EÖTVÖS LORÁND UNIVERSITY

FACULTY OF INFORMATICS

DEPARTMENT OF CARTOGRAPHY AND GEOINFORMATICS

Web application for telecommunication cartography in Miskolc

GAIJI MOEMEN

Student of Cartography MSc

DR. BÉLA KOVÁCS

Assistant Professor

ELTE Department of Cartography and Geoinformatics

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General Introduction

Over the previous two decades, the telecommunications industry has undergone substantial technological and regulatory developments. The growing use of geographic information systems (GISs) for tracking broadband and mobile infrastructure around the world is one of the major factors driving up demand for these systems in the telecom industry. Many telecommunications businesses utilize GISs to research the areas where they plan to expand their operations in the future. This is because these systems allow for the collecting of information and data from a variety of sources on a single platform, which aids businesses in determining the issues they will face when they construct broadband infrastructure in certain locations. The massive investment supplied to many telecom businesses by both private and public organizations for expanding their broadband network and improving its speed and connection across the globe is another important factor driving the use of GISs in the telecom industry. Aside from these causes, the increasing need for broadband and mobile network construction in several countries around the world is driving up GIS sales. The two most common deployment techniques for geographic information systems in the telecom business are cloud and on-premises. According to P&S Intelligence, a market research agency, telecom companies will prefer the adoption of GISs via online solutions over the other approaches in the next years. This is since online adoption allows access to data and information from both web browsers and mobile phones (GIS and the Telecom Market, 2020). This present work which is part of the Master Thesis course constitutes a synthesis of the graduation project report presented in the context of the study and the main results obtained in 3 major parts:

- The first part presents a general overview of the use of GIS to map the telecommunication in Hungary with historical background.
- The second part concerns the description of the adopted methodology.
- The third part is preserved for the presentation and the discussion of the results obtained by the QGIS software and HTML language.

As a cartographic student, my academic objective is to visualize this topic in a cartographic manner; therefore, I prepared different maps and web pages. The data availability was a big problem in my thesis, however, I managed to collect spatial and some attributes data.

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3G HSPA: (high-speed packet access) is a 3G UMTS upgrade that provides much greater data speeds in both the uplink and downstream.

4G LTE: (Long-Term Evolution) is a wireless broadband communication standard based on the GSM/EDGE and UMTS/HSPA standards for mobile devices and data terminals.

4G NB IoT: (Narrowband Internet of Things) is a low-power wide-area network and Internet of Things radio communication protocol.

ADSL: (Asymmetric Digital Subscriber Line) is high-speed digital communication technology and device that uses a regular twin-cable telephone line.

Business main lines: business subscribers are economic organizations

Cable television network: a network that transmits radio and television signals, including systems within the site's boundaries.

ISDN: (Integrated Service Digital Network) is a telecommunications service that uses a terminal adapter to connect networks via a digital line.

LAN: (Local Area Network) is a network for communication between computers confined to a single building or in a closely located group of buildings

Other main lines: are non-revenue main lines.

Public main lines: are main lines assigned to public telephone stations operating in public areas.

Telephone main lines: are private and public (most recently business and institutional) subscribers' telephone stations in use or on hold

VSAT: Very Small Aperture Terminal

xDSL: (Digital Subscriber Line) is a technology that enables high-speed digital communication over a regular copper-wire telephone line.

1. Introduction of the telecommunication section in Hungary

Overview of mapping of the telecommunication

Telecommunication network mapping is critical for both urban and rural areas, especially as telecommunication networks become increasingly important in our daily lives. One area of attention for researchers and planners is studies that forecast the location of cellular network towers. Terrain, vegetation, urban areas, and other potential sources of interference are frequently evaluated simultaneously, and GIS tools like ArcGIS have become industry standards for predicting cellular tower placements. Furthermore, data is not always static, as some interference may be one-time, long-term, or recurring. Another dimension that GIS techniques (such as line of sight) incorporate is forecasting the best height of a tower. This necessitates a multi-criteria approach that includes features of potential interference time fluctuation (Kashyap et al., 2014). The Continuous Space Maximal Coverage Problem (CSMCP) is a related topic that looks at continuous coverage planning in specific locations, with some places posing higher difficulty. Finding appropriate placements is a difficult task with large areas of research since information must be kept at a small spatial scale. Discrete coverage models, which break the problem down into discrete sets like terrain, are commonly used to compute detailed area coverage quickly and optimize coverage in diverse places (Wei, 2016). Furthermore, because the construction of towers frequently involves numerous organizations, data between them is frequently unknown. Web GIS apps are being created to assist share data and improve corporate operations and administration to make planning more efficient. As an example, consider how Web GIS can be used to plan and manage cellular towers, see (Jiang, 2014). Human and traffic mobility studies that use cellular network data from mobile phones have been a bigger topic of research in recent years. Given its ability to comprehend issues like traffic, where consumers are, pollution studies, regions of infrastructure demand, and general human behavior, this has been a growing subject of research (Williams et al., 2015). In effect, the location of telecommunication towers becomes more important since increased data demand is likely to occur now that advertisers and others are aware of mobile data's potential.

The Use of Geographic Information Systems (GIS) in Telecommunications

One of the world's fastest-growing GIS markets is telecommunications. GIS in telecommunications grew at a compound annual growth rate of 10.89% from 2013 to 2018, according to the Technavio blog. The key driver of rising demand is real-time information for strategic planning. Telecommunications networks are vast, and they generate massive amounts of asset data that is scattered around the globe. The optimum tool for managing the data is GIS. Telecom companies can use GIS mapping to improve network planning, deployment, maintenance, operations, and even sales and marketing. Integrating GIS into daily operations can assist telecom companies in achieving the following goals:

- Increase the availability and consistency of infrastructure data.
- Reduce operational costs.
- Improve the quality of operational decisions.
- Simplify network planning in the future.
- Improve the time it takes to respond to network problems.
- Invest the resources wisely.

In the end, these advantages boil down to increasing operational efficiency by streamlining daily procedures and gaining access to critical data.

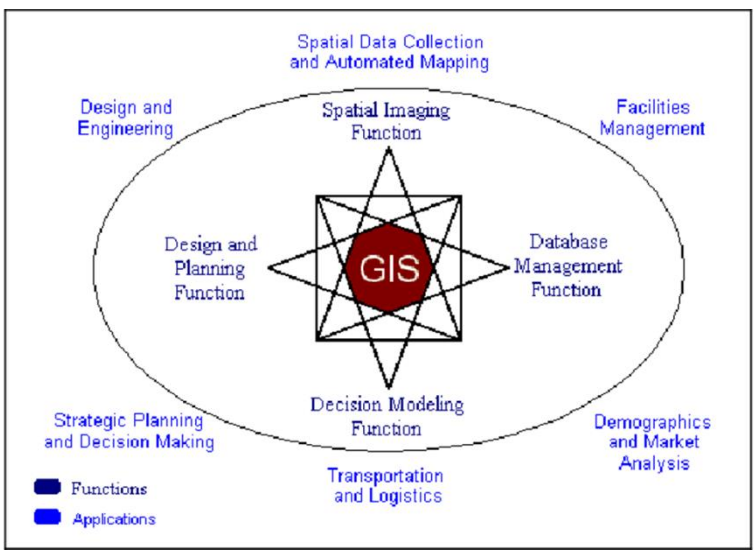


Figure 1: Functions and Applications Of GIS after Mennecke (2000)

The Use of GIS in Network Planning and Deployment

The purpose of successful network planning is to meet the needs of both the operator and the subscriber. Topological design, network synthesis, and network realization are the three main components of network planning.

- Topological survey: determining where and how network components should be connected.
- Choosing the right size components for the network
- Network realization entails devising a strategy for meeting capacity requirements while also ensuring network dependability.

After finishing the planning of the network, it's time to start deploying it.

The deployment of a telecom network resembles that of a construction project in many ways; yet, unlike most construction projects, network deployment is distributed across wide areas. Users can utilize GIS to combine a range of project data, such as topography, population density, and projected demographic trends. This contributes to the creation of a single source of project data, allowing providers to track progress and communicate more efficiently between the field and the office. Finally, GIS improves organizational operations by bringing data together and closing communication gaps.

Before expanding, another crucial part of network design is assessing the prospective market size. Telecommunications operators can use GIS to identify possible locations for client expansion. Providers can develop maps that help pinpoint potential areas for network expansion using extensive demographic information such as employment, affluence, and neighborhood features.

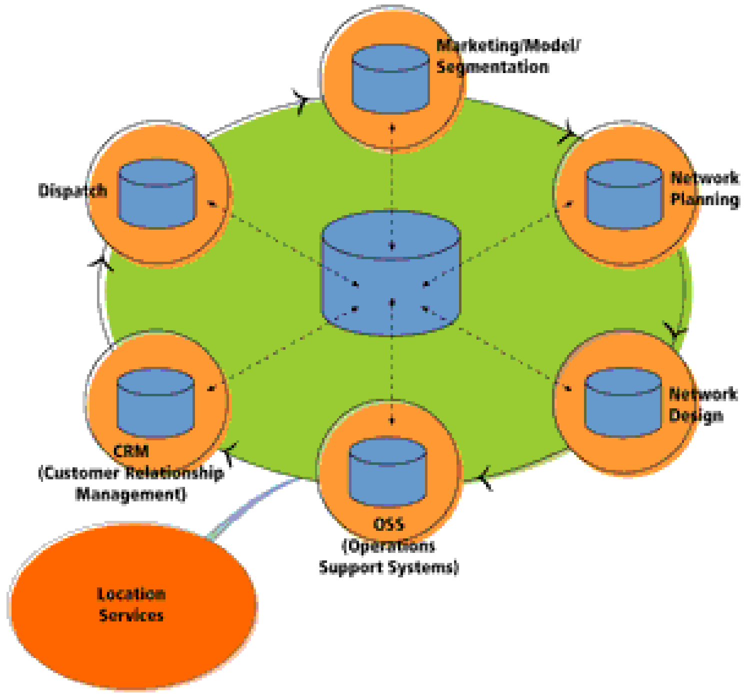


Figure 2: Telecommunications companies are integrating GIS into the overall workflow (ESRI 2001)

The Use of GIS in Existing Structures Maintenance and Operation

The use of GIS mapping in the maintenance and operation of existing network architecture can be beneficial. The optimal system for documenting infrastructure conditions and repair history combines data management and location. It's much easier to keep track of all the various network components, such as cables, ducts, towers, and even splice points, when everything is organized by location. Companies may quickly generate a geo-located record of asset inspections, historical maintenance, and notes for future work after network assets have been added to the map. GIS, like planning and deployment, serves as a centralized repository for all operations and maintenance data, assisting in the creation of a solid record for future work. Historical asset data is easily available, and field inspection teams spend less time onboarding now that all network data is in one location. Accurate data, especially when available in real-time, also aids in ensuring that work is completed correctly the first time, decreasing the need for rework.

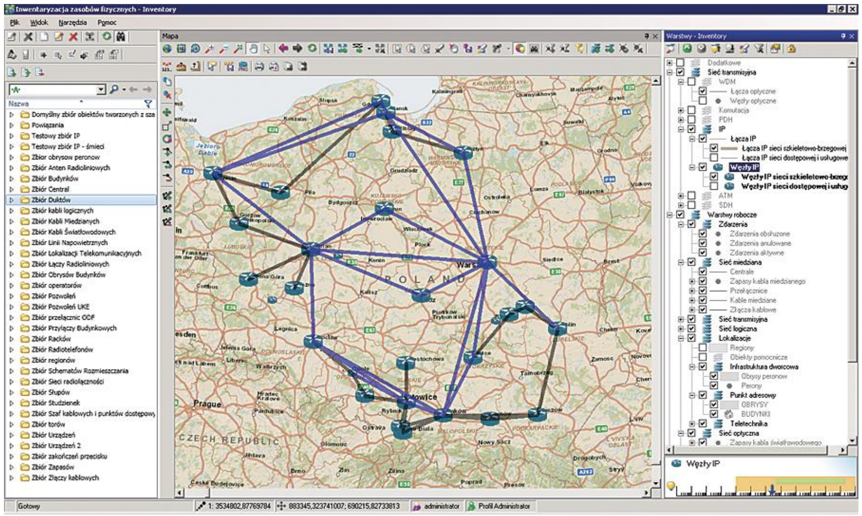


Figure 3: Implementation of a Seamless Network Inventory at Poland's TK Telekom based on ArcGIS for Server and Microsoft SQL Server platforms (Facilitating and Improving Telecom Network Management, 2013)

The Use of GIS in Sales & Marketing

GIS can also be used to do market research. To establish well-informed market strategies, telecom businesses can examine consumer preferences, lifestyles, and demographics.

Organizations can use GIS for telecom market analysis to:

1. Seek fresh possibilities

2. Examine sales data from the past and present.

3. Keep an eye on consumer feedback.

4. Improve market demand understanding

Companies in the telecommunications industry must reduce costs, recruit new clients, and stay ahead of the competition. It's not as simple as locating the oldest equipment and updating it; businesses must concentrate on the areas that are most likely to attract new clients. The great dollar reigns supreme once more, with revenue growth as the primary goal. GIS helps telecommunication providers successfully identify regions of prospective expansion by allowing them to layer diverse types of information on a single map, boosting the possibilities of a favorable return on investment.

Online GIS for Fiber Optic Network Deployment: A Deep Dive

The planning and deployment of fiber optic networks is a fantastic illustration of how GIS can help telecommunications companies. Fiber-optic cable is replacing obsolete copper wire and long-distance landline networks as technology advances. 5G networks, like their predecessors, rely on fiber-optic connection since they require more speed and bandwidth. GIS may be used to identify which areas need the most attention, create a network layout plan, and inform methods for meeting capacity requirements. In general, the deployment of a fiber-optic network goes something like this:

- Identify the coverage area and the best cable routes.
- Engineering: Layout the network and calculate the costs.
- After the system is up and running, gather information for maintenance and expansion.
- Creating a GIS Database: Organize and store geospatial data

Every stage of this procedure can be made more efficient with the help of online GIS. All planning, engineering, and data are maintained in one location with online GIS, and the data can be updated and seen in real-time. Companies can easily generate layered, data-rich maps by combining aerial and subsurface photos, then adding geo-located asset data. This type of detailed documentation reduces the chances of human error and improves communication throughout the company. Online GIS can be accessed through any web browser and often includes native mobile applications, making it ideal for any type of geographically dispersed work.

While inspecting assets and/or doing maintenance, field staff can utilize a smartphone to gather data and make adjustments. Office teams may design maps on their desktop computers, while project managers can assign tasks and track progress on a tablet. Anyone, using any device, may develop, examine, and amend deployment plans using online GIS. Field teams must record data on one device and then manually move it to another with most desktop GIS solutions. Field teams can collect data directly into the cloud GIS platform with cloud-based GIS, eliminating data transfer, lowering the potential for error, and speeding up the data collection process overall. (How to Optimize Telecom Network Operations with GIS)

Figure 4: GIS in Telecom Market (Market Outlook)

The telecommunication section in Hungary

Radio, television, fixed and mobile telephones, and the Internet are all examples of telecommunications in Hungary.

