INFORMATION AND COMMUNICATIONS TECHNOLOGIES

MAJOR TECHNOLOGIES AND PRACTICAL ASPECTS OF THE DIGITAL TRANSFORMATION OF BUSINESS IN A BIG DATA ENVIRONMENT

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Abstract: In contemporary business development, digital transformation has become a major challenge to big data management. In an environment of increasing volumes of data, the major factors that are crucial to business development relate to big data processing and analysis. Open-source data processing technologies employ an innovative approach to the design of data processing and data analytics tools in cooperation among developers, which ensures the transparency, accessibility and continuous improvement of those tools.

The main objective of this article is to review popular open-source technologies for big data processing and identify trends in employing big data in business applications.

Key words: big data, digital transformation, big data technologies
JEL: O33, C88.

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Introduction

The process of digitalisation began in the 1950s by changing analog signals and any form of data into a digital form that could be processed by computer systems or electronic devices and taking an analog process and changing it to a digital form without any different-in-kind changes to the process itself (Gartner Glossary). Advancements in internet technologies in the 1990s and electronic commerce in 2000 changed the manner in which people work, do their shopping, travel, communicate, train, manage and live in general. The wide use of intelligent devices such as smartphones, tablets and mobile applications created a new market reality which merchants need to adapt to in order to remain competitive. Digital technologies have enabled consumers to be constantly online and to expect content that matches their activity at anytime and anywhere and is accessible from a device they prefer.

Gimpel, H. and Röglinger, M. (2015) define digitisation as 'the widespread adoption of digital technologies in society and related changes in human behaviour'. Yet, the definition they give refers to the social aspect of the phenomenon only. New customer behavior forces business to embrace new technologies in order to offer advanced business processes, products and services.

The process of adapting business to the new market reality due to the changes in customer behavior refers to the business aspect of the process of digitilisation. Gartner approaches digitilisation from a business perspective as 'the use of digital technologies to change a business model and provide new revenue' and adds that 'it is the process of moving to a digital business'.

Kurt Brand (2017) upgrades the concept of digitilisation and defines it as 'creating new business models and processes that offer new digital (business) opportunities, for example, through digital platforms that ensure value creating ecosystems as the basis for the provision of data-based value creating services'. According to Brand, digitalisation refers to the change in **business processes** that is driven by new customer demands by employing digital technologies; using **new data sources** that are continuously analysed through the integration of sensors in products, processes and systems; **changes in organisational culture** with a greater focus on customers and

creating a **digital ecosystem** outside the organisation to embrace customers, suppliers, partners and even competitors.

The process of substituting existing traditional business models with new innovative ones by employing advanced technologies, which has changed fundamentally the economy, organisations and society is known as **digital transformation**. Amazon's digital ecosystem is an example of an innovative business model in retailing that has changed customers' and suppliers' access to the market. The business model which Amazon has established and the market power acquired by the company forces merchants to use the platform in order to make significantly more sales. Since Amazon has access to and controls all data of merchants, it can totally take over their business if that is in line with the strategy of the company. Furthermore, the wide variety of transactions provides Amazon with a huge volume of data, which the company could use to predict, control and even manipulate the behaviour of clients and suppliers to its advantage.

The business factors that have become the drivers of the digital transformation of business are:

- Offering a consistent and personalised range of products to customers along all possible channels;
- Developing competitive advantages by creating unique opportunities to improve customer satisfaction;
- Acquiring increased awareness about customer behaviour in order to increase customer loyalty;
- Running effective and purposeful marketing campaigns, analysing data from multiple sources;
- Reducing costs by optimising stock-taking and managing the supply chain.

The Internet of Things, Artificial Intelligence, Virtual Reality, cloud technologies and social media are the major **technological drivers** of the process of business digitalisation and offer opportunities for accessing **large volumes of new data** that may be analysed and used in management decision-making processes.

