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ANALYSIS OF POSSIBILITIES OF BUSINESS ANALYTICS SYSTEMS FOR HEALTHCARE

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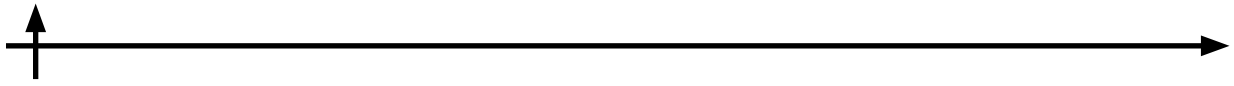
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Abstract. Rapid development of information technologies determines the need in usage of various digital solutions in order to conduct operational analysis and processing of large amounts of information. In today's age, the introduction of digital solutions is especially relevant in the healthcare system. The development of conditions for such analysis of information is one of the main tasks of digitalization of the healthcare system. Nowadays, there is no significant experience in conducting digital data analysis in the field of healthcare. Because of that, it is highly beneficial to study the experience of various non-medical organizations in this field, including the ones that effectively use Business Intelligence technologies for such tasks. Thus, this article explores data storage and analysis tools, as well as the market of existing BI-systems and the specifics of the application of these systems in the healthcare sector are examined.

Keywords: business intelligence, healthcare, business analytics, digital technologies, data analysis

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Научная статья

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АНАЛИЗ ВОЗМОЖНОСТЕЙ СИСТЕМ БИЗНЕС-АНАЛИТИКИ В СФЕРЕ ЗДРАВООХРАНЕНИЯ

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Аннотация. Стремительное развитие информационных технологий определяет необходимость использования различных цифровых решений для оперативного анализа и обработки больших объемов информации. В современный век внедрение цифровых решений особенно актуально в системе здравоохранения. Создание условий для такого анализа информации является одной из основных задач цифровизации системы здравоохранения. В настоящее время отсутствует значительный опыт проведения анализа цифровых данных в сфере здравоохранения. В связи с этим весьма полезно изучить опыт различных немедицинских организаций в этой сфере, в том числе эффективно использующих технологии Business Intelligence для решения подобных задач. Таким образом, в данной статье исследуются средства хранения и анализа данных, а также рассматривается рынок существующих BI-систем и особенности применения этих систем в сфере здравоохранения.

Ключевые слова: бизнес-аналитика, здравоохранение, бизнес-аналитика, цифровые технологии, анализ данных

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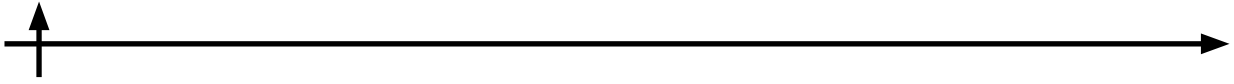
Introduction

Nowadays, the Russian Federation has adopted and is implementing the federal project “Digital Technologies”, which is a part of the state program “Digital Economy of the Russian Federation” (until 2024), as well as the state program “Development of Health Care” (until 2020) (“The main directions of budgetary, tax and customs-tariff policy for 2019 and for the planning period of 2020 and 2021 (approved by the Ministry of Finance of Russia),” n.d.). These programs determine the development and digital transformation of priority sectors of the economy based on end-to-end digital technologies.

Main goals of the Digital Technology project are following:

- “providing support to the leading high-tech companies on the Russian market, the ones developing products, services and platform solutions based on end-to-end digital technologies aimed at digital transformation of priority sectors of the economy and social sphere, with focus on domestic developments”;
- “providing support for projects aimed at scaling technological solutions based on “end-to-end” digital technologies used in priority sectors of the economy and social sphere” (*Decree of the President of the Russian Federation of 05/07/2018 No. 204 “On national goals and strategic objectives of the development of the Russian Federation until 2024,”* n.d.).

Implementation of a unified state healthcare information system provides a solid basis for the creation of a system intended to collect and sort indicators of regional healthcare systems. However, it is



necessary to develop the means of effective support in managerial decision-making in the healthcare sector both at the level of individual medical organizations and at the regional and country-wide levels (“Thirteenth General Programme of Work 2019–2023,” n.d.). Business Intelligence (BI) systems provide said means of effective support in managerial decision-making and present an ideal tool for the health indicators analysis of Russia’s federal subjects. One of the main advantages of such systems is the ability to create visual tools for making both strategic and operational decisions at various levels of the medical structures.