Historical view about the construction of the infrastructure of the telecommunication

In December 1847, the first telegraph station on Hungarian soil was established in Pressburg/ Pozsony/Bratislava (it was a state monopoly). Another telegraph center was erected in Buda in 1848, during the Hungarian Revolution, to connect the most significant administrative centers. In 1850, the first telegraph line between Vienna and Pest - Buda (later Budapest) was built. In 1884, the Kingdom of Hungary had 2,406 telegraph post offices (Telegráf). By 1914, the number of telegraph offices in post offices had risen to 3,000, with another 2,400 placed at the Kingdom of Hungary's railway stations (Szabó et al).In Budapest, the first Hungarian telephone exchange was established on the 1st of May 1881 (Institute)

In 1893, the telephone exchanges of all cities and towns in Hungary were linked. By 1914, the Kingdom of Hungary had telephone exchanges in over 2,000 villages. (Szabó et al). In the same year, the Telefon Hírmondó (Telephone Herald) service was founded. Residents of Budapest could listen to the news, cabaret, music, and opera at home and in public settings, two decades before radio was introduced. It had its network and functioned on a specific form of telephone exchange system. Later, Italy and the United States licensed the technology.

János Neuhold established the first Hungarian telephone factory (Factory for Telephone Apparatuses) in Budapest in 1879, producing telephones, microphones, telegraphs, and telephone exchanges. (M) (Eötvös Loránd Matematikai és Fizikai Társulat Matematikai és fizikai lapok, 1932) (Múzeum, 1971). In 1884, the Tungsram company also started to produce microphones, telephone apparatuses, telephone switchboards, and cables. (Jeney, Gáspár, & English translator:Dunay, 1990) In Budapest, the Ericsson business opened manufacturing for telephones and switchboards in 1911 (IBP, 2015).

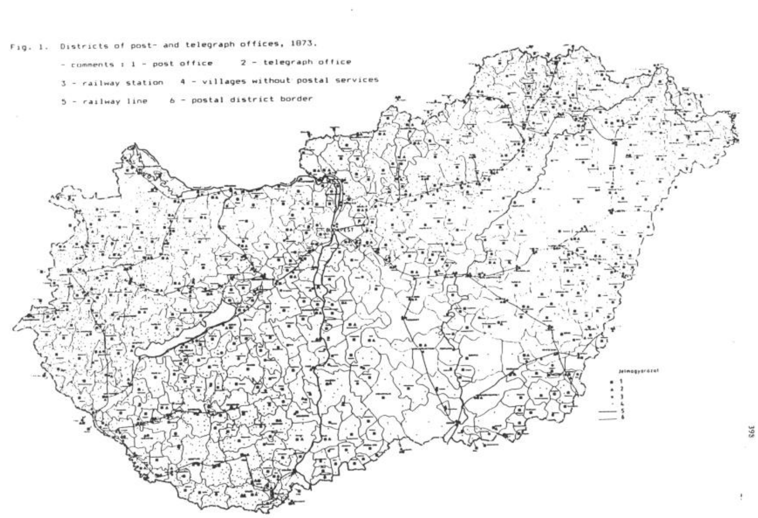


Figure 5: Map of Districts of post and telegraph offices in 1873 (Erdősi, 1992)

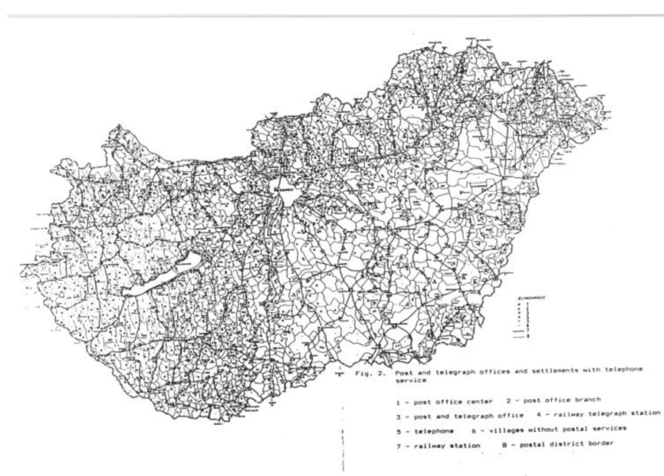


Figure 6: Map of post and telegraph offices and settlements with telephone service (Erdősi, 1992)

Progressing of the projects released during the last decencies

Hungary features a combination of public and private broadcasters, both of which are subsidized by the government. The digital transition in Hungary has been postponed until the end of 2014 (Hungary). There are 35 high-power repeaters and 161 low-power repeaters in 1995. 36 or 36 is the calling code. The international telephone prefix is 00 or +. 3.0 million lines in use, ranking 51st in the world (2012). Mobile network: 11.6 million lines, ranked 72nd worldwide, with 117 lines per 100 people (2012). Telephone system: upgraded and capable of meeting all telecommunication service needs; digitized and highly automated system; trunk services are delivered by fiber-optic cable and digital microwave radio relay; Since 2000, competition among mobile network service providers has resulted in fast growth in the use of mobile phones and a drop in the number of fixed-line connections; fiber-optic cable links with all surrounding countries; the international switch is in Budapest (2011). The domain name at the top level: .hu

* Satellite earth stations: 2 Intelsat (The Atlantic Ocean and Indian Ocean regions), 1 Inmarsat, 1 VSAT (2011)

Users of the internet: 72 percent of the population, 45th in the world (2012); 7.2 million users, 47th in the world; with 6.2 million users, it is ranked 41st in the globe (2009). Hosts on the Internet: 3.1 million, ranking 33rd in the globe (2012). IPv4: 5.5 million addresses allocated, accounting for 0.1 percent of global addresses, or 550.9 addresses per 1000 people (2012). Fixed broadband: 36th in the world with 2.3 million subscriptions; 22.9 percent of the population, 41stin the globe (2012). ADSL was first introduced in Hungary in 2001, followed by ADSL2+ in late 2005. Broadly speaking, the share of broadband customers and houses connected to the cable television network reveals the same spatial organization. Regional disparities in the development of landline and mobile networks, as well as in the use of devices, have significantly lessened. This is critical because having consistent, quick internet access can help with a variety of jobs (e.g. purchases and the payment of bills and taxes). Working from home, online education, viewing movies, listening to music, and ordering meals have all changed as a result of the Covid-19 epidemic in 2020 and 2021, and the majority of these changes may become a permanent part of our existence (Pál, et al., 2021).

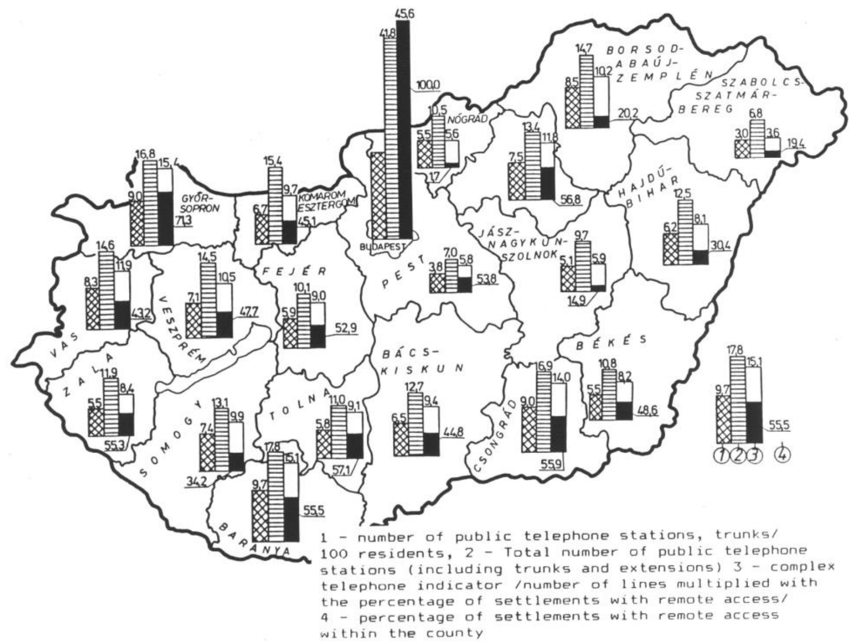


Figure 7: Telephone service indicators in Hungary in 1990 (Erdősi, 1992)

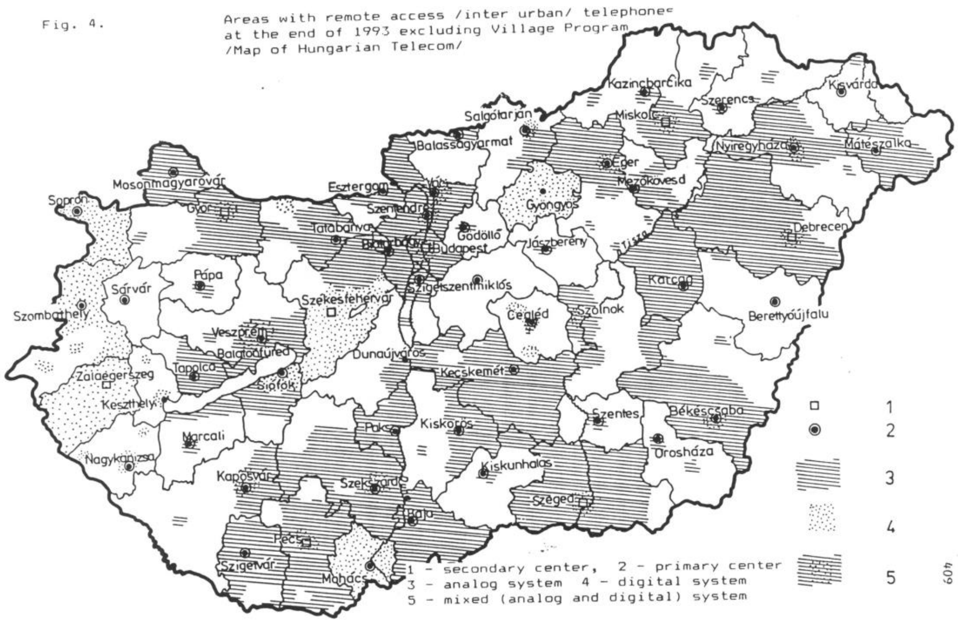


Figure 8: Map of Hungarian Telecom at the end of 1993 (Erdősi, 1992)

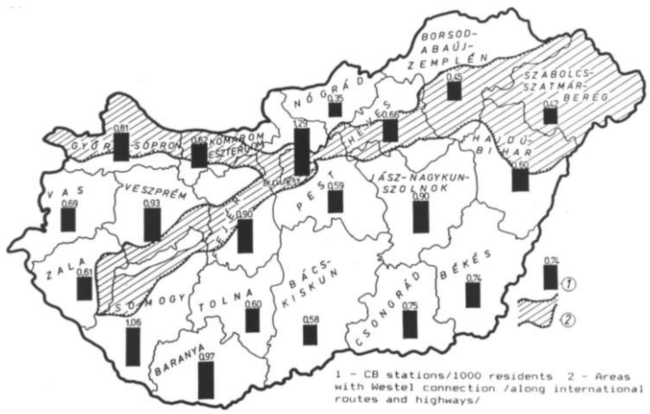


Figure 9: The spatial division of telephones with international call facilities in 1991 (Erdősi, 1992)

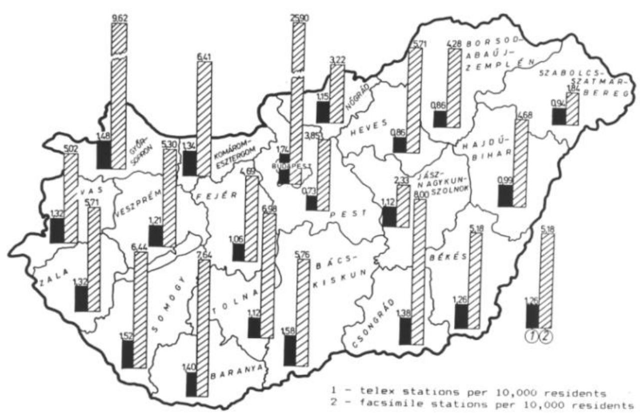


Figure 10: The spatial division of telex and telefax stations in 1991 (Erdősi, 1992)

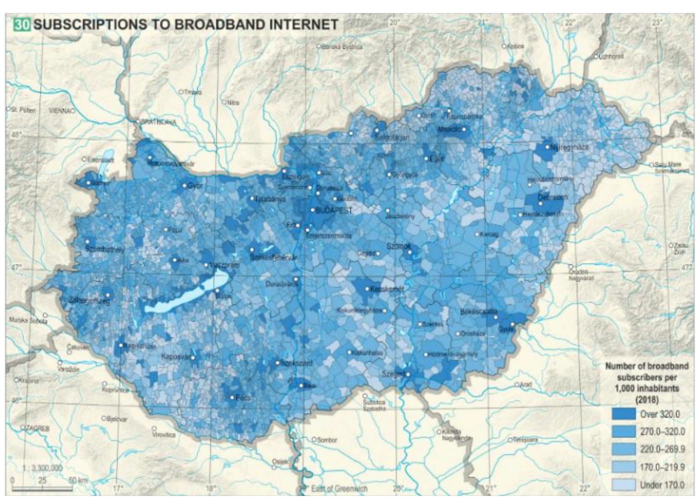


Figure 11: Subscriptions to Broadband Internet in Hungary in 2018 (Pál, et al., 2021)

The different problems intercepted for the development of the quality of the services

1. Censorship and surveillance on the internet

Although Hungary does not have an OpenNet Initiative (ONI) nation profile, the ONI global Internet filtering maps reveal no indication of filtering in any sectors (political, social, conflict/security, and Internet tools). (GLOBAL INTERNET FILTERING MAP). There is no evidence that the government monitors e-mail or chat rooms on the Internet. Individuals and organizations use the Internet, especially e-mail, to peacefully communicate their opinions. (BUREAU OF DEMOCRACY, 2011). The National Media and Infocommunications Authority temporarily restricted access to seven gambling-related websites for three months on July 15, 2014, at the request of Hungary's National Tax and Customs Authority. The Tax and Customs Authority has an up-to-date list of gambling-related websites that have been prohibited. (Tóth, 2014) Freedom of expression and the press are guaranteed by the constitution and the law, and the government generally upholds these rights in practice. Arbitrary interference with private, family, home, or correspondence is prohibited under the constitution and law, and the government generally adheres to these prohibitions in reality. Provisions of the new media rules demanding fair reporting and registration of media outlets lacked defined limitations, according to European Commissioner Kroes, NGOs, and the international press, and might be interpreted to encompass blogs. Because blogs are not considered "commercial endeavors," the government and the National Media and Infocommunication Authority (NMHH) contended that they would be excluded from these rules in practice.