Models of digital transformation nowadays are designed based on **big data**, the technologies of the Internet of Things and big data management and analytics. According to a survey conducted by Dresner

Advisory Group of the market of Big Data technologies in 2018, big data analytics is crucial to the digital transformation of the telecommunications, the advertising and the insurance industry and is a major factor for the development of healthcare and commerce. Eighty per cent of all companies stated that big data were the most important element of their strategies for developing business intelligence (Columbus L, Forbes 2018).

Big data is becoming a key driver of digital transformation since it provides opportunities for access to new clients, new channels for product distribution and new markets, as well as improved business management. In an environment of increasingly growing volumes of data, the major challenge which businesses face relates to collecting, storing, processing, integrating and analysing big data.

1. Big Data in Business

Big data are high-volume, high-velocity and/or high-variety information assets that demand cost-effective and innovative forms of information processing and enable enhanced insight in decision-making and process automation. In 2001, Gartner identified volume, velocity and variety as the three characteristics of big data. The number of these characteristics increased over the years, and in 2017, Tom Shafer (Data Scientist) from 'Elder Research' presented an updated list of the 42 V's of big data.

- Volume is the most obvious feature of big data. The annual increase in big data volume has been 40 per cent, and forecasts are that it will reach nearly 40 ZB in 2020 (A. T. Kearney). Such huge volumes of data can only be processed, managed and analysed by specialised big data technologies.
- Velocity refers to the rate at which data is generated, produced, created, updated and processed in order to extract useful knowledge.
- Variety refers to different data types (structured, semi-structured, and unstructured data) and data sources.

The other characteristics of big data – variability, veracity, validity, etc. – refer to the other major challenges and advantages related to the use of big data.

Specialised literature classifies big data in terms of their format (structured and unstructured), volume and velocity, i.e. the rate at which big data is generated and used (Rozados and Tjahjono, 2014; Deloitte, 2012, Hortonworks/Terradata).

Structured internal data generated from business processes within the company, such as the Enterprises Resource Planning Systems (ERP), Customer Relationship Management Systems (CRM), etc.:

- Sales data (POS and history);
- Data about/from suppliers;
- Data about transportation and warehouse activities;
- Data from invoices and transactions;
- Data from customers' profiles, contracts, etc.
- Marketing data (prices, pricing, etc.);
- Procurement management data;
- Online shops data;
- Finance and budget data;
- Merchandising data;
- Data from web logs, traffic data from customers, user clicks on the web pages of companies, etc.

Structured external data generated from external sources:

- Internet of Things sensing;
- GPS data and smart phones data;
- Gamification data;
- Data from simulations and other means of virtual and interactive product experiences;
- Data from virtual reality, augmented reality and mixed reality devices;
- Syndicated data from organisations specialising in trade, such as business associations that aggregate data from multiple merchants and publish structured data in the sphere;
- Data from distributors and suppliers;
- Weather data;
- Macro and micro economic data from public sources (demographic, statistical, etc.);

Unstructured internal data generated from e-mail, websites, call centres and other internal business processes, mainly in text, audio and video format and images:

- Market research data (questionnaires, etc.);
- Customer service and call centers data;
- Data from companies' pages in social media;
- Data from job interviews;
- Data from performance appraisals as well as documents with feedback from employees;
- Data from documents (reports, diaries, research, e-mail);
- Data from the social business networks of suppliers, distributors and merchants; from employer association networks and networks for open innovations and cooperation.

Unstructured external data generated from externals sources:

- Customer applications;
- Product reviews from customers;
- Product reviews from experts;
- News media;
- Comments, blogs, review sites that contain user appraisals of products and services (user-generated content);
- Video and social networks and platforms;
- Images and image recognition;
- Video tracking and monitoring from video surveillance systems in stores;

The volume of structured data generated from internal and external organisation is low, so they are stored in relational databases and/or data warehouses. Unstructured data do not have a pre-defined data model in a text, video, image or sound format. They are stored in NoSQL data bases, data lakes or other warehouses. Since most of the sources that generate unstructured data are external to organisations, their volume is increasing most rapidly.

Continuously growing volumes and variety of big data formats require special technologies of data management.