This article explores the concept of the term Business Intelligence from the point of view of various authors and research organizations, highlights the key features of Business Intelligence, and also presents the advantages and disadvantages of using Business Intelligence technology. In addition to that, the article discusses data storage and analysis tools and examines the market of existing BI-systems and the specifics of the application of these systems in the healthcare sector.

Materials and methods

The rapid development of technologies, including the ones used in the healthcare system, determines the need for the usage of various IT-solutions for conducting multi-aspect operational analysis of the available information.

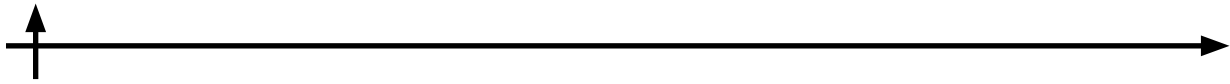
One of the main goals of digitalization of the healthcare system is the development of proper conditions required for such analysis. Active implementation of the National Healthcare Project and the “Creating a Unified Digital Circuit Based on EHISS” Federal Project allows to create a convenient environment for analytics but the current level of experience of medical staff and executive authorities in the healthcare sector highlights the lack of ready-made, well-established IT-solutions and significant experience in conducting digital data analysis (“Federal project ‘Creation of a unified digital circuit in health care based on a unified state information system in health care (EGISZ),’” n.d.; “National projects ‘Healthcare’ and ‘Demography,’” n.d.).

Consequently, it is highly beneficial to study the experience in the field of data analysis and the creation of proper conditions for decision-making in organizations of various non-medical areas of activity. Most organizations effectively use Business Intelligence (BI) technologies to solve such problems.

The term Business Intelligence was first used by Hans Peter Lun in 1958 in the article “A Business Intelligence System”, published in IBM System Journal. The author divided this term into components and characterized them separately. Lun described Business as a set of various activities undertaken in science, technology, commerce, industry, legislative activity, defense, etc. Various communication systems that provided and supported these types of activities he called “intelligence system”. In general, term “intelligence” Lun defined as the ability to establish a relationship between the representations of individual facts in order to better solve the goals and objectives.

Late in the 1980s, Gartner analysts under the leadership of Howard Dresner gave a broader definition of the term – “user-oriented process, which allows access and research of information, its analysis, development of an understanding, which, in turn, leads to improved and informed decision-making”. Later in 1996, Dresner added the following to the definition: “Business Intelligence is a tool for analyzing data, creating reports and queries that can help business users to overcome the large quantities of data in order to synthesize meaningful information from it” (Iliashenko et al., 2017).

There are other interpretations of this term. The Data Warehouse Institute, an organization that studies the analysis and storage of data, gives the following definition: “Business intelligence allows to turn data into knowledge, and then that knowledge is used to formulate business actions ensuring profit.” Forrester Research defines Business Intelligence as “a set of methodologies, processes, architectures and technologies for processing primary data into meaningful and useful information used by management teams to better understand business processes and make informed decisions at the strategic, tactical and operational levels” (I. Ilin et al., 2018).



So, despite slight differences in definitions, a number of common attributes of Business Intelligence can be distinguished. Today BI-solutions are not only used for to conduct analytics and form reports, but also for data collection and quality management.

Based on previous statements, it can be concluded that business analytics, in the broad sense of the word, means:

1. The process of turning data into information and knowledge about the business in order to ensure improved decision-making;

2. Information technologies, methods and tools for data collection and information consolidation;

3. Business knowledge gained from in-depth data analysis.

The presented technology is based on the principles of end-user access to the analysis of structured data. This creates an integration process, allows end users to interpret transactional business information in the most simple, understandable way suitable to be the basis for business analysis and development of an effective strategy for changing the organization. Business Intelligence has a wide range of users, including both ordinary employees, as well as analysts and managers at various levels. In relation to medical organizations, it should be noted that Business Intelligence technologies are of interest both to doctors of various departments, as well as to heads of departments, statisticians and heads of organization (“Sustainable Development Goals,” n.d.).