2. Protests and an Internet tax

Thousands of Hungarians demonstrated in Budapest in October 2014 against a proposed new tax on Internet data transfers, which they claimed would not only increase the tax burden but also restrict fundamental democratic rights and freedoms. The draft tax plan includes a clause that requires Internet providers to pay a tax of 150 forints (60 cents) per gigabyte of data traffic; however, it also allows corporations to deduct the new fee from their corporate income tax. (Staff, 2014) An estimated 100,000 Hungarians marched in protest of the internet data fee on October 29, 2014 (Day, 2014)"The internet tax is a symbol of the government's oppression," said internet developer Zsolt Varady to the marchers…

Not only do we need to defeat the tax, but we also need to believe that we can criticize and influence the government." "This is limiting free access to the Internet and information...It is an attempt to erect a digital iron curtain around Hungary," said Balazs Gulyas, a former socialist party member, and critic of the tax who prompted the week of growing protests from Facebook. Zoltan Kovacs, a government representative, denied that the tax was intended to stifle debate not controlled by the ruling Fidesz party (LYMANOCT, 2014).

The different operator companies working in the telecommunication sector

Hungary's Telecommunications Market

Hungary's telecom regulator has completed the multi-spectrum 5G auction.

Hungary has a well-developed telecom infrastructure, with operators focusing on developing 5G and upgrading fixed networks to deliver 1Gb/s service. The January 2021 multi-spectrum auction for spectrum in the 900MHz and 1800MHz bands has paved the way for 5G services. After failing to gain spectrum, Digi Mobile's parent firm decided to sell the company to 4iG.

Fixed-line users are migrating to the mobile platform for voice and data services, as they are in many other markets in the area. As a result, operators have turned to packaged packages to increase revenue and keep subscribers. Vodafone Group was able to buy UPC Hungary in mid-2019 as a result of this strategy.

With an enormous cable network competing against DSL services and a thriving and constantly increasing fiber sector, the broadband market enjoys effective infrastructure-based competition. The regulator has also implemented a variety of measures aimed at increasing market competition, such as encouraging operators to invest in technology updates and pushing for faster platforms. Hungary now has the highest fixed broadband penetration rate in Eastern Europe as a result of this. Maygar Telekom, the incumbent carrier, had offered a 1 Gb/s service to around 2.5 million premises across the country by the beginning of 2021. Superfast broadband connections (those with speeds greater than 30 megabits per second) accounted for 78 percent of all fixed broadband connections.

Four mobile network operators (MNOs) and a limited number of mobile virtual network operators (MVNOs) serve the dynamic mobile market. Mobile adoption in the region is relatively high, and mobile broadband services offered through enhanced networks continue to increase rapidly. Operators are focusing their revenue growth on mobile data as they battle competition, regulated tariff reductions, and MTR reductions.

Maygar Telekom is in the vanguard of 5G development, with assistance from the Hungarian 5G Coalition, which includes the government, universities, other telecoms, and vendors. By March 2021, Vodafone Hungary had installed over 300 5G base stations in Budapest and its environs, as well as many other cities.

This report (Lancaster, 2021)gives an overview of Hungary's telecoms sector, focusing on legislative trends, key operators, fixed-line network infrastructure, and a variety of statistics. The mobile voice and data sectors are also covered in the report, which includes a review of legislation and operator strategy for embracing new technology. The paper also examines the fixed and wireless broadband markets, providing market analysis, statistics, and subscriber predictions through 2024.

The Covid-19 pandemic continues to have a substantial impact on the telecoms sector, according to BuddeComm. On the consumer side, the financial impact of large-scale job losses and the resulting constraint on disposable incomes is putting downward pressure on spending on telecom services and gadgets. However, the importance of telecom services as a tool for both general communication and home-working has alleviated such demands. The net consequence has been lower (and even negative) subscriber growth in several markets, which will continue beyond 2021.

In other nations, development toward 5G could be postponed or impeded.

The importance of telecom services, both for general communication and as a tool for home-working, will, however, counteract such pressures. The net effect should be a steady but slower increase in subscriber growth in many markets.

Although it is difficult to foresee and assess the long-term effects of the crisis as it unfolds, the industry forecasts included in this report reflect this.

The research also looks at how telecom companies, government organizations, and regulators are responding to the issue to ensure that citizens may continue to make the most use of communication services. Subsidies and the development of telehealth and remote education, among other alternatives, reflect this. Digi Communications sells Digi Hungary and its subsidiaries to 4iG, an ICT developer; the 900/1800MHz spectrum auction is completed, and an IoT-based smart agricultural service is introduced on farms.

Utility tax changes favor superfast broadband network rollouts; FttX customer base hits 1.03 million; Maygar Telecom expands its e-health projects;

The report has been updated to incorporate market data from the regulator up to February 2021, financial and operating data from telcos up to Q4 2020, Telecom Maturity Index charts and analyses, and recent market events.

Figure 12: ICT Sector in Hungary (hipa-ict-in-hungary, 2018_09_20)

1. MAGYAR TELEKOM

Magyar Telekom Nyrt., founded in 1991, is Hungary's and Macedonia's primary telecommunications operator. It provides a comprehensive set of telecommunications and information technology (ICT) services, including fixed and mobile telephone, data transfer, and non-voice, as well as IT and systems integration. Magyar Telekom Nyrt is a Hungarian telecommunications firm (formally Magyar Telekom Távközlési Nyilvánosan Mköd Részvénytárság, lit. 'Hungarian Telecom Telecommunications Public Limited Company'). Deutsche Telekom owns the company (59% of shares). Matáv (Magyar Távközlési Rt. - Hungarian Telecommunications PLC) was the company's previous name until May 6, 2005. In December 1989, when Magyar Posta (Hungarian Post) was separated into three distinct enterprises, Magyar Távközlési Vállalat (Hungarian Telecommunications Enterprise) was founded. The corporation was restructured as a public limited company, Magyar Távközlési Rt., on December 31, 1991, and it remained wholly owned by the government until the end of 1993. The Telecommunications Act, which became effective on July 1, 1993, allowed the corporation to be privatized. Between Deutsche Bank and a group of investors, a consortium has been formed. MagyarCom, a joint venture between Deutsche Telekom and Ameritech, purchased a 30.1 percent stake in the company for $875 million. The number of employees is 10,870 (2014)

T-Home for home services, T-Mobile for mobile communications, and T-Systems for corporate services are the three brands operated by Magyar Telekom. Makedonski Telekom, Macedonia's leading fixed-line and mobile provider, Crnogorski Telekom, Montenegro's leading telecommunications operator, Novatel Bulgaria, and Romania's Cambridge are among the international member firms managed by Magyar Telekom. 30 is the calling code.

Telekom was the first telecoms carrier in Hungary to introduce a 4G/LTE-based mobile Internet service on January 1, 2012, providing full outdoor 4G coverage of Budapest and 4G mobile internet to over 27% of the population.

T-Systems Hungary launched an online ticketing service for BKK, Budapest's unified transportation provider, in July 2017. Multiple security flaws were purportedly found in the program. T-Systems Hungary notified the police about internet attacks on the application. An 18-year-old student reported a serious problem to BKK and was later held by police in the middle of the night, generating a public outcry when it was revealed that the detention was ordered following the T-Systems complaint.

Headquarter: Budapest, Könyves Kálmán krt. 36, 1097

Official Website: https://www.telekom.hu/lakossagi

Coverage Map: https://www.telekom.hu/lakossagi/english/customer-centre/coverage

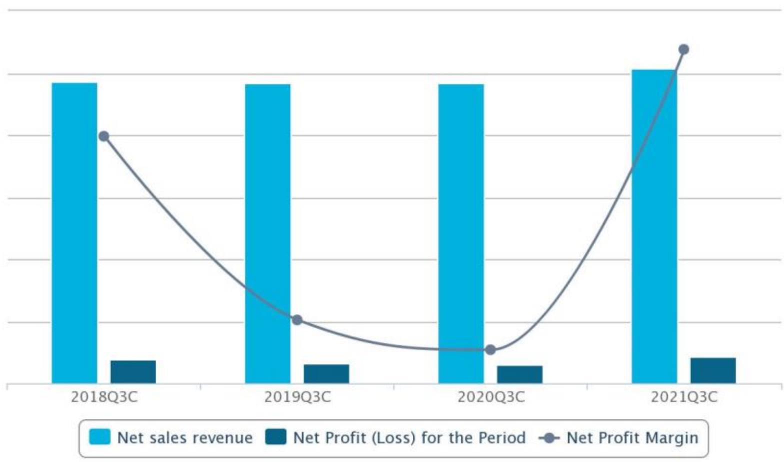


Figure 13: Magyar Telekom Performance from 2018 to 2021 (EMIS)

Annual growth percentages for latest two years in local currency HUF. Absolute financial data is included in the purchased report.

Net sales revenue	4.62%▲
Total operating revenue	4.69%▲
Operating profit (EBIT)	14.01%▲
EBITDA	7.7%▲
Net Profit (Loss) for the Period	44.99%▲
Total assets	5.64%▲
Total equity	4.68%▲
Operating Profit Margin (ROS)	1.1%▲
Net Profit Margin	2.42%▲
Return on Equity (ROE)	1.82%▲
Debt to Equity Ratio	4.67%▲
Quick Ratio	0.12%▲
Cash Ratio	0.01%▲

Figure 14: Magyar Telekom Key Financial Highlights (EMIS)

2. YETTEL MAGYARORSZAG ZRT. (HUNGARY)

Yettel (formerly Telenor, Pannon, and Pannon GSM), a Norwegian telecommunications corporation, is Hungary's second-largest mobile phone company. Wireless telephony and mobile internet services are the company's main activities. The Telenor Group owns the business.

Yettel Hungary Ltd. was established in 1994 as Pannon GSM Telecommunications Ltd.

Pannon GSM Telecommunications Ltd. signed a concession deal in November 1993 and began operating on the 900 MHz frequency in March the following year. The firm was awarded the 1800 MHz frequency in a tender in 1999. It began operating on the 1800 MHz frequency in Budapest in November 2000, then the entire country in March 2001.

99 percent of Hungary is covered by the network. The company employs 1,060 individuals and has 13 switching centers with around 1500 base stations. In 2001, the company made HUF 132.8 billion in revenue and HUF 18.7 billion in profit before taxes.

On January 31, 2003, the company had 2,627,000 users, accounting for 40% of the Hungarian mobile market at the time, which was split between three competitors.

The company's main brand was changed to Pannon on February 14, 2006, and its visual appearance was revised to match the new corporate identity of its parent, Telenor. The corporation changed its name to Telenor on May 18, 2010.

The company's management verified media reports in January 2018 that there is interest in selling Telenor's Southeast European operations, including Telenor Hungary.

Telenor sold its Southeast European business (Bulgaria, Hungary, Montenegro, and Serbia) to the investment fund PPF in March 2018 for 2.8 billion euros.

Telenor announced in January 2022 that on March 1, 2022, they would change their name to Yettel.

Yettel's IMSI - Network Code is 216-1, and its MSISDN Network Code is 20 (international: +36 20).

Yettel's display name is Yettel HU.

Headquarter: Pannon út 1, Törökbálint, 2045

Official Website: https://www.yettel.hu/

Coverage Map: https://www.yettel.hu/halozat#lefedettseg-terkep

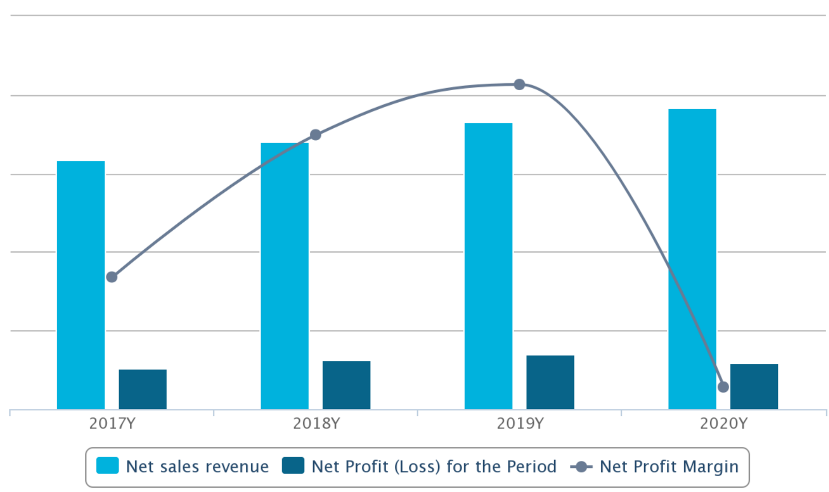


Figure 15: Yettel Hungary Performance from 2017 to 2020 (EMIS)

Annual growth percentages for latest two years in local currency HUF. Absolute financial data is included in the purchased report.

Net sales revenue	5.1%▲
Total operating revenue	3.57%▲
Operating profit (EBIT)	-14.06%▼
EBITDA	-15.07%▼
Net Profit (Loss) for the Period	-16.06%▼
Total assets	-4.94%▼
Total equity	-34.38%▼
Operating Profit Margin (ROS)	-3.88%▼
Net Profit Margin	-3.85%▼
Return on Equity (ROE)	10.33%▲
Quick Ratio	-0.03%▼
Cash Ratio	-0.03%▼

Figure 16: Yettel Hungary Key Financial Highlights (EMIS)

3. VODAFONE MAGYARORSZAG ZRT. (HUNGARY)

Wireless telecommunications, phone services, and mobile internet services are the company's major activities. Vodafone Europe B.V. owns 100% of the company.

Vodafone is Hungary's third-largest mobile network operator. It began operations in 1999 after obtaining Hungary's third GSM 900/1800 MHz license and it was the country's first DCS-1800 service provider. In 2020Q2, the operator had a market share of 27 percent. In December 2019, they owned roughly 27% of the market. Wireless telecommunications, phone services, and mobile internet services are the company's major activities. Vodafone Europe B.V. owns 100% of the company.

Vodafone Hungary's MCC-MNC Code is 216-70, and its Mobile Network Code is 70 (international: +36 70).

Vodafone Hungary's display name is Vodafone HU.

Vodafone has a 900/1800 MHz GSM, GPRS, and EDGE network, as well as a 900/2100 MHz HSDPA+ network. The company has over 2600 active Base Transceiver Stations (BTS), with the entire network capable of LTE transmission thanks to a 2011 upgrade. In May 2012, the GSM network reached 98.6% of Hungary, while the 3G network covered 90.1 percent.

Vodafone inked a sponsorship agreement with the Hungarian Water Polo Association and Tamás Kásás in October 2007. When the sponsorship agreement was extended for another four years in 2009, Vodafone Hungary became the Association's principal sponsor.