2. Technologies and Tools of Big Data Management

Figure 1 shows established processes in big data management, i.e. data ingestion and data collector, data storage and data processing, data queries, analytics and visualisation (Gill, 2017).

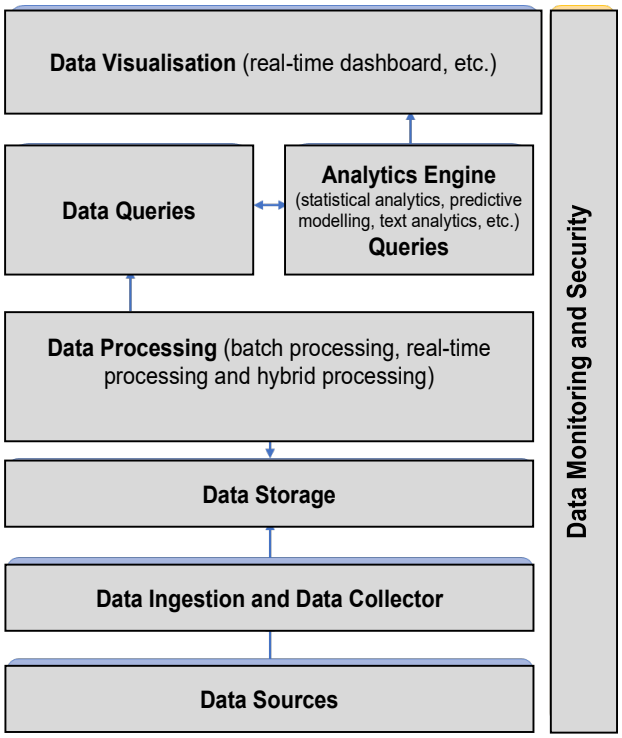

Figure 1. Stages in big data processing

The processes at each stage are implemented by numerous commercial and open-source technologies. Traditional commercial solutions for data integration are solid, reliable and supported by maintenance and development teams. At the same time, these products usually follow traditional models of architecture and might be difficult to adapt to a big data environment, so their introduction may incur substantial costs.

In contrast to them, open-source technologies offer licensing flexibility and are cost-efficient. Their greatest advantage, though, relates to the innovative partnership approach to technology design and development, and Apache projects are a good case in point. Due to these advantages, open-source technologies are popular and frequently used. The findings of a research conducted by Dresner Advisory Group in 2017 of the market of big data technologies identified Spark SQL, Hive, HDFS, Amazon S3, HBase, Impala, MongoDB and Cassandra as the most popular technologies for accessing and processing big data. This article gives a summary of some popular open-source technologies that are frequently used to implement the different stages of big data processing.

Data Ingestion and Data Collection

Data ingestion starts with prioritising data sources, validating and routing data to the correct destination, ingested in batches or streamed in real time. In addition to data ingestion, collection and integration, the tools also modify and format data so that it could be stored and analysed. The major parameters of the data ingestion process are data velocity (i.e. the speed at which data flows in from different sources); data size (an enormous volume of data that is increasing); data frequency (real-time or in batches) and data format (structured, semi-structured and unstructured). Different tools may be employed to extract open-source big data. Some of them are:

- Apache Kafka is a system that processes big data in real time. Kafka processes streams of data regardless of their source or destination. Use cases include website activity tracking; stream processing; metrics collection and monitoring.
- Apache Flume is a system for collecting, aggregating and moving large amounts of data from multiple sources (logs, sensors, machines, social media) to centralised data warehouses like HDFS and Hbase. In contrast to Kafka, which can process and monitor data in distributed clusters, Flume collects data from distributed clusters to move them to a centralised data warehouse. When properly configurated, Apache Kafka and Flume are very reliable and guarantee zero loss of data.
- Apache Nifi is a tool used to load data from multiple sources and transfer it to a different source.

- Apache Sqoop is a tool for parallel data transfer between Hadoop and SQL data base.
- Cloudera Morphlines is an open-source system which integrates, designs and modifies applications for Hadoop processing that ingest, transform and load data into HBase or HDFS or corporate data warehouses. It is used for real-time applications as well as in batches.

