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Address of the Editor
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e-mail: isim@sggw.pl, www.isim.wzim.sggw.pl

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Wydawnictwo SGGW
ul. Nowoursynowska 166, 02-787 Warszawa, Poland
e-mail: wydawnictwo@sggw.pl, www.wydawnictwosggw.pl

INFORMATION SYSTEMS IN MANAGEMENT

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Supporting Knowledge Workers: Case Management Model and Notation (CMMN)

Agnieszka Grudzińska-Kuna

Department of Computer Science, University of Łódź

Since the intensive computer automation of operational and administrative processes there has been an increase in demand for knowledge-intensive work. Knowledge workers have a significant impact on the companies they work in, but the processes they use in their work are not well supported by technology. Case management, with its data-centric and artefact-based approach to business process management, is emerging as a way to provide knowledge workers with the flexibility they need in planning and executing their tasks. In January 2013, the Object Management Group released the specification of Case Management Model and Notation (CMMN). The aim of this paper is to present CMMN basic concepts and provide some insights into ways CMMN can be used to support knowledge workers and their effectiveness and efficiency.

Keywords: knowledge workers, case management, model, notation

1. Introduction

Growing importance of knowledge workers as a valuable organizational asset has its origins in economic and organizational trends of the 20th and the beginning of the 21st Century. As production technologies developed, they generated more information flows and needed more communication to manage organizational processes. As a result, the demand for informational labour that is capable of handling, synthesizing, and creating knowledge has grown, while the demand for traditional manual work that can be easily replaced by automation and mechanization has reduced. Increase in industry productivity made room for new workplace in services re-
quired to meet the needs of modern, post-industrial society where economic success increasingly depends on ability to wisely use knowledge.

Workers who engage knowledge-intensive tasks in their daily work are referred to as knowledge workers. Their primary job is to create, distribute and apply knowledge. Knowledge workers differ from other workers in their autonomy motivation and attitudes [7]. Almost all types of job entail some mental effort but what differentiates knowledge work from other conventional work is processing of non-routine problems that require non-linear and creative thinking. In solving problems knowledge workers organize information artefacts, consider and transform them. They are guided by plans which are continuously adapted in reaction to changes of working environment. In modern organizations there are many people who do both knowledge and manual work. Drucker calls them “technologists”. Knowledge in technologist work is relatively subordinate but always necessary [5].

Over last decades it has been reported a growth not only in number of knowledge workers but also in their importance to organizational success. In 2007 McKinsey expected that by 2015 knowledge workers would have accounted for about 44 per cent of total US workforce.

Knowledge workers have significant impact on companies they work in but the processes they use in their work are not well supported by technology. In appraising performance of knowledge worker quality is the first criterion. It means that knowledge worker must or, at least, should concentrate on his or her tasks and eliminate everything else. Case management with its data centric and artefact based approach to business process management is emerging as a way to provide knowledge workers with flexibility they need in planning and executing their tasks.

In January 2013 Object Management Group (OMG) released specification of Case Management Model and Notation (CMMN). Aim of this paper is to present CMMN basic concepts and provide some insights in ways how CMMN can be used to support knowledge workers in improving their performance.

2. Case management

Case management as a practice was developed to help organizations such as government agencies, banks, big legal firms and insurance providers handle complex customer and service interactions. Set of activities, interactions with customer and other parties that are necessary to deal with customer request is known as a “case”. All information concerning the case is gathered in the case folder during the processing to record and to evaluate case progress. The staff working on the case can decide how some parts of the case should be handled relying on his or her judgement and discretion. Although cases follow some general patterns, each particular case can take its own path depending on circumstances and whose case is being processed.
In the business process management literature term “case handling” was introduced by van der Aalst and Weske in 2005 [8] who described it as “a new paradigm for supporting flexible and knowledge intensive business processes”. Building on deficiencies of traditional workflow systems they proposed case handling meta model which position case as a central concept - a “product” with structure and state. Proposed model assumed data and process integration because the state of case (i.e., which activities were enabled) was determined by the presence of data objects. Case workers (actors) could play multiple roles with different rights in model what guaranteed them some degree of freedom.

Forrester analysts define case management as “a highly structured, but also collaborative, dynamic, and information intensive process that is driven by outside events and requires incremental and progressive responses from the business domain handling the case” [5]. Whereas BPTrends in one of white papers characterizes case management as ”long-lived collaborative processes that coordinate knowledge, content, correspondence and resources to progress a case to achieve a particular goal; where the path of execution cannot be predetermined in advance of execution; where human judgment is required to determine how the end goal can be achieved; and where the state of a case can be altered by external out-of-band events” [7].

Both definitions highlight role of knowledge and information in case processing, unpredictable nature of cases, their dynamics, multiplicity of participants and roles, importance of collaboration and coordination. These characteristics indicate not only reasons why case management is so poorly supported but also challenges of its automation.

Staff acquire their knowledge through their experience working on similar cases and through collaboration, becoming thoroughly familiar with the tacit and explicit rules governing how cases should be managed. Obtained knowledge should be quickly applied to process definitions to improve them according to the assumption that solving new problems can be based on solution of similar past problems.