Nowadays, the categories of BI-products are usually divided into: BI-tools and BI-applications. BI-tools, in turn, are classified into the following types (Iliashenko et al., 2017):

1. Query and report generators – desktop tools that provide users with access to databases, perform analysis and generate reports;

2. Developed BI-tools (most importantly, OLAP analytical processing tools);

3. Enterprise BI Sets (EBIS) – a set of BI-tools that were previously presented as separate products;

4. BI-platforms – sets of tools for creating, implementing, supporting and maintaining BI-applications.

Given the diversity of various types of BI-solutions used for working with typical tasks, it is easier to talk about the typical blocks of modern BI-systems. The main capabilities of Business Intelligence systems are focused in the following directions: storage, integration, analysis and presentation of data.

Data storage

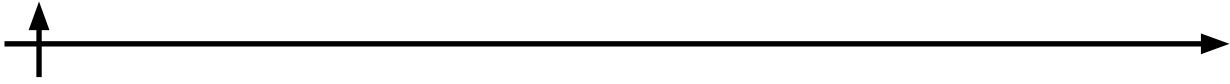
To store the data used by BI-systems throughout their work, special storages called data warehouse are organized. The stored information should present a valid, real and comprehensive view of the organization because of that the data is collected from various operating systems. For a more efficient analysis, the data storage structure is formed in a way most suited for creating and processing various requests, while in ordinary databases, optimization of the execution time of transactions is often more important.

It should be noted that if the data size is too large, specific subsets of information can be formed, called data marts, in order to solve narrow, specific tasks.

There are several different approaches to data integration. The so-called data warehouse management tools, ETL tools, are used to form and maintain the data warehouse. The ETL abbreviation itself stands for Extract, Transform, Load, which is a brief description of the function of these tools. Thus, ETL tools are tools that allow to extract, transform and convert data to a specific required format. These tools are used for uploading data to the repository or another database.

Alongside ETL tools, BI-systems include tools that allow to work with a programming language used to manage real-life databases in database management systems (DBMS). One of the most common ones is the Microsoft DBMS – SQL Server. The abbreviation “SQL” stands for structured query language, which means that it allows users to directly access the data.

It should be noted that recently the tools for generating and processing requests have become more geared towards unprepared users, rather than on qualified IT specialists (Ilin et al., 2017).



Data analysis and visualization

Modern BI systems cannot be imagined without using OLAP (Online Analytical Processing) technologies for data analysis. This technology involves the acceleration of the processing speed of large data arrays by structuring information according to a multidimensional principle. Storing information in separate database tables often leads to an increase in the complexity of processing multi-table queries. Because of this an OLAP structure of joining tables in the “star pattern” or “snowflake pattern” is currently used in BI systems.

The presented tools allow to quickly generate the required data slices, and then visualize the given information in a number of different ways such as graphs, charts, reports, all customizable according to various parameters. Using the OLAP structure allows to quickly make changes to the presented data (Ilin et al., 2017).

It should also be noted that a number of the most developed BI-solutions support the data mining technology. This usually means as a group of tools designed to facilitate the search for hidden, unknown and non-trivial patterns. This group of tools includes various modeling and forecasting methods based on neural networks, the decision tree, Bayesian networks, regression and correlation analysis, and various other methods. Data mining technologies are designed to facilitate the analysis of huge amounts of information, as well as to ensure the competence of strategic decision-making by using the analysis of various event scenarios.

Dashboards and scorecards are the most widespread and generally accepted means of displaying data in modern BI-systems. Information panels are visual solutions on which the main parameters are displayed in the form of charts, scales and indicators. These tools allow users to both evaluate and monitor the current values of the parameters, as well as making the comparisons with the various values of the indicator and, as a result, identifying the existing risks and threats.

Scorecards are a visual solution directly related to the analysis of key indicators (KPI – key performance indicator). In this case, we are talking about a comparison with the target indicator values. These cards are the simplest and most convenient form of studying and preventing the risk of not achieving the planned values of indicators (Ilin et al., 2019).