In 2013, the Vodafone Group was the primary sponsor of the McLaren Mercedes Formula One team, which was previously known as McLaren. In 2010, Vodafone established Europe's first Vodafone McLaren Mercedes store in Budapest. During the 2010 Hungarian Grand Prix, Vodafone also made it feasible for the Pick Szeged emblem to be placed on the McLaren Formula 1 vehicles.

On May 1, 2012, Vodafone brought Formula One racing to Budapest's streets. As part of Vodafone Hungary's 'Raise your game' weekend, Jenson Button demonstrated what it's like to drive at 172 mph on a downtown avenue.

Vodafone Hungary was the major sponsor of the Sziget Festival from 2010 to 2011.

Between 2021 and 2022, The UEFA Europa Conference League's main sponsor was Vodafone.

Headquarter: Lechner Ödön fasor 6 Budapest 1096

Official Website: https://www.vodafone.hu/magyar

Coverage Map: https://www.vodafone.hu/english/coverage

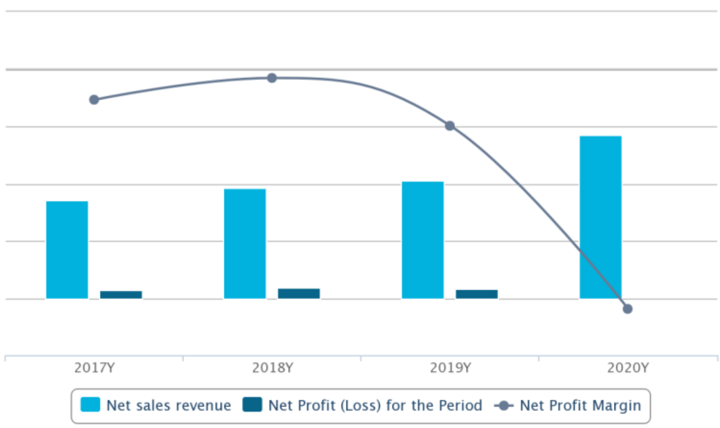


Figure 17: Vodafone Hungary Performance from 2017 to 2020 (EMIS)

Annual growth percentages for latest two years in local currency HUF. Absolute financial data is included in the purchased report.

Net sales revenue	38.4%▲
Total operating revenue	33.62%▲
Operating profit (EBIT)	-58.35%▼
EBITDA	42.21%▲
Net Profit (Loss) for the Period	N/A
Total assets	40.72%▲
Total equity	-7.24%▼
Operating Profit Margin (ROS)	-5.8%▼
Net Profit Margin	N/A
Return on Equity (ROE)	N/A
Quick Ratio	-0.7%▼
Cash Ratio	0.04%▲

Figure 18: Vodafone Hungary Key Financial Highlights (EMIS)

4. DIGI TAVKOZLESI ES SZOLGALTATO KFT. (HUNGARY)

In Central Europe, the DIGI group, formerly RCS and RDS, is a Romanian telecommunications holding company with operations in Romania, Hungary, Spain, and Italy, is a significant telecommunications business. In Hungary, the Czech Republic, Croatia, Romania, Serbia, and Slovakia, the company is very important. The group's Hungarian affiliate, DIGI Kft, was created in 2000. Cable television, internet, and telephone services are among the company's offerings. Digi was formed by majority owner Zoltán Teszári and has been listed on the Bucharest Stock Exchange since May 16, 2017. The mobile phone service was revived in 2014, and 4G service was provided in 2015. Digi purchased the Invitel cable provider in Hungary in 2017. It was approved in May 2018 but was revoked in November 2018 after non-competitive issues were discovered in specific locations. These issues were resolved, and the deal was closed in March 2020.

New mobile tenders were announced by the National Communications Authority in October 2008 to increase competition in the telephone and internet markets. DIGI has also filed a patent application, mostly for the 450 MHz frequency. DIGI appeared to have the finest deal, with the business providing the mobile service as soon as April 2009 - which, according to press sources, seemed doubtful. NHH suddenly stated in April 2009 that it will not be the fourth mobile operator. The authority alluded to the current economic situation. Digi won a 10 MHz (2x5 MHz FDD) frequency block in the 1800 MHz frequency range in another frequency competition that ended in September 2014. As a result, the DigiMobil service was introduced on May 27, 2019, and will remain in beta testing until December 31, 2020. In Hungary, it had 511,000 customers. The number of customers climbed to 1.1 million with the acquisition of Invitel. On its network with the area code +3650.

The monthly subscription fee was HUF 0 during the test period, and calls and SMS within the network are also free. In other domestic directions, a fee of HUF 5 / minute and a fee of HUF 21 / SMS had to be paid, MMS service is not available. The mobile internet service became unlimited from 4 July 2019. The Digi prefix is 0650 and number portability is possible. From July 26, 2019, the roaming service became also available. From September 2019, the network became available on the M2 and M3 metro lines. RCS & RDS announced on March 29, 2021, that they would sell the whole Hungarian DIGI group of enterprises (DIGI Kft., Invitel Zrt. And ITV Zrt.). 4iG Plc. a subsidiary of Antenna Hungária is the buyer..

Current information can be found here: https://digi.hu/mobil

Headquarter: Váci út 35 Budapest 1047

Coverage Map: https://digi.hu/mobil/lefedettseg

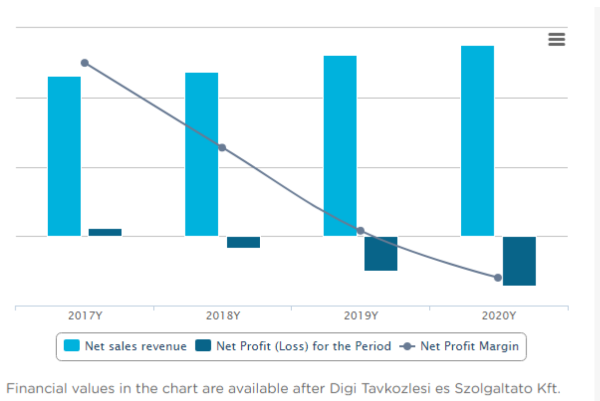


Figure 19: DIGI Hungary Performance from 2017 to 2020 (EMIS)

Annual growth percentages for latest two years in local currency HUF. Absolute financial data is included in the purchased report.

Net sales revenue	5.5%▲
Total operating revenue	4.67%▲
Operating profit (EBIT)	-11.46%▼
EBITDA	-41.11%▼
Net Profit (Loss) for the Period	-42.66%▼
Total assets	1.1%▲
Total equity	-62.86%▼
Operating Profit Margin (ROS)	-0.71%▼
Net Profit Margin	-6.77%▼
Return on Equity (ROE)	-143.19%▼
Debt to Equity Ratio	-46.73%▼
Quick Ratio	-0.04%▼
Cash Ratio	-0%

Figure 20: DIGI Hungary Key Financial Highlights (EMIS)

2. Methodology

Geographic Information System (GIS)

Introduction:

It's a database management system for gathering, storing, managing, manipulating, transforming, analyzing, modifying, displaying, and mapping geographically referenced data. We wish to create the data that will assist decision-makers in resolving complicated management and planning difficulties. A Geographic Information System (GIS) is a computerized instrument (app for smartphones, software for laptops, etc.) that may process geographical data and contribute to the management of territories. The approach of multiple disciplines is favored in this notion. The study of complicated systems that integrate a large amount of data from various sources and formats.

The following five functions are fulfilled by a GIS:

1. Abstraction: this is the modeling of data.
2. Acquisition: this is the retrieval of existing data and feeding of the data system.
3. Archiving: storing data in a format that allows it to be easily integrated.
4. Analyze: request-response and data integration in a GIS
5. Display: This is the graphic reconstruction used to make topographic, thematic, and geographical maps...

Fields of application:

GIS is used to manage and research a wide range of phenomena and resources, including:

a- Natural resources:

- Wetland protection
- Environmental impact assessment
- Groundwater modeling
- Mine search

b- Urban networks:

- Transportation planning
- Evacuation plan development
- Accident location...

c- Municipal administration

- Land registry management
- Layout plan...

d- Installation management:

- Cable and pipe location on land
- Energy cost location (air conditioner, region, messages, etc.)

e- Commerce:

- Examine market structures
- Plan development...

f- Health:

- Epidemiology
- Disease and Famine Distribution and Evolution
- Health-care center distribution (hospital, social health services, etc.)

g- Environmental protection:

- Global change research, followed by climate change research...

In a very tangible way, a GIS will be able to answer a question, with the response effectively taking the form of a map (geographically localized information). GIS comes to reply to a well-defined problem and strives to respond to reality as faithfully as possible. It is most commonly used in geoinformatics or geomatics fields.

Data types:

➢ There are two types of them.

a- Data in the form of vectors:

Geographical objects can be represented spatially utilizing vector and localized data. They are made up of three different sorts of entities: points, polylines, and polygons. Roads, departments, parcels, and so forth are examples of geographical objects. A road is made up of a series of polylines. A department is a collection of connected polygons. Plans or theme layers are used to arrange vector data. It's frequently fascinating to see how each plan corresponds to a specific topic (road plan, land use plan, etc.). A geometric shape and an attribute make up the feature.

Digitization of map pieces and photo interpretation on the screen are examples of this type of source. Vector-type digital data is imported from another system (software or an external database, such as the Internet). The data is alphanumeric, which means that the table properties contain characters.

b- Raster data is also known as mesh or matrix data.

They are situated in the center of the meshes of a regular grid and give timely information. This data is a summary of the values that have been recorded or calculated for each mesh. The mesh size is the same as the resolution of the system. These are photos (scanned plans, aerial photographs, satellite images, maps, etc.) Satellites are connected to them (accuracy determined by pixels). The information comes in the form of numeric attributes.

The data was processed in the geographic information software QGIS (v3.14.15)

HTML language and Web GIS:

The Web page was created by HTML5 supported by CSS for the style and JavaScript for some interactive functions. Besides, the layers were created by leaflet using QGIS software. HTML is the abbreviation for Hyper Text Markup Language which is used to create web pages. The structure of a Web page is described in HTML. It is made up of several different elements. HTML components specify how the content should be displayed in the browser. They are used to identify different types of information, such as "this is a heading," "this is a paragraph," "this is a link," and so on. HTML files usually have the .html or .htm extension. This is a text file format; to edit an HTML page one only needs a plain text editor. HTML5 is a World Wide Web Consortium (W3C) suggestion for the fifth and final major HTML version. It was originally made available to the general public on January 22, 2008, with a major update and "W3C Recommendation" designation following in October 2014. HTML5 introduces markup and Application Programming Interfaces (APIs) for complex online applications, as well as detailed processing models to encourage more compatible implementations. It also extends, enhances, and rationalizes the markup accessible for documents. The language we use to style an HTML document is CSS (Cascading Style Sheets). It specifies how HTML elements should appear. CSS is a set of rules. A rule is made up of two parts: a selector that specifies which elements the rule applies to, and one or more key: value pairs (separated by semicolons) that describe the styling. JavaScript is the most widely used programming language on the planet. It is the Web's programming language. HTML documents can contain JavaScript code (Attaching code from a separate file, embedding code with a Script node, as event handlers of HTML elements, as the URL of a link...).The leaflet is a well-known open-source Javascript library for creating web mapping apps. The qgis2leaf plugin makes it simple to convert a QGIS map into a leaflet-based web map. This plugin can help to get started with web mapping by allowing the creation of an interactive web map from static GIS data layers.

```html
          <div class="logo">
            <a href="index.html"><img src="images/logo.png" alt="#" /></a>
          </div>
        </div>
      </div>
    </div>
    <div class="col-xl-9 col-lg-9 col-md-9 col-sm-9">
      <nav class="navigation navbar navbar-expand-md navbar-dark ">
        <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarsExample04" aria-controls="navbarsExample04" ari
        <span class="navbar-toggler-icon"></span>
        </button>
        <div class="collapse navbar-collapse" id="navbarsExample04">
          <ul class="navbar-nav mr-auto">
            <li class="nav-item active">
              <a class="nav-link" href="index.html">Introduction</a>
            </li>
            <li class="nav-item">
              <a class="nav-link" href="about.html">About</a>
            </li>
            <li class="nav-item">
              <a class="nav-link" href="Telephone lines.html">Telephone lines</a>
            </li>
            <li class="nav-item">
              <a class="nav-link" href="Internet.html">Internet</a>
            </li>


          </ul>
        </div>
      </nav>
    </div>
  </div>
```

Figure 21: Structure of the main page

Thematic aspect

Used graphic methods of data visualization for creating the maps:

Choropleth maps: much often used. Optimal for expressing only quantity for area type map object (enumeration is a reference area) where quantities don't have exact locations, but, we communicate in aggregate numbers of map objects above enumeration area. They have the different forms:

- Statistical areas: administrative units (Nomenclature of territorial units for statistics (European Union): NUTS1, NUTS2, NUTS3…Local differences can be presented ➔best using homogeneous distributions.
- Geographical areas: Natural characteristics (not randomly): agriculture topics…
- Geometric areas: Triangle/Square network to gather data for a very special survey (slope/angle/declination➔geomorphological maps).

Diagrams: used for quantity, point, and area type map objects. It is a detailed representation. For point type, diagrams behave as symbols in the Choropleth maps➔quantitative components. The chart must be measurable. The estimation or the exact values. I used a simple bar chart and pie chart in my maps.

- The pie chart represents totals according to range grading. They are linked to settlements (center of the pie chart) to compare some values. The size of the pie chart may be different depending on the total value (can be range grading). If there is only one data, we cannot use a pie chart pattern. (Because it is expressed in %).
- The bar chart is a good solution to show components when the data are not relative (we don't have the total), for example comparing over time.

Used methods of data classification (intervals) for creating the maps:

Natural breaks (Jenks): natural intervals are commonly used in most cases; we have split gaps in values (missing numbers): natural concentrating of data along "breaks" or "splits**".** Its goals:

- Concentrate similar values as much as possible
- Isolate groups of values as much as possible

➔Maximum homogeneity in the groups (values are close to each other)

<u>Advantage:</u> Based on the values of variables.

<u>Disadvantage:</u> Intervals are subjective, not always obvious not easy in large databases.

Equal intervals: The same value ranges, differences in every data group (1-10, 11-20, 21-30…). The number of elements may vary largely within the groups (frequency). There cannot be a group with no element.

<u>Advantage:</u> very easy to understand and calculate (not always) rows of data in legend is continuous (not interrupted).

<u>Disadvantage:</u> does not take into account the dispersion of the data.

Equal frequency/count (Quantile): Each group contains the same number of data. There cannot be a group with no element. Quantile (5 groups: 20% of the data per group)

Advantage: Can be used for ordinal data, easy to create and understand.

Disadvantage: the interval of each category can vary widely.

