types and forms of recreational activities, as well as the type of the recreation complex, depends on what set of natural resources the territory has.

On the one hand, mountainous areas with a frequent change of landscapes are quite attractive for holidaymakers who are seduced by picturesque landscapes, clean mountain air, the opportunity for sports, etc. But on the other hand, the mountainous terrain creates certain difficulties in the development of the territory. The recreational potential of mountain landscapes is made up of the following resources:

- sightseeing tourism (including scientific, memorial);
- sports hiking, water, mountain, speleotourism;
- sport fishing (hunting, fishing);
- therapeutic recreation;
- mass recreation (picnic, beach-bathing, summer and winter sports and recreation);
- field rest (collection of medicinal herbs, mushrooms, berries, nuts [28].

The assessment of the value of landscapes is determined by the possibilities of using them for recreation, and the sensitivity is evaluated in relation to the potential for the occurrence and activation of exogenous relief-forming processes as a result of anthropogenic activity [30].

When studying tourism infrastructure, it is proposed to use the combination of qualitative methods of sociology, as well as statistical, economic, physiographic and cartographic methods, as the most reliable way to understand the mechanisms and ways of interaction between social communities between themselves and with nature, what happens in reality and what lies behind generalizations of statistical data.

Depending on the nature of activity, geographically specific formal and informal offers of tourist services have been identified depending on the existing natural and infrastructural conditions.

### III. RESULTS

In the Baikal settlements in connection with bans on any construction, with the exception of individual housing, a transfer of objects built for individual housing construction to hotels, cafes, etc. is revealed. In addition, there is an illegal reception of tourists by local residents who are deprived of other types of employment due to environmental restrictions. However, by comparing the Baikal and resort settlements of the latter, even more widespread informal rental housing is observed than on the shores of Lake Baikal. For example, in Zhemchug settlement there are 10 official camp sites and about

70-80 families who unofficially rent housing (with 3-4 houses) and about 300 houses with ~ 3 beds, in Arshan settlement there are 29 official hotels and other places of accommodation, the number of unofficially renting housings is several times more (as a result of a study of the central streets of the village in 2018, 71 advertisements are revealed ("Rent an apartment", "Rent out") - this is taking into account the fact that many remove signs, due to the tightening of checks by the administration and other authorities). Informal provision of tourist accommodation is observed both in the areas of developed tourism and in the areas of developing tourism with underdeveloped infrastructure. In the areas of developed tourism of Russian and international scale, the total number of tourists increased by 20-30%, which significantly reduced the seasonality factor. About 30% of travel agencies (most of which have regional sites on the offer of accommodation) lead to the camp sites, 50% from booking.com, the rest by the recommendations of friends, acquaintances, former clients, social networks vk.ru, viber, through their own availability) and other sites. In this regard it is possible to note the increase in the share of tourists arriving using the website booking.com: if in 2014 they were used by 15-20% of tourists, now they are used by 40-50%.

### IV. DISCUSSION

This service stratification allows building a network model of industry, including the six layers listed above. In accordance with the general approach of LUN, another network model can also be presented in the form of a structure, with combined unions in the short and medium term, the so-called «bouquets» of actors. They take into account the presence of different nature of private components (citizens, organizations, elements of information, transport systems, accommodation systems, catering, excursions, entertainment, as well as medicine, law enforcement, etc.) that are important for managing the tourism industry.

In the region of tourism development on a regional scale, Arshan and Zhemchug (the main stream of tourists are representatives of the Irkutsk region), the practice of «catching tourists» is widespread (offering accommodation services on the highway when entering a village, and there is a queue system for the most popular fishing sites), but there is also the rise in the drive of tourists through reservation systems. In Arshan, there are 27 hostels in the booking.com system, in Zhemchug there are 7. Tourists in Arshan come through on-site service offerings - 40-50% and through other regional and local tourist sites, «word of mouth» (through friends), booking.com - 20-30%. In the settlement of Goryachinsk (the majority of holidaymakers from the Republic of Buryatia) also note that informal tourist channels («word of mouth», «from former visitors», «by sign on the street» are 50%), booking.com - 20% - 30%, the rest - other sites and travel agencies.

In regional centers of tourism development, the seasonality factor remains significant. Many chalets open only from June to September. 15% of the total number of tourist centers in Zhemchug and Goryachinsk constantly work. In Arshan, traditionally, the majority of residents provide housing for rent, and rest «on weekends and holidays» is common here, so the



seasonality factor is smoothed out precisely because of such tourists. Severobaykalsk city is an example of an area with poor infrastructure development. Here, due to the pronounced seasonality of tourism, the owners of guest houses can open their business for 2-3 summer months and close it for the remainder of the year and continue to work as cashiers, teachers, railway workers, etc.