Benefits of using Business Intelligence Technology

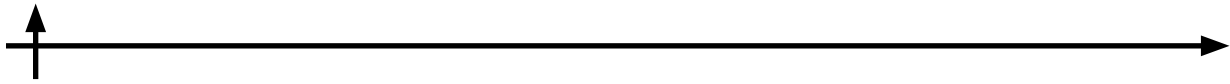
The usage of BI-systems makes it possible to solve a very wide range of tasks, including monitoring and analysis of the current values of indicators, as well as determining strategic and operational goals of the organization's development. Among the advantages of using BI-systems there are:

1. creation of a support system for the development of existing business processes and structural changes in the organization;
2. the emergence of opportunities for modeling business cases;
3. creation of conditions for operational analysis and work with non-standard query forms;
4. redirection of human resources from routine analytical activities and filling out reporting documentation to deeper analytical work;
5. the growth in the volume of processed and analyzed information due to the possibility of scaling the system.

Also, the use of BI-solutions provides some additional opportunities in the field of strategic development. They include (Iliashenko et al., 2017):

1. evaluation of the effectiveness of various activities;
2. operational and continuous monitoring of the attainability of key goals and objectives;
3. the formation of a method for assessing the effectiveness of the use of available resources;
4. calculation of the effectiveness of financial activities;
5. cost and investment management.

According to experts from MiPro Consulting, the use of a BI-system in the organization has a number of significant advantages compared to the use of standard analytical tools integrated into the organization's existing information systems. These benefits include:



1. improving the visibility and increasing the convenience of working with data;
2. the possibility of using several analytical solutions, depending on the nature of the problem and the direction of activity of a particular unit of the organization;
3. the ability to work with various data sources and data types;
4. continuous development and improvement of existing BI-platforms;
5. high level of scalability, performance and efficiency of the analysis of indicators;
6. the emergence of conditions for building and supporting end-to-end procedures throughout the organization;
7. the possibility of creating analytical centers responsible for studying information about the organization's activities;
8. variety and flexibility of analytical tools for solving tasks;
9. the ability to provide users with data and analytical tools in accordance with their access rights.

It is important to note that the use of analytical tools integrated into the other information systems that are not directly intended for analytical activities usually has a number of limitations:

1. the lack of differentiation of user access rights to analytical tools;
2. extremely limited set of analytical tools;
3. the necessity to export and analyze data in other software products, for example, in the Microsoft Office Excel package because of disadvantages of the built-in tools for visualization and analysis of the information;
4. inability to work with external data sources is not available;
5. the limit on the number of users using the analytical extension of the information system, due to the fact that the widespread use of this product can significantly impair the work of the application for other employees of the organization;
6. limitations on the formation of flexible, non-standard queries;
7. the use of large amounts of historical information is limited (I. V. Ilin et al., 2018).

Disadvantages of using Business Intelligence Technology

In practice, in the process of forming a BI solution, the first task is to organize a scheme for collecting information and creating a unified database of the organization as the main information space of the institution. The storage of the BI-system should provide for the possibility of the receipt of information from any available, including external sources. In reality, the tasks of implementing an immediate solution fade compared with the tasks of creating an integrated digital space within the organization.

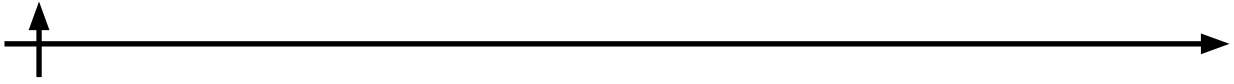
Standard reports are only a small part of the capabilities of BI-systems. These solutions have significant potential for creating a powerful analytical tool that will provide an opportunity to analyze all the activities of the company. And it does not even require the implementation of new independent programs to solve individual problems. However, the presented positive side carries a number of disadvantages. BI-systems are tools built on rapidly changing technologies. Significant pace of development and improvement of existing solutions require constant monitoring of existing BI-systems.

Another important risk of the practical use of BI-systems is the performance degradation with insufficient data quality. If the data are not properly processed and cleared, then none of the possible BI-tools will not achieve significant results in the analysis of information. This situation is not always clearly presented to the main stakeholders, and BI-solutions are often associated with inefficient work of the analytical group, and not with problems with the data collection structure. BI-technology itself is not able to comprehensively solve these problems, and neglect of them returns to information anarchy (Iliashenko et al., 2017).

Results

Market overview of existing BI-systems

According to Gartner, in 2018, the explosive development of the business analytics industry was recorded, which was largely due to the development of machine learning technologies and neural net-



works. Today, there is every reason to argue that the trend of increasing influence of the new generation BI-platforms continues.