Database recourses

The database contains information that is utilized to create various network models. The database is made up of the following sorts of information: equipment type and data, transmission line cost models, data from nodes (demand termination and transmission points), topology, grouping levels, grouping rules, and routing rules. (L. Jereb, 1994)

The data set is downloaded from different resources and they were mostly in table format and combined and processed to be ready for the analysis. The shapefile of the different administrative units (Regions, Counties, Districts, and Settlements) were digitalized from Open Street Map website. The shapefile of the countries, roads, railways, rivers, graticules… from Natural earth website large scale. The main dataset (population, internet, telephone …) was obtained from the official website of the Hungarian Central Statistical Office in table format where there are more detailed explanations about the different parameters related to our topic (Figure 22). Note that we tried to get more databases about the network coverage from the concerned companies; however, we got informed that they are confidential data that needs permission and a long time; therefore, we just used extracts of the maps available on their official websites.

	NAME	Population	ons, through cable	LAN, leased lines,	otions, through xD	iptions per thousa	f internet subscrip	e lines per thousar	in lines switched t	iber of other main	nber of main lines	of telephone main	nain lines differenc	public
1	Alsózsolca	213	0	2	12	225.5	1252	225.5	947	5	952	1135	-183	
2	Arnót	132	0	0	294	280.4	648	280.4	457	2	459	528	-69	
3	Berzék	107	173	40	4	192.2	217	192.2	110	0	110	169	-59	
4	Bőcs	105	278	3	6	258.6	662	258.6	749	1	750	604	146	
5	Bükkaranyos	56	0	0	5	229.5	338	229.5	268	0	268	274	-6	
6	Bükkszentkereszt	42	0	0	7	0	451	396	455	2	457	452	5	
7	Emőd	95	296	11	8	265.5	1239	265.5	1214	1	1215	1139	76	
8	Felsőzsolca	387	1243	3	36	293.5	1847	293.5	2040	1	2041	1569	472	
9	Gesztely	87	165	31	186	239.5	600	239.5	496	2	498	519	-21	
10	Harsány	54	0	0	349	176.7	349	176.7	356	0	356	440	-84	
11	Hernádkak	147	77	4	165	232.9	372	232.9	273	3	276	267	9	
12	Hernádnémeti	121	0	32	378	224.8	780	224.8	519	4	523	703	-180	
13	Kisgyőr	22	0	0	7	216.6	342	216.6	282	0	282	386	-104	
14	Kistokaj	240	498	0	134	274.4	643	274.4	455	2	447	430	17	
15	Kondó	30	118	0	21	238.4	139	238.4	82	0	82	133	-51	
16	Köröm	160	145	25	17	140.4	187	140.4	87	0	87	128	-41	
17	Mályi	369	0	11	205	311.5	1295	311.5	1223	3	1226	943	283	
18	Miskolc	637	24064	1540	5324	392.7	59178	392.7	65866	230	66096	58319	7777	
19	Nyékládháza	198	1043	2	243	344.7	1685	344.7	1677	3	1680	1305	375	
20	Onga	155	746	0	28	237.2	1154	237.2	1104	4	1108	975	133	

Figure 22: Database collection (Hungarian Central Statistical Office)

3. The telecommunication network in Miskolc

Geographic presentation of the area of study

Miskolc, a heavy-industry district in northeastern Hungary, is Hungary's fourth-largest city, with a population of 150,695 and many of dwellings of 77,352 in 23,667 hectares as of January 1, 2021 (behind Budapest, Debrecen, and Szeged). It is also the county capital of Borsod-Abaj-Zemplén and northern Hungary's regional center. HCSO code is 30456. The area code is 46. The postal code ranges between 3500 and 3549. A NUT 3 code is HU311. It is 182 km (113 mi) East of Budapest. Coordinates of the city center are 48°06′15″N 20°47′30″E. Its official website in English is https://en.miskolc.hu/. Its official flag is shown in figure 23.

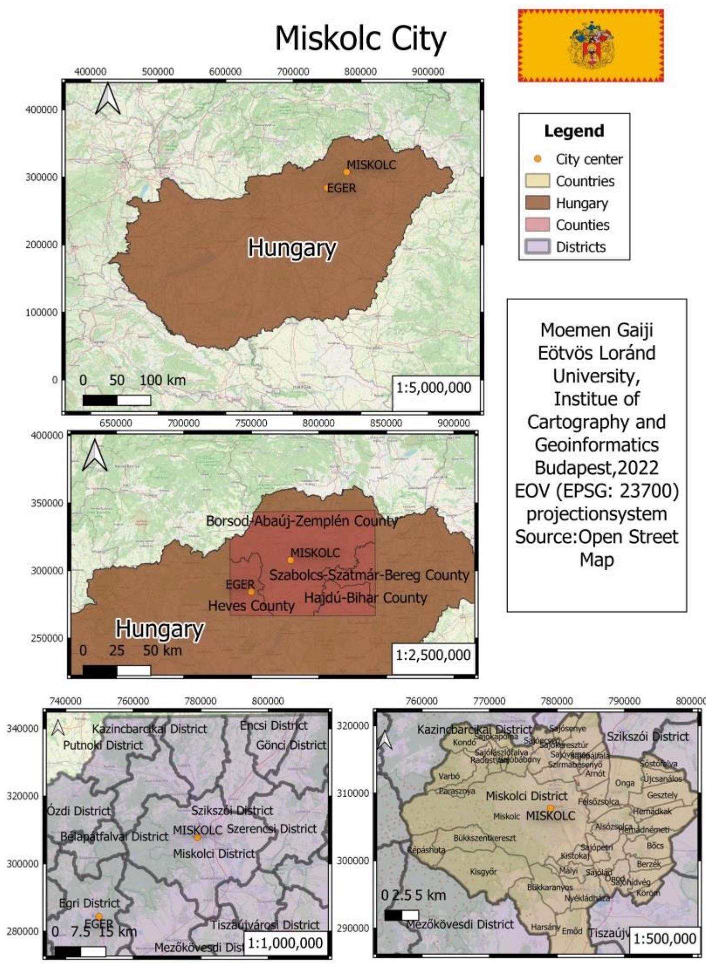


Figure 23: Geographical location of Miskolc

Summers in Miskolc are cool, although they can also be hot and humid. Temperatures of 20–30 °C (68–86 °F) or higher are normal during the day. During the winter, the weather is dominated by snow and ice. Each year, Miskolc receives roughly 120 cm of snowfall. In the winter, days below freezing and nights below 20 °C (4 °F) are both common. The railway station is Miskolc-Tiszai 2.6 km from the city center. Miskolc is crossed by major highway number 71or motorway 3 and a network of railways. It is divided in 39 settlements (Alsózsolca, Arnót, Berzék, Bőcs, Bükkaranyos, Bükkszentkereszt, Emőd, Felsőzsolca, Gesztely, Harsány, Hernádkak, Hernádnémeti, Kisgyőr, Kistokaj, Kondó, Köröm, Mályi, Miskolc, Nyékládháza, Onga, Ónod, Parasznya, Radostyán, Répáshuta, Sajóbábony, Sajóecseg, Sajóhídvég, Sajókápolna, Sajókeresztúr, Sajólád, Sajólászlófalva, Sajópálfala, Sajópetri, Sajósenye, Sajóvámos, Sóstófalva,Szirmabesenyő, Újcsanálos, Varbó) where the most populated is Miskolc (673/km^2) and the least populated is Kisgyőr (22/km^2) in 31st December 2020 (Figure 24).

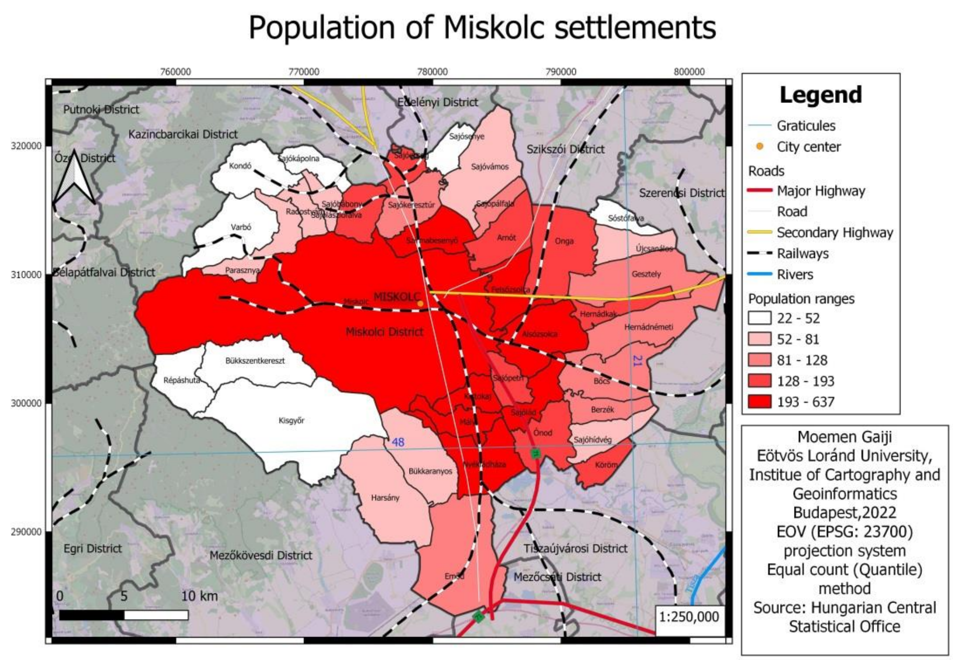
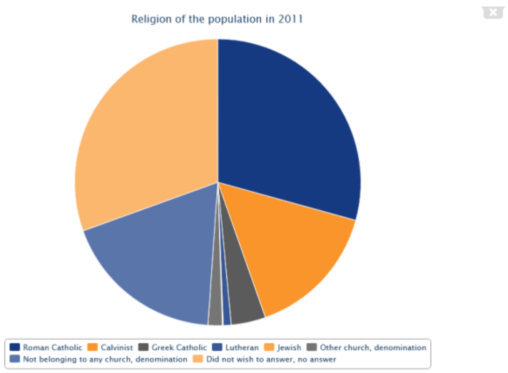


Figure 24: Population distribution in Miskolc in 2020 per km^2

According to Hungarian Central Statistical Office, most of the population is Roman Catholic (29.3%) with a big minority of Calvinists (15.3%), and the majority are Hungarian (84.6%) … in 2011 (Figures 25 and 26).



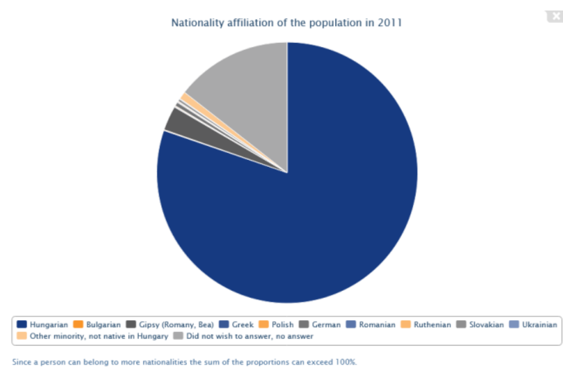


Figure 25: Religion of population 2011 (Hungarian Central Statistical Office)

Figure 26: Nationality affiliation 2011 (Hungarian Central Statistical Office)

Telephone lines network in Miskolc

Analysis of the progression of the fixed telephone services over the time

According to the statistics collected from 2002 to 2014 of the fixed telephone services shown in Figure 27, the total of conventional (analogue) mainlines decreases progressively (approximately 200000 services in 2000 to quite above 150000 in 2014) in parallel with the Residential type. However, the number of ISDN lines showed a peak (maximum value is around 28000 services) in 2004, then decreases again. The other types vary slowly (the approximate average of Business is 20000, of Public, is 1000)

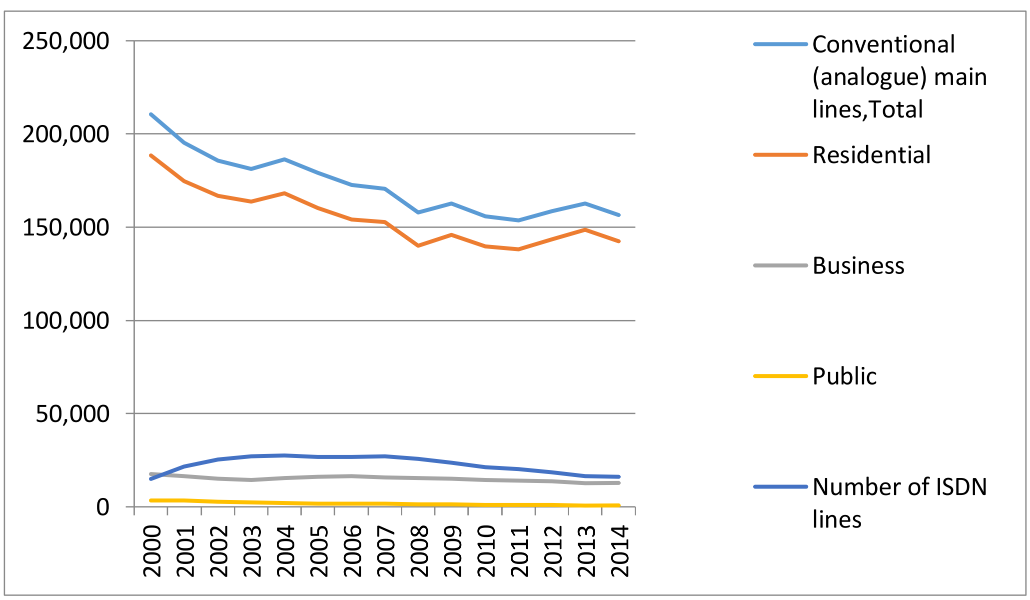


Figure 27: Fixed telephone services by type of subscription in Miskolc 2000_2014

Analysis of the main telephone lines per thousand capita

The main telephone lines per thousand capita_2020 vary from 107 to 396, Ónod and Köröm in the southeast have the lowest values (107- 165) and Nyékládháza, Répáshuta, Miskolc, and Bükkszentkereszt in the west have the highest values (338-396) as shown in Figure 28.