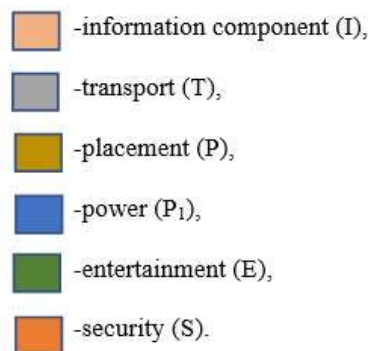
Other geographically specific services:

- the specialization in spa treatment determines the popularity of massage therapists in the Tunkinsky district,

- in the village of Khuzhir, due to the poor condition of the roads, transport services by UAZ 3741 minibuses are widespread (the "tablets" are estimated to be about 300 cars on the island, taking into account summer season), which carry out almost all tourist traffic around the island (at that time as ordinary buses quickly become unsuitable because of a bad road), the road to Cape Khoboy, which has become a tourist attraction, serves as a full-time tourist for one day; at a distance of 40 kilometers, it takes about 6 hours one way. Thus, the road becomes a factor in the hours-long employment of guides and local residents — drivers of "pills" (many drivers can conduct tours themselves). Almost all drivers of the "pills" do not officially register their transport services. The average age of drivers is 40-50 years old, many of them work shifts (at the bakery, at the Emergencies Ministry, etc.) or are retired (former police officers). In the village of Khuzhir most of the proposals for the rental of bicycles are found (in almost every major hotel). Tourism remains one of the very few options for a local, previously rural economy. However, the majority of low-skilled professions provided by the development of tourism are traditionally occupied by women (accommodation, cooking, retail and catering). Through the example of the practice and strategies of legitimizing informal transport services for drivers of "tablets", it is possible to note the change in the place of perceptions of ordinary land rights in the global gender division of labor.

- in Okinsky district, due to the poor quality, it is expensive to transport tourists to mineral springs and natural sights using off-road equipment (GAZ-53, UAZ, etc.) (Approximately there are 23-25 cars in Orlik, in 2012 there were only about ten cars). Sources Joygan / Choygan are located 8 km from the foot of the Joygan-Daban Pass, the nearest place where cars carrying tourists can travel. The route to the sources runs through a rather steep pass with a 300-meter ascent and 400-meter descent. At the foot of the pass there is a hut in which local residents live all summer, offering their horses for the transportation of tourists and their goods. The cost of horse breeders' services varies depending on the origin of a tourist and his methods of communication. If a tourist easily agreed to the proposed price, then a horse breeder said that he had to go with a horse himself; therefore, a tourist still has to pay for escort. Horse breeders offering cargo and passenger transportation services are practically already focused on summer employment: their services are used by water-boating tourists who ride their boats and backpacks on horseback, as well as those who are engaged in hiking-trips to the Valley of Volcanoes and on Peaks Topografov and Kropotkin. As in 2012 (Kuklina, 2012), medical aid points are not provided for tourists: there is one

hospital in the Okinsky district, and the radius of service of the medical and obstetric points reaches 200 km. Hotel service is provided only in Orlik. The skills of providing first aid to local guides are formed empirically. Locals offer their transport services on the Internet in social networks, as well as through friends.



Tourists (consumers), C;

Providers, P

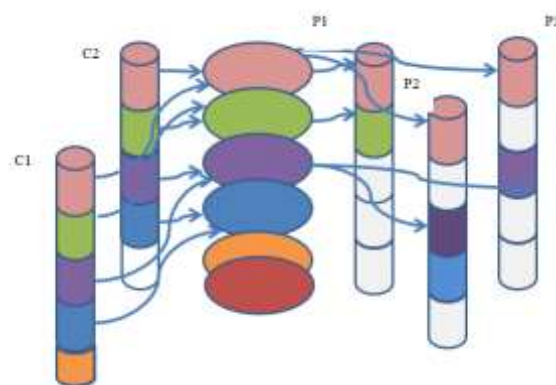


Fig. 2. Network ontology of tourism industry

In the settlement of Listvyanka water excursions prevail due to the location of the pier in the very center of the village, many hiking excursion routes.

In Severobaykalsk, trips to mineral springs and active tourism, which do not require large infrastructure investments, predominate.

In the Baikal region, the following components and their actors were identified as the main intermediaries for the design and operation of tourist networks:

- information component (I),
- transport infrastructure - aggregated actors - carriers (including carriers themselves: formal and informal, vehicles, roads) (T),
- the representatives of accommodation services (including: owners of accommodation facilities: formal and informal, buildings) (A),
- aggregated actors representing catering services (including: personnel, buildings, menu) (M),

- aggregated actors representing entertainment services (including: owners, staff, buildings, entertainment facilities provided) (E),
- security assurance actors: medical aid actors, law enforcement agencies (S).

## V. CONSLUSION

Considering the network model of the tourism industry in detail with the calculation of both individual network elements and the aggregated characteristics of the network and its components, communities and the network as a whole will make it possible to identify structurally vulnerable places in the regional tourist system and at the same time propose topological solutions that bring the system to a new level of development. It is the interdependence of networks and its components that stimulates the unification of the multiplicity of network entities into a single object of analysis, which contributes to the construction of a cross-disciplinary ontology of the tourism industry using the combined network platform.

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