Gartner analysts urge suppliers of all BI-systems to pay attention to the realities of the information space and radically revise their point of view on working with data: BI-systems can no longer rely on standard data mining methods. The rest of the technology world is moving to bring machine learning, NLP and AI to customers, so BI-industry must do the same.

One of the easiest ways to form an idea of market leaders is to present the magic square of market leaders used by the Gartner analytical agency. So, at the beginning of 2018, there are three main leaders on the market: Qlik, Tableau and Microsoft with its Power BI solution.

Market overview of BI-systems in healthcare

According to Marketsand Markets, the global healthcare BI market amounted to about \$ 2.38 billion in 2013. And in 2019, it is expected to reach \$ 4.74 billion (average annual growth of 14.8%). In the medical market, technology is dominated by traditional Business Intelligence, while cloud-based BI and mobile BI represent great potential for growth: on the one hand, hospitals, in the face of limited economic resources, need more accessible, flexible, transformable and scalable forms of business intelligence, and on the other hand, the demand of medical institutions for mobile solutions is growing (“Transforming our World,” n.d.).

The further market growth can go mainly due to the implementation of BI solutions directly in medical organizations. However, it should be noted the importance of using BI systems in executive bodies in the field of healthcare management.

There are a lot of vendors of analytical solutions in the healthcare sector. Among them, the largest include IBM, Information Builders, Microsoft, MicroStrategy, Oracle, Qlik Technologies, SAP, SAS, TIBCO Software, Tableau Software, Computer Sciences Corporation, Dimensional Insight, Jaspersoft, Klipfolio, Perficient, Agilum Healthcare Intelligence, Siemens Healthcare, Tata Consultancy Services, Infosys, Wipro Limited, Hexaware Technologies Limited and others (Mackenbach and McKee, 2013).

Let's take a closer look at the solutions that are recognized as market leaders.

1. QlikView from Qlik company

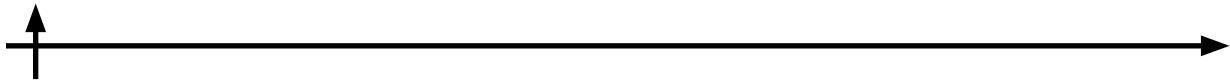
This platform focuses on the needs of the user as the ultimate recipient of data. There is a high flexibility to study and visualize data, as well as the presence of a relationship between the data and the dip function, which allows obtaining detailed information about each studied parameter. Key product features are (Troyansky et al., 2015):

1. opportunities to create advanced dashboards based on data from a variety of sources;
2. the presence of a tool for automatic recognition of relationships between data, which can significantly simplify the work of the end user in the process of creating reports and dashboards;
3. data storage in the server RAM, which speeds up the process of query execution when working with a large data array;
4. QlikView reports and dashboards have a low entry threshold, which allows even beginners to use these functions. However, the process of creating dashboards itself requires advanced development and SQL skills, as well as the presence of certain practices in the QlikView programming language.

It should be noted that when using QlikView, the main thing is a clear understanding of current goals and objectives, as well as a vision of the final result. This solution allows to demonstrate amazing results with a clear consistent course and its implementation.

2. Tableau

As a BI solution, Tableau's main focus is the presentation of data through visualization. The system makes it easy to create interactive dashboards, with a dip function and transitions to trend indicators. It should be noted the wide possibilities of the visual library, which includes word clouds, bubble and tree diagrams, and other tools (Nair et al., 2016). Also there is a function of combining elements, which allows you to reduce and overlap various visual solutions, which is especially important in view of the need to save work space in the monitor space.



The main difference between this solution and competitors is the ability to mix data from different databases and sources, as well as the ability to work with a significant number of different types of data.

It should also be noted that the functionality of the program allows simultaneous use by several users in real time.

It is important to note that Tableau is relatively loyal to beginners who were not previously interested in data visualization issues. There is an intuitive interface, well-described technical guidance and assistance. It is convenient to work with the program both from the side of the user creating the report, and from the end-user studying the result and making strategic decisions.

3. Power BI by Microsoft

A service developed by Microsoft as an extension of the existing functionality of Microsoft Office Excel. The solution is characterized by a relatively simple and intuitive interface, as well as the presence of many functions similar to the apparatus of the latest version of Microsoft Office Excel. In addition, the system is as friendly and compatible with another development of Microsoft – the SQL Server hardware product (Ferrari and Russo, 2016).