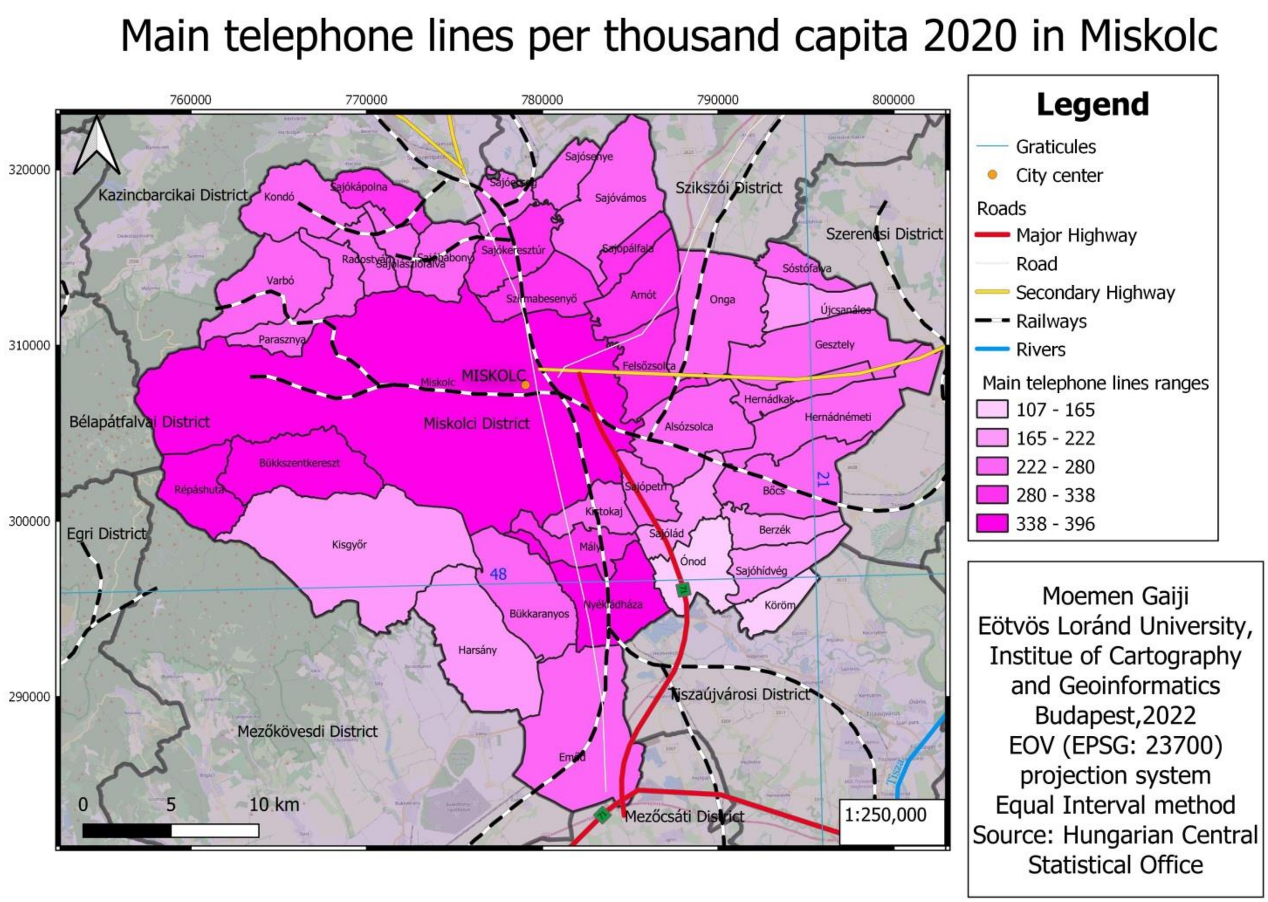


Figure 28: Main telephone lines per thousand capita_2020

Analysis of the number of the public station

In 2014, the total number of public telephone stations (pieces) was 256, the most crowded settlement is Miskolc with 199 stations and most of the western and the northern have a lower number (0 in Sajósenye) than the eastern and southern settlements (ranges between 2 and 4) (see Figure 29)

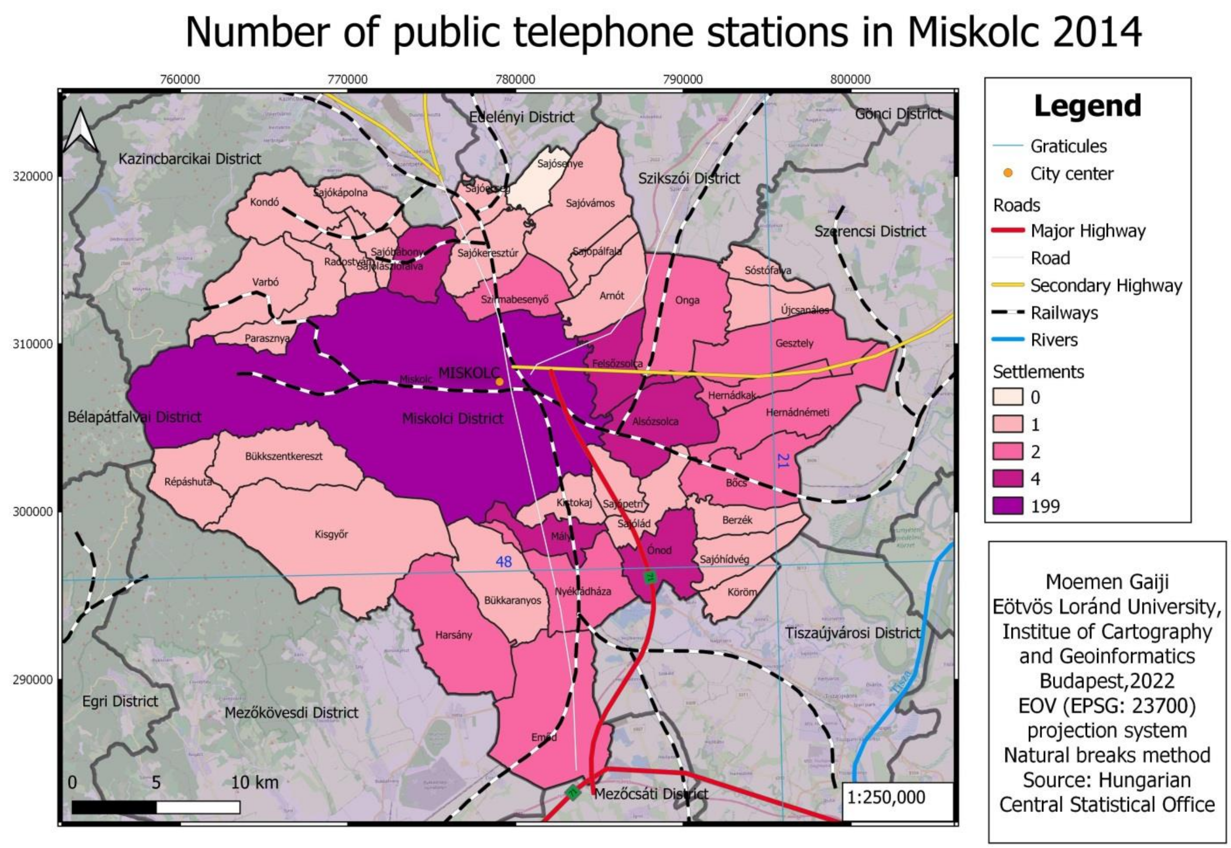


Figure 29: Number of public telephone stations

Analysis of the main telephone lines pieces

The settlement of Miskolc has the biggest number (66096) of the total main telephone lines pieces in 2020, as the number of public telephone stations, the northern and western settlements have lower values (ranges between 0 and 212 or 212 and 523) than the southern and eastern settlements where the values are from 523 to 1226 or from 1226 to 2041 pieces. Concerning the type of the lines, most of them are switched to networks in all of the settlements as shown in Figure 30.

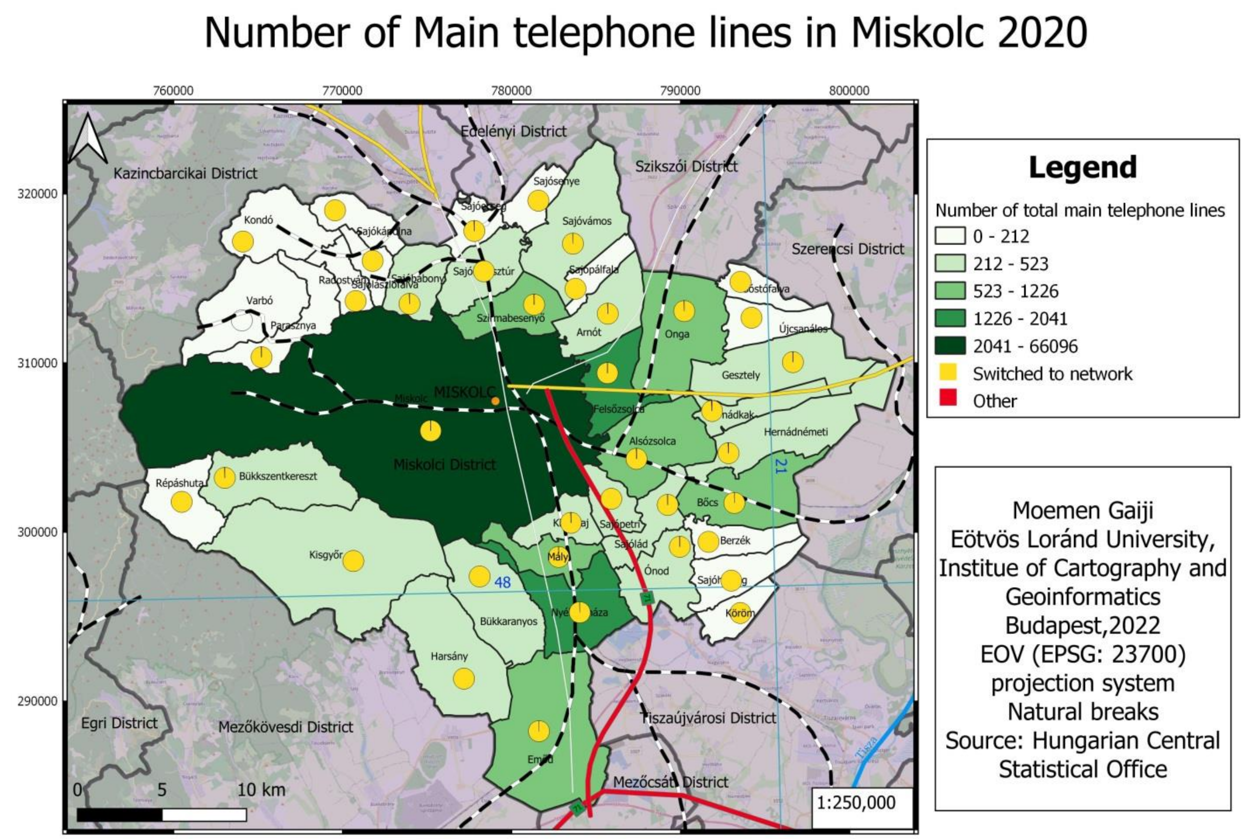


Figure 30: Number of main telephone lines pieces in 2020

Analysis of the change in the number of the main telephone lines over 18 years

In total there are 7206 new main lines from 2002 to 2020. As is shown in Figure 31, Miskolc, Bõcs, Emõd, Felsõzsolca, Mályi, Nyékládháza, Onga… the industry of the main telephone lines shown a development (bar charts show the comparison between 2002 and 2020). In contrast to the other settlements, where this industry has shown a regression due to the decline of the number of main telephone lines over 18 years, especially in Alsózsolca, Hernádnémeti, Kisgyõr, Ónod, Sajóbábony, Sajókeresztúr, Sajólád, and Újcsanálos.

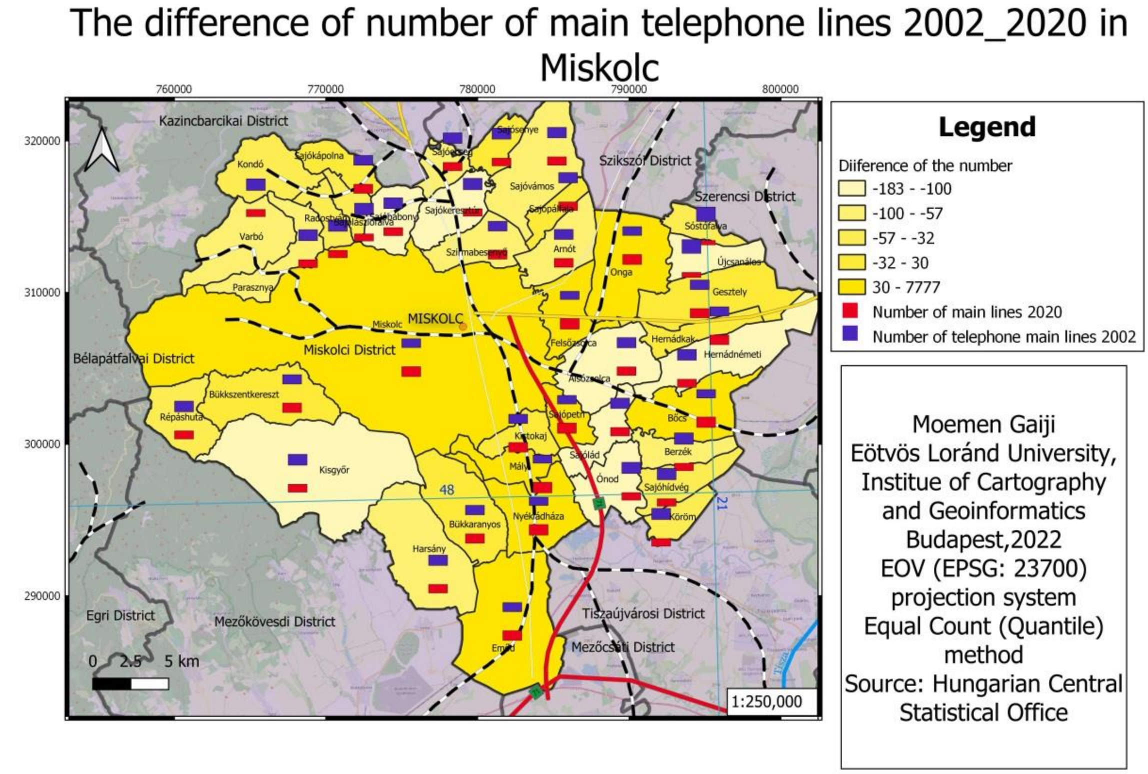


Figure 31: Difference in number of main telephone lines

Conclusion:

First, we notice that the fixed telephone services have been reduced in during the two last decades, due to the decline of the population in Miskolc (Figure 32). The distribution number of public telephone stations and the number of telephone lines (most of them switched to networks) are also influenced by the distribution of the population. The most populated in the southern and eastern parts have the highest values and the city center is the maximum. During the eighteen last years, some localities have shown an obvious development in the number of the main telephone line, especially in the central, the others decreased it. But, the main telephone per thousand capita is higher in some western regions with low populations.