Data Storage

This stage refers to the storage of structured data in systems for managing relational databases and unstructured data in specialised file systems such as Hadoop Distributed File System (HDFS) or NoSQL data base.

- Hadoop Distributed File System (HDFS) is a classic file system for big data. Hadoop ensures parallel data processing on different computing nodes to maximise the speed of computation and reduce latency. Data is saved once and then read multiple times, in contrast to file systems where data is constantly read and written. HDFS is reliable in case of server failure since it breaks information into pieces which are stored on different nodes in a cluster on multiple machines. The technology is very popular due to the solidity and the unlimited volume of the hardware. It requires a special set of skills as well as the complex integration of numerous open-source components.
- HBase is a non-relational system for managing database in columns. It is extremely efficient and fast for reading and writing big data sets in real time. The system works with HDFS and supports MapReduce queries.
- MongoDB is a non-relational database that is used to store any type of data in a separate document. Access to documents is indexed and ensures fast response to queries. MongoDB's speed is 100 times as fast as that of a relational database. Some of the disadvantages of MongoDB are that it provides limited analytical options and does not support transaction data.
- Amazon Simple Storage Service (Amazon S3, AWS) is object storage. Every object is stored as a metadata file with an identification number which applications use to access the object. Its main advantages are security, productivity, inexpensive and flexible data storage and fast

performance. Some authors criticize the speed at which data is extracted and the complicated settings required for communication between data management software and AWS.

Data Processing and Data Management

Data processing relates to data transformation, classification and optimization (in batches or real time) to facilitate analysis.

- Apache Sqoop is a batch processing system that transfers data between Apache Hadoop and structured data stores. Sqoop may also be used to import data from external structured data stores into HDFS or related systems like Hive and HBase. Sqoop can also be used to extract data from Hadoop and export it into external structured data stores.
- Apache Spark is a real-time processing system which has been designed to overcome some of the disadvantages of Hadoop. For example, it can process data both in batches and real-time and its performance is 100 times as fast as that of MapReduce. Spark enables in-memory data processing and runs with HDFS and Apache Cassandra.
- Apache Flink is an open-source framework for processing distributed streams. It is stateful and fault-tolerant and can seamlessly recover from failures; it runs on thousands of nodes with excellent throughput and latency characteristics; the framework has API and libraries for batch, streaming, machine learning, and graph processing. It can be used to optimize real-time e-commerce search results; for network/sensor monitoring and error detection; ETL for Business Intelligence Systems.
- Apache Cassandra is one of the technologies to which Facebook owes its immense success, since it is designed to handle large amounts of structured data across many commodity servers. Cassandra organises data in columns, yet, in contrast to traditional databases where only metadata is stored in the names of columns, with Cassandra, actual data is stored in the column name. Some of the advantages of the technology are its linear scalability; constant data replication in nodes; easily adding nodes to or removing them from a working cluster; high fault tolerance.
- Apache SAMOA (Scalable Advanced Massive Online Analysis) is an open-source platform for mining big data streams. The platform provides a collection of distributed streaming algorithms for the most common data

mining and machine learning tasks such as classification, clustering, and regression, as well as developing new algorithms.

SQL Queries Apache Hive is data warehouse software that facilitates reading, writing and managing large sets of data in a distributed data warehouse through SQL. Hive provides SQL query interface for data stored in different databases and file systems that integrate with Hadoop.

- Apache Impala is an open-source analytical database for Hadoop. It is used by Cloudera, MapR, Oracle and Amazon. Apache Impala supports SQL queries for data stored in HDFS and HBase in real time.