However, it should be noted that there are certain limitations in the examples of data visualization, and the program also notes a relatively small number of tools for cleaning and processing data (Mackenbach and McKee, 2013).

The specifics of BI-systems in healthcare

It should be noted that the use of Business Intelligence technologies in healthcare has a number of features.

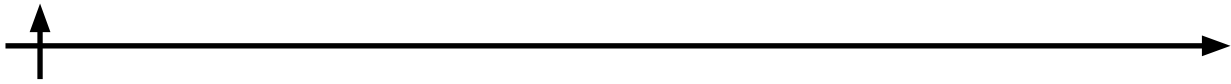
Medical organizations operate with various layers of data: personal information about patients, test results, radiological and computer images, video recordings of studies, as well as information from management systems and others. For quick and timely decision-making in the presence of such an array of data, careful collection and analysis of information is necessary. Automation of medical analytics requires taking this feature into account (Ritsatakis et al., 2009).

It is also important to remember that medical activity is associated with the concept of medical confidentiality. So, according to Article 13 of the Federal Law of November 21, 2011 No. 323-FL (as amended on May 29, 2019) “On the Basics of Protecting the Health of Citizens in the Russian Federation” (“United Nations Millennium Development Goals,” n.d.) information about a citizen’s appeal for medical assistance, his state of health and diagnosis, or other information obtained during his medical examination and treatment, constitutes medical confidentiality and it is not allowed to disclose information constituting medical confidentiality, with the exception of cases established by parts 3 and 4 of this article. It should also be noted that there is a significant amount of depersonalized data that is not a medical confidentiality, but has a limited level of access, since its wide dissemination can influence on the security of the Russian Federation (“Federal project ‘Development of a network of national medical research centers and the introduction of innovative medical technologies,’” n.d.).

An essential feature of medical organizations is that usually two types of BI are required by healthcare institutions. Firstly, this is analytics aimed at supporting the healing process, and secondly, managerial analytics. These two systems solve different problems, determined during the treatment process at various levels and practically do not intersect. It should also be noted that organizations responsible for studying existing health systems can be interested in a separate type of management analytics (World Health Organization, n.d.).

Conclusions

The quality of decisions made by the management of medical organizations and state bodies of the healthcare system depends on the corresponding information support, which is directly related to BI-systems. Today, BI technology allows to better understand the structure of medical care and increase the speed of informed decisions. BI is not only a business analysis of information, but also work with



big data from different sources, their processing, testing, presentation and servicing of requests for this information. It is important to automate the processing of information, because it will reduce the time to perform routine operations and receive relevant quality information.

The article discusses market leaders. It is a QlikView platform that focuses on the needs of the user as the ultimate recipient of data. The platform has high flexibility to study and visualize data, as well as the presence of a relationship between data and a dip function. The Tableau system is characterized by the presentation of data through visualization and the ability to work with a significant number of different types of data. Power BI service is characterized by a relatively simple and intuitive interface, as well as the presence of many features similar to the apparatus of the latest version of Microsoft Office Excel.

The article also considered a number of features in the healthcare system when using Business Intelligence technologies. Thus, medical organizations work with large amounts of data, which require careful collection and analysis of information presented in the form of reports and forecast models. Often, such data is the personal information of patients and is not subject to disclosure. An essential feature of medical organizations is that healthcare institutions require two types of BI – analytics aimed at supporting the treatment process, and managerial analytics. These two systems solve different problems that are determined during the treatment process at different levels and practically do not intersect.

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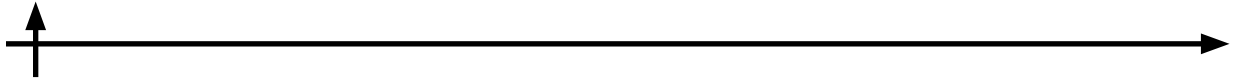
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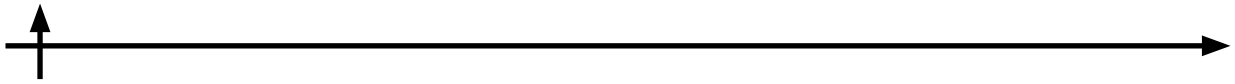
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