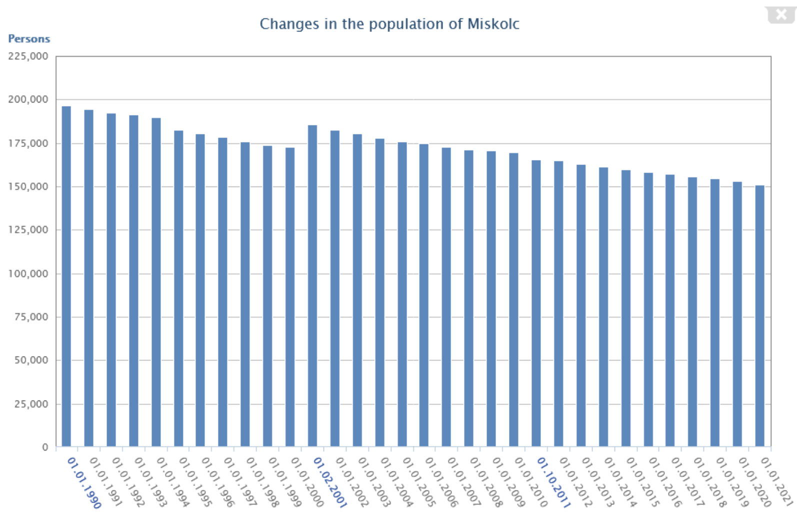


Figure 32: Changes in population in Miskolc

Internet network in Miskolc

Analysis of the number of Internet subscriptions

The last statistics of 2020 shows heterogeneity in the spatial repartition of the number of internet subscription. It seems the most beneficiary area is the city center (59178) than the nearest eastern and southern regions (780-1847). But the western regions (0-217) are fewer beneficiaries (Figure 33).

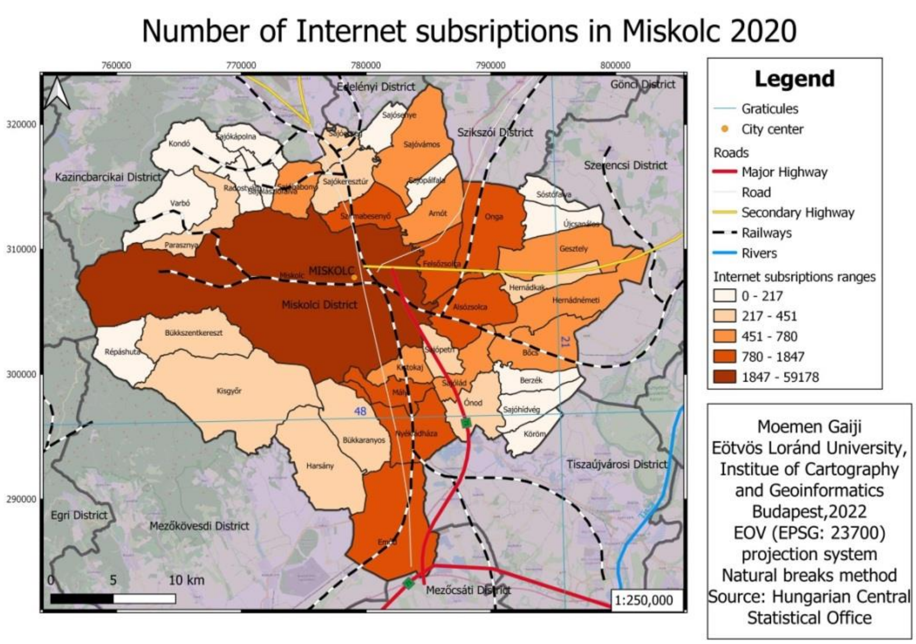


Figure 33: Number of internet subscription

Analysis of the type of Internet subscriptions

In Figure 34, we can see that the number of internet subscriptions per thousand capita in 2020 ranges between 314 and 393 in Miskolc, Répáshuta, Nyékládháza, and Bükkszentkereszt and low (107-165) in Ónod and Köröm. Concerning the type of subscription, some localities such as Kisgyőr, Harsány, and Arnót are only linked to the xDSL network. Others are entirely based on cable television networks like Varbó, and Sajósenye …Finally, the rest can rely on different types with other connections (LAN, leased lines, modem, wireless (excluding mobile internet), etc. from 2016) for example Sóstófalva, Köröm and Gesztely.

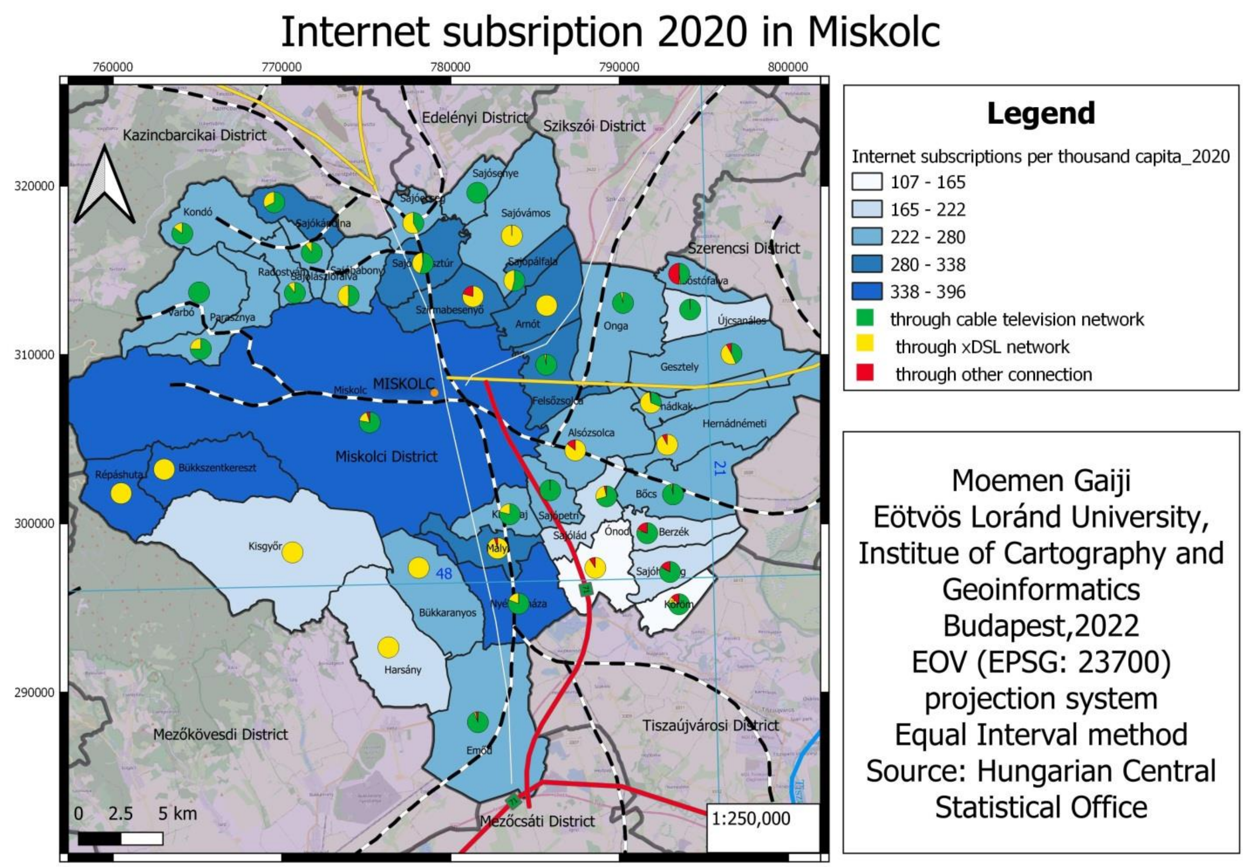


Figure 34: Internet subscription types

Analysis of Coverage maps

These maps were created by the overlaps method when we can see the different types of connection in form of layers based on company confidential measurements in some special and interpolated by software (2G/3G/4G…) overlapping the background (Google maps/Satellite images/…)

1. MAGYAR TELEKOM

In the following Figure 35, just 2G exists approximately in the whole area, but, 3G, 3G HSPA, 4G LTE and 4G+ (the most developed structure) of Magyar Telekom Company are mostly in the eastern area, but, 5G is absent (Figure35).

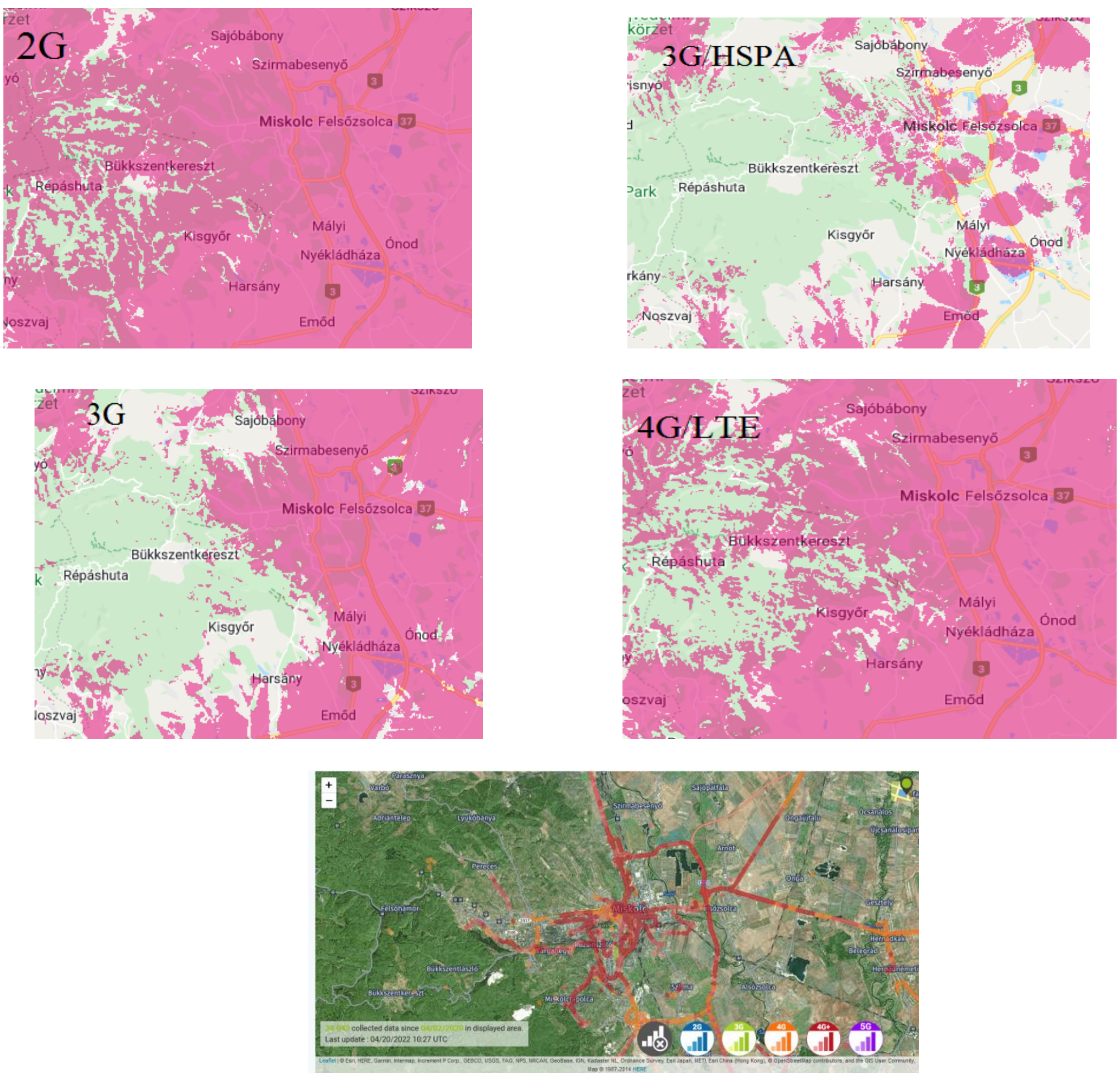


Figure 35: Magyar Telekom coverage maps (Magyar Telekom Website)

2. YETTEL MAGYARORSZAG ZRT. (HUNGARY)

As Magyar Telekom, just a 2G network is the most existed in the largest area, but, 3G indoors and outdoors and 4G (the most developed structure) and 5G is absent (Figure 36).

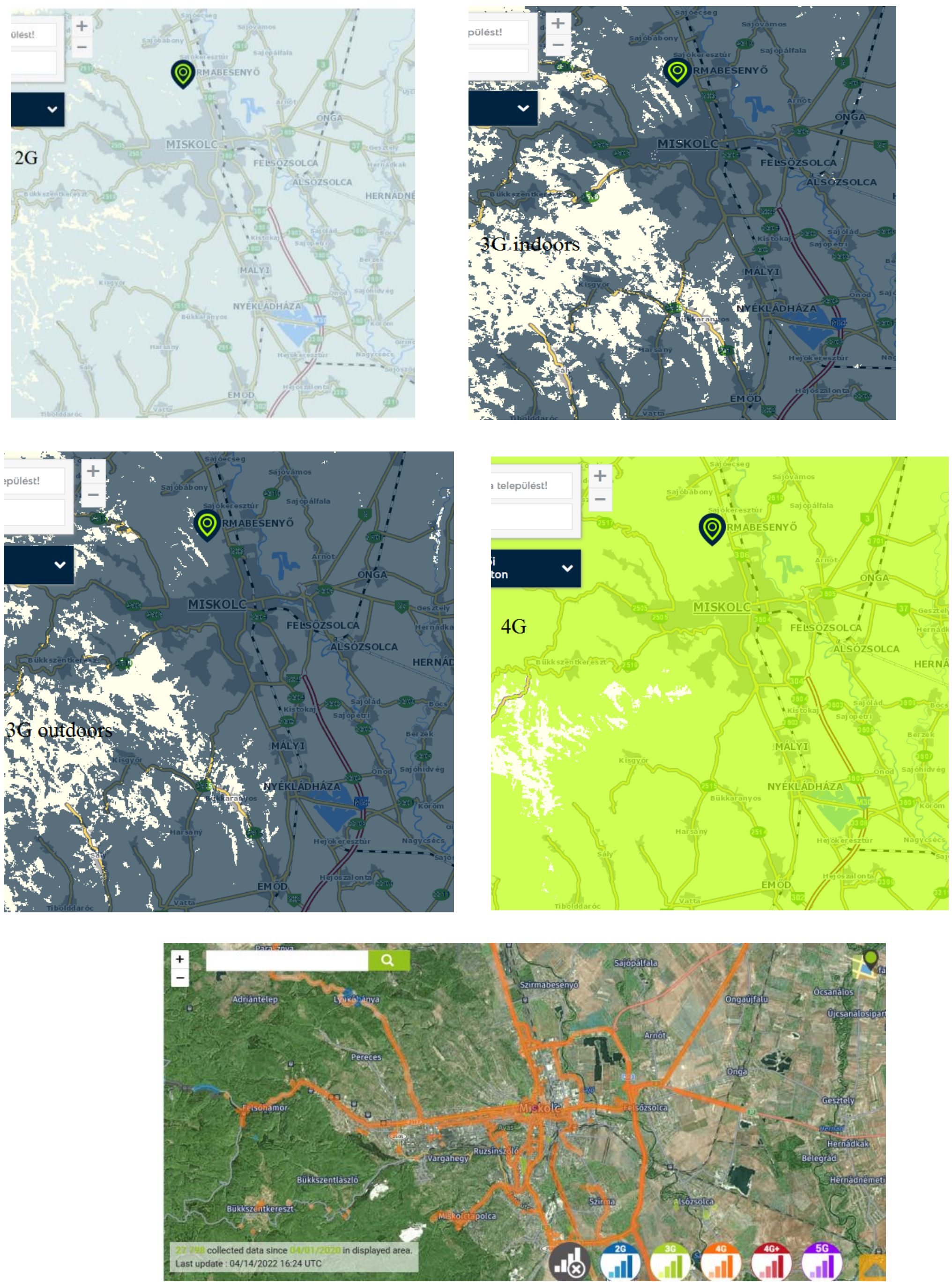


Figure 36: Yettel coverage maps (Yettel Website)

3. VODAFONE MAGYARORSZAG ZRT. (HUNGARY)

For Vodafone company, not just 2G network used approximately in the whole area, but also 3G and 4G NB IoT, and there is 5G in a small area, 4G is the most developed network (Figure 37).