Data Mining Tools

At the stage of big data mining analytics, machine learning libraries and data mining tools are employed. Data mining is a process of discovering patterns in large data sets to extract new knowledge from data. The process uses specific algorithms, statistical analysis, artificial intelligence and database to extract information from huge data sets and transform that information into a comprehensible structure. Some of the most popular tools for industrial big data mining are:

- MLlib is Apache Spark's machine learning library which contains algorithms and methods for the entire machine-learning process.
- Apache Mahout is a framework used to create machine-learning algorithms that are focused on data clustering and data classification. Mahout is written in JAVA and contains JAVA libraries for math operations such as linear algebra and statistics. Apache Mahout's major features include: extensible programming environment; premade algorithms; math experimentation environment.
- Rapid Miner is a software platform for data analysis that combines data preparation, machine learning, text extraction and processing and predictive analysis. It is one of the leading data mining systems. The programme is written in the JAVA programming language and offers the opportunity to experiment with a large number of operators and a graphical user interface for fast modelling and data mining.
- KNIME (Konstanz Information Miner) is an open-source data analytics platform that enables users who are not experienced in programming to design predictive models. The platform contains multiple

modules and ready-to-use examples, as well as an array of integrated tools and algorithms for data analysis. KNIME rivals RapidMiner in data analytics and data mining.

- Python is a general-purpose programming language that can be run in Windows and Linux environments. Python is widely used in business and academic settings since it contains a large number of libraries for analysis, visualisation and machine learning.
- Rattle GUI is a free open-source software package that provides a graphical user interface for data mining and uses the R statistical programming language. Rattle is also used as a teaching facility to learn the R software language, for statistical analysis or the generation of predictive models and provides models for training, validation and testing.

Business Intelligence and Visualisation

Data ingestion collects raw data that is required for analytics; data integration brings different types of data together; data processing optimizes and arranges data for the purposes of analysis and visualisation. The aim of Business Intelligent Analysis is to answer different business-related questions and to improve management decision-making. By employing Business Intelligent Technologies, business analysts may summarise data and examine it in detail for designing dashboards and for interactive data visualisation.

There is a wide variety of BI software, some of the versions are free (QlikSense, Microsoft Power BI), while others are very expensive (Tableau, QlikView) but offer free additional features. Some are more suitable for specific applications, whereas others require comprehensive encryption skills or extensive experience in data analytics.

BIRT is a popular open-source technology platform. According to the Eclipse Foundation, BIRT is one of the most widely adopted technologies with over 12 million downloads and over 2.5 million developers across 157 countries. Major companies like Cisco and IBM have incorporated BIRT into their product lines. The platform can be incorporated into many other business applications, yet it requires extensive encryption skills, so organisations which do not have such resources may find it difficult to use.

Chartio is a cloud data-exploration tool that ensures easy and direct access to data in CVS or Google Sheets, as well as integration with other cloud applications. Looker is another BI software and SQL big data analytics platform.

3. Big Data in Business

The technologies presented so far make it possible to collect, process and analyse big data in order to solve different business problems that companies face. The major aspects of employing big data in business relate to the provision of operational activities, managing customer relations, marketing and pricing, and fraud detection.

Operational Analytics

Operational analytics relates to using big data in systems that analyse machine and sensor data in order to detect anomalies and problems in operational activities. Sensors and programs monitoring the operation of equipment feed data into operational analytics systems which is then used for analysis and preventive maintenance to lessen the likelihood of incidents or equipment failure. For many manufacturing processes, it is also important to predict the remaining optimal life of systems and components to ensure that they perform within specifications.

Optimising production lines can decrease costs and increase revenue. Big data can help manufacturers understand the flow of items through their production lines. Data analysis helps reveal which steps lead to increased production time.

Optimal network performance is essential in the telecommunications business. Network usage analytics can help companies identify areas with excess capacity and reroute bandwidth if needed. Big data can help companies plan for infrastructure investments and design new services that meet customer demands.

Customer Analytics

- *Studying consumer behaviour*

Businesses sell their products to customers using different channels, websites and even directly from their suppliers. This generates a large

volume of data about the interactions between merchants and their clients. Thanks to digital technologies, customers today are free to choose and buy products in physical or online shops by comparing their prices or they can even buy items from competitors' websites. Using data from real-time sources has proved to be difficult and historical data analytics of customer behaviour is not sufficient. By correlating sales figures with factors such as the time of purchase, demographic statistics, the items in the market basket, discounts and vouchers used, and external factors such as seasonality, merchants can learn more about customer behaviour. By integrating data from censors and CCTVs, they can understand purchasing patterns better and improve their offers.