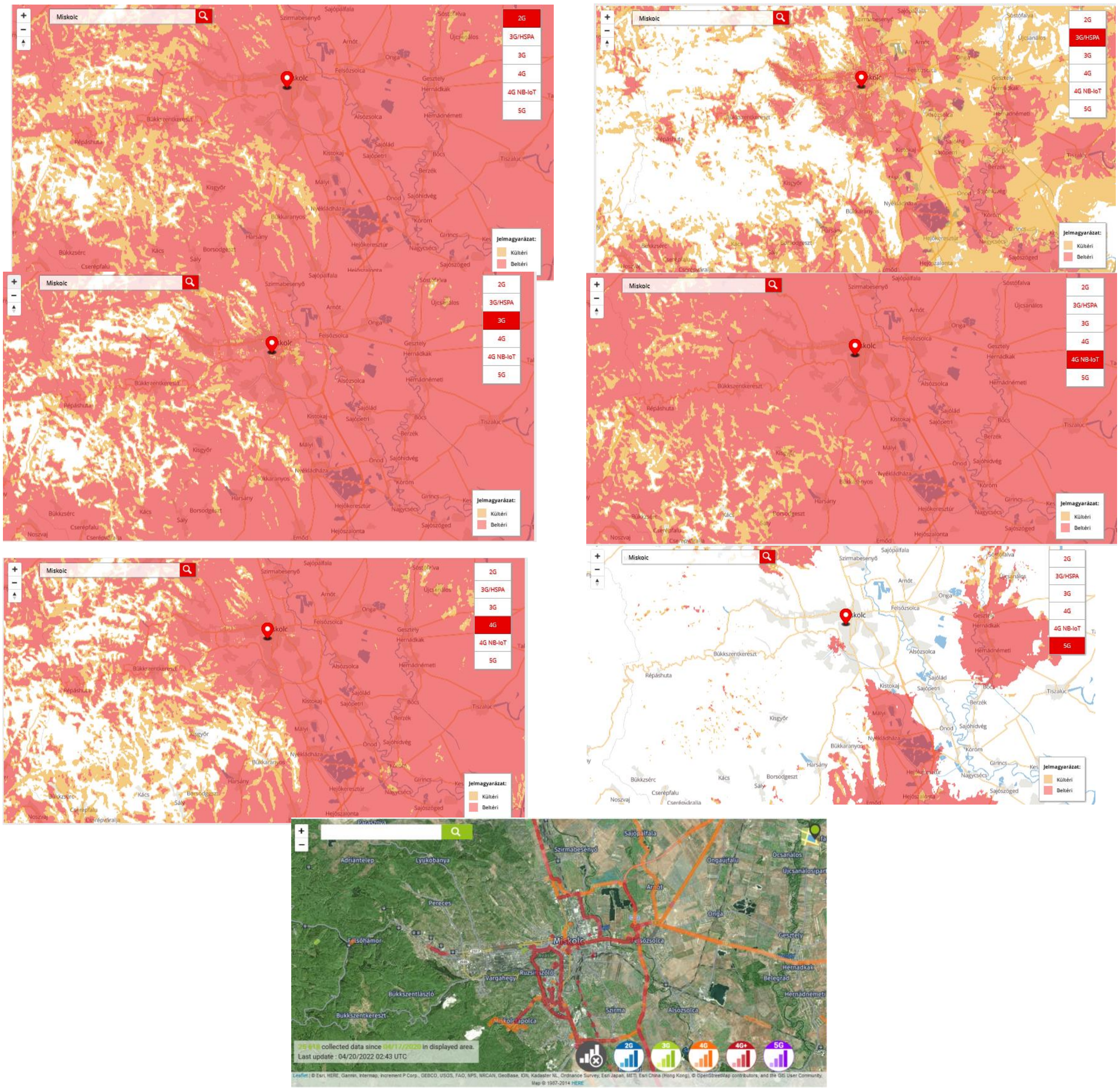


Figure 37: Vodafone coverage maps (Vodafone Website) Beltéri: Indoor/ Kültér: Outdoor

4. DIGI TAVKOZLESI ES SZOLGALTATO KFT. (HUNGARY):DIGI

The internet network of DIGI Company is provided especially in the eastern and southern parts and 4G is the most developed structure (Figure 38)

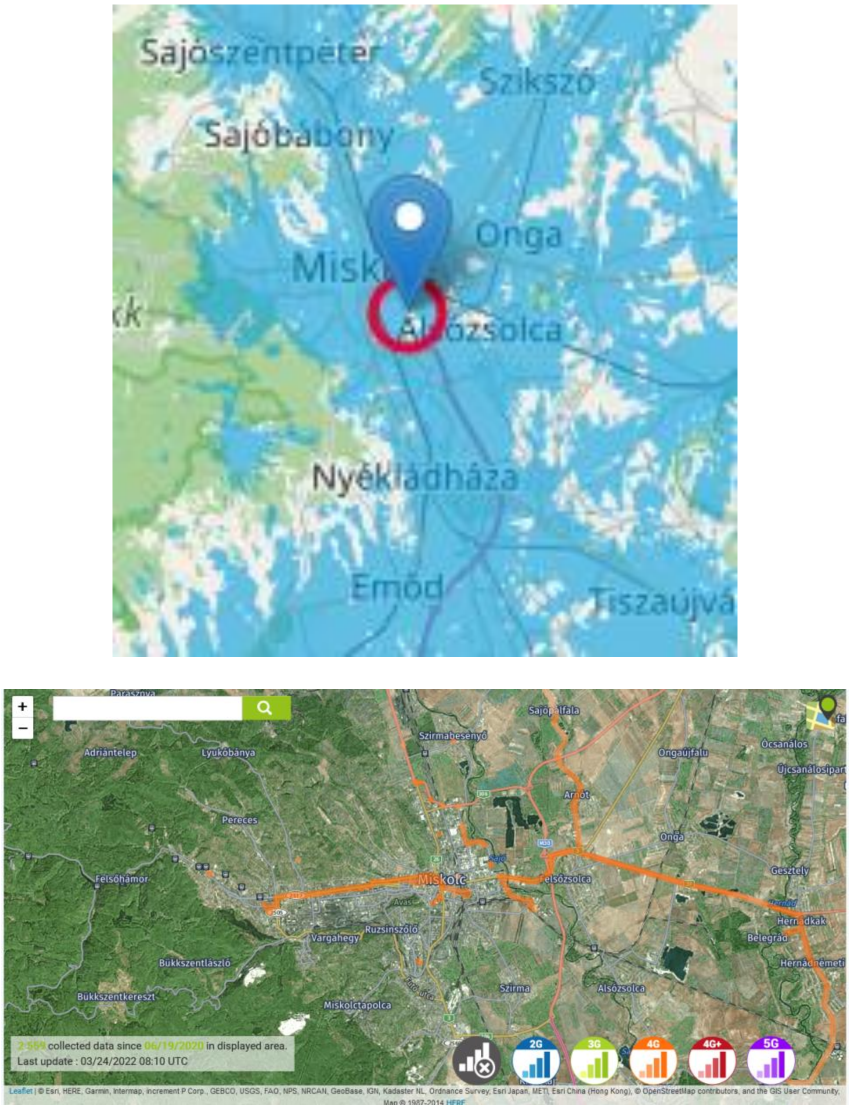


Figure 38: DIGI coverage maps (DIGI Website)

<u>Conclusion:</u>

To sum up, the spatial distribution of the internet subscription is heterogonous where the east and the south are rich and the west part is poor like the telephone lines network due to the population distribution. These results are proved also by the coverage maps of the four companies which show as well the absence of 5G networks except Vodafone and the development structure especially 4G networks and the good coverage of 2G network.

The Web Page

A Web site is a location on the Internet that is recognized by a URL. The home page is the first file in a collection of Web files about a specific subject. It is used to encode data that can be read by a Web browser. My Web page shows 4 windows: The first window for the introduction, the second window for the data of the creator, the third one is reserved for the interactive maps and the main results of the Telephone lines network, and the last page shows the interactive maps of the internet network and coverage map. The web page which represents the final results of the work could be developed and updated (Figure 39).

The links are:

Home page: http://mercator.elte.hu/~dil6g9/Miskolc/Telecommunications/index.html

Data of creator: http://mercator.elte.hu/~dil6g9/Miskolc/Telecommunications/about.html

Telephone lines network maps:
http://mercator.elte.hu/~dil6g9/Miskolc/Telecommunications/Telephone%20lines.html

Internet network maps:
http://mercator.elte.hu/~dil6g9/Miskolc/Telecommunications/Internet.html

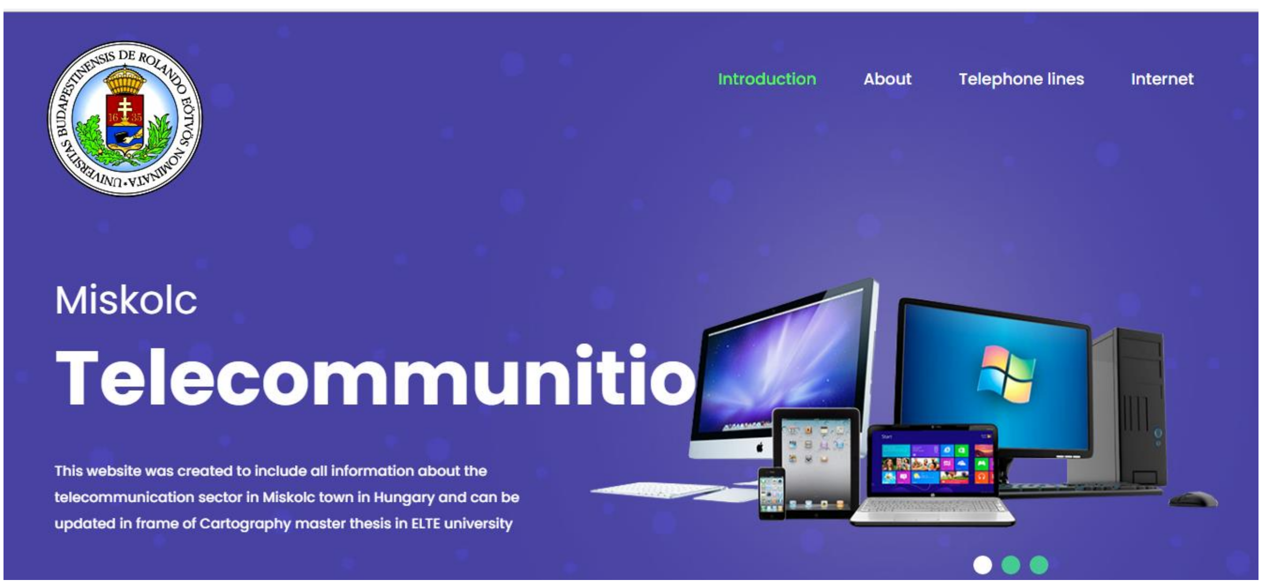


Figure 39: The home page of the website

General Conclusion

Magyar Telekom, Yettel, Vodafone, and DIGI are the four mobile telephony and internet providers in Hungary. They began operations in the mid-1990s, quickly became quite successful, and now control a large portion of the Hungarian mobile market. T-Mobile is the country's major GSM mobile network operator. After the millennium, a new field of competition emerged, with a concentration on the development of broadband networks. The most recent result is each operator's expanding 3G/HSDPA (High-Speed Downlink Packet Access) coverage network. The number of Wi-Fi hotspots internet (Wireless Fidelity) 'hotspots,' which encourage the usage of mobile internet, has skyrocketed. The majority of hotspots are located in publicly accessible areas (hotels, restaurants, taverns, cafés, etc.) or near mobile phone towers with aerials (Telecommunications Wired Telephony.). In the Miskolc district, the production of telecommunication networks (telephone and internet) has shown an evaluation depending on the distribution of the community. In general, the public services of the fixed telephone retreated in the face of the development of the infrastructure of the new technology, most of the main telephone lines have been switched to the network, same for the internet networks, and the distribution is based on the population. Except for the Vodafone company, the industry of the 5G network hasn’t arrived yet in the region, which is planned to be mapped in future projects.

Summary

This graduation project focuses on the mapping of the telecommunication network in Miskolc and creating a web page showing the main results. The GIS technique has been used since the development of the communication tools in different ways up to online GIS. Although, the new financial issues, the construction of the telecommunication structure in Hungary, which began in the 19th century, has shown fast progress with the extension of the market including 4 main providers. Using different thematic methods used in QGIS software and the collected data from the Hungarian Central Statistical Office databases, we were able to create maps clarifying the differences in the spatial distribution of the telephone lines and the internet network compared to the population repartition in the study area. Finally, with the basic background of HTML language, we created our web page for this topic.

Keywords: Telecommunication, GIS, Miskolc, Web Page.

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Moreover, I would like to express my regards to all the Jury members, for kindly agreeing to judge this work.

It is my genuine gratefulness and warmest regards that I dedicate this

work to the spirit of my Grandma.

To my beloved Parents,

Thank you Mum and dad for your understanding and your

overwhelming support morally and financially, for your Eternal Love.

No dedication could express all my gratitude.

To my dearest brothers as a testimony of my brotherly affection, of their deep gratitude,

. *To the beloved of all my professors, who have meant and continue to do so much for me.*

Finally, I Dedicate my work to the strongest person I know: MG

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Twechmapit/WIRELINE COMMUNICATIONS http://twechmapit.com/GIS.php?name=GIS

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I, undersigned *GAIJI MOEMEN* (NEPTUN CODE: *DIL6G9*), declare that the present master's thesis is my original intellectual product in full and that I have not submitted any part or the whole of this work to any other institution. Permissions related to the use of copyrighted sources in this work are attached.

I AGREE to the publication of the accepted master's thesis in pdf form on the website of the Department of Cartography and Geoinformatics.

Budapest, *15, May 2022*

(Signature of the student)