Analysing all personal data about customers, customer interaction data and data from social media could result in optimised customer experience along all communication channels, improved brand loyalty, having end consumers personally engaged through personalised offers and effectively offering the right products or promotions at the right time.

- *Improving customer loyalty programmes*

Customer loyalty programmes are widely used to retain customers. The challenge now is to retain customers when competitors offer similar loyalty programmes.

Loyalty programmes provide valuable data to customers to identify information that can be extrapolated to larger unknown audiences. Furthermore, merchants can cooperate by creating unique offers based on combined purchases in addition to loyalty programmes.

- *Studying consumer opinion*

Advancements in digital and web-based technologies have equipped customers with multiple ways in which they can express their opinion about products via tweets, likes, mentions and recommendations. Since opinions are in a text format, text mining methods in big data systems help businesses detect patterns in unstructured data and identify fans, dissatisfied customers and users who influence other users in their buying decision-making. Analyses may relate to specific products, stores and staff in order to identify achieved remarkable results or areas that need to be further improved.

- *Raising customer satisfaction*

The use of technologies such as virtual reality, image recognition, artificial intelligence, etc. could significantly improve the choice of products and raise customer satisfaction with the purchase they have made. Examples include virtual product sampling (clothes, shoes). Lacoste created an application that enables their customers to virtually try on shoes and there are already more than 30,000 users of the application. Sephora introduced a virtual artist application that uses phone cameras to allow customers to try virtual make-up. In 2003, IKEA introduced image recognition and augmented reality in its catalogue applications so that customers could have an idea how the company's products would fit in their homes. The use of virtual reality helps customers make more informed purchasing decisions, increases customer satisfaction and results in fewer product returns.

Fraud Detection

Fraud detection is a topic applicable to many industries today. Fraud detection is an activity that is conducted in cooperation with financial organisations. Data analytics tools make it possible to monitor credit-card transactions in real time, while machine learning technologies design behaviour models to predict fraudulent attempts. Real-time analytics helps detect fraud and block potential fraudulent transactions in advance, thus preventing huge financial losses for both individual customers and companies.

Dynamic Pricing

Consumer demand is influenced by a number of external factors such as the season, the time of day, traffic and news about major events. Real-time automated analysis of competitors' pricing (using data from their sites) and external data which affect demand would enable businesses to adapt their prices on the spot.

Big data analytics may also be employed to segment customer profiles and design models of different customers that would be ready to pay a higher price under different circumstances.

In-store Optimisation

Geospatial data provided by GIS technologies helps track the movement of customers in stores. Data analytics about the movement of

customers in shops helps identify the most and the least frequently visited zones in a shop. Data from store premises and about customer movement may be combined with sales data (shopping history, online activity, etc.) in order to create personalised navigation routes and build shopping lists.

Conclusion

Big data is essential to the digital transformation of business. Artificial intelligence, machine training and the internet of things continue to be important factors to the digitisation of business, and companies increasingly rely on automated big data analytics performed by powerful business intelligent systems. Big data processing and analytics technologies are therefore rapidly improving to meet specific business requirements.

Due to their advantages, i.e. low costs and an innovative approach to design, open-source technologies are developing quickly and so is their application in the implementation of projects about using big data in business activities. The article presents some popular open-source technologies for big data processing which are also used in big data solutions by providers like Cloudera, Hortonworks, MapR, etc.

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BUSINESS management

D. A. Tsenov Academy of Economics, Svishtov

Year XXIX * Book 1, 2019

CONTENTS

In 2019, the printing of the journal will be funded with a grand from the Scientific Research Fund, NP 07/58 by the competition Bulgarian Scientific Periodicals - 2018.

Submitted for publishinq on 01.03.2019, published on 13.03.2019, format 70x100/16, total print 100

ISSN 0861 - 6604

BUSINESS management

PUBLISHED BY
D. A. TSENOV ACADEMY
OF ECONOMICS - SVISHTOV

1/2019

BUSINESS management 1/2019

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