Case management entails collection of diverse data including documents, records, e-mails etc. They can be in different formats, structured and unstructured, can come from different resources. There is a need to effectively store, maintain and retrieve case information. Case data should be always provided in the context of current state of the case. Moreover it should be presented to all users in appropriate way and time so they do not become overwhelmed by its volume.

A case can change in unpredictable, dynamic and ad hoc ways as it is progressed through an organization. Although overall pattern of typical case is known, each stage can result in range of outcomes which determine next stage or stages. Traditional process automation assumes that a sequence or pattern can be defined a priori during analysis or design phase. Any routing that is not specified at design
time will not be supported by the system at run-time. However, as far as case automation is concerned, there is no predetermined sequence, and new tasks and processes can be added at any point during the life cycle of the case as the need for them arises. It does not mean that case management cannot be supported by IT or even automated. Any job represents a certain point of a spectrum running from “well defined procedure” to loosely defined “discretionary practice” [7].

Cases can evolve based on users’ decisions and experience. In the beginning of formalization case management practice users have to learn how to specify applicability rules for case activities. Over time they might find out some recurring patterns in case processing.

Presented characteristics of case management cannot be expressed in Business Process Model and Notation (BPMN) which is de facto modelling standard of control flow based processes adopted by most state-of-art business process management systems (BPMS). Dealing with unique, unpredictable cases requires different analysis techniques, different notation and new tools that will implement them. The tools should allow knowledge workers to be involved in designing of processes they participate in. Knowledge workers should be able to define the processes, make changes to them by themselves as a part of their process work. For these reasons OMG and several BPMS vendors have shown an interest in standardization of case management modelling.

3. Case management model and notation (CMMN)

3.1. Background

In January 2013 OMG released beta version of CMMN specification which is currently in finalization phase [5]. It has been developed to complement BPMN in modelling and managing processes that depend on circumstances and ad-hoc decisions of knowledge workers. CMMN draws on variety of concepts. Many of them can be traced back to the literature and commercial products.

Business artefact is one of the most important notions that laid foundation for CMMN. According to Bhattacharya et al, a business artefact is defined as a business entity used to store information pertinent to a given business context and meaningful to the business user. It has a lifecycle from creation to completion and unique identifier that allows identification of an artefact across the enterprise. Business artefacts allow for measuring whether or not business goals are going to be achieved. [5]. To represent artefact lifecycle, finite state machines were widely used (e.g. by Kumaran et al in ADocs ) [5]. The states are thought of as milestones, i.e., business-relevant operational objectives that an artefact may meet (c.f. Business Entity Lifecycle Analytics method). Declarative lifecycle models were adopted for process management flexibility. The Guard-Stage-Milestone (GSM) ap-
proach was introduced by Hull et al for specifying business entity lifecycles [8]. It enhanced business artefacts to the point that OMG has found GSM to provide basis for CMMN core model.

At least three commercial products have been influential in CMMN development: FLOWer by Pallas Athena (meta-model presented by van der Aalst and Weske was formalization of FLOWer assumptions), IBM Case Manager (developed on GSM ideas, deploys case folder hierarchy and document classes) and Cordys Case Management (uses concept of case file as an information model and activity cluster as building block of behavioural model, offers ability for users to alter run-time plan).

3.2. Model

A case is a central notion of CMMN meta-model. OMG defines case “as a proceeding that involves actions taken regarding a subject in a particular situation to achieve a desired outcome” [1, p.15].

Case is top level concept that combines all elements that constitute case model: case file, case plan and case roles. Figure 1 presents relations between case and its plan model.

A case is different from a process which is predefined, fully specified and repeatable. Process model specified at the design time serves as its plan for execution. Process planning is equivalent to process modelling. Fundamental characteristic of case management is planning at run-time. During the design-time phase, business analysts define tasks that are always part of pre-defined segments in the case model, and “discretionary” tasks that are available to the case worker, to be applied in addition, to his/her discretion. In the run-time phase, case workers not only execute the plan, particularly by performing tasks but they can add discretionary tasks to the plan of the case instance as well. This run-time planning is based on information that has become available to the case.

Documents and other unstructured or structured data about a case are captured and referenced in the case file for decision-making by case workers. Case file is logical information model. Information in the case file serves as context for raising events and evaluating expressions as well as reference point for case parameters, such as inputs and outputs of tasks. Case file also serves as a container for data that is accessible (through case parameters) to other systems and people outside the case.

Plan model contains all elements that represent initial plan of the case and all elements that support the further evolution of the plan through run-time planning by knowledge workers. Plan consists of tasks, event listeners and milestones organized by stages, meant to handle the case.

Task is an atomic unit of work. It can denote human task or serve to invoke processes or other cases. Event listener is used to capture time and user events.
Milestone is a plan element, which represents an achievable target, defined to enable evaluation of progress of the case. Stage can contain any element required to construct and further evolve case plans. It is a recursive concept - stages can be nested within other stages. The “most outer” stage is associated to the case as its plan. Stage has its run-time representation, thus its progress and completion can be tracked based on its lifecycle.

Sentry is a criterion to enable or terminate a task or stage or to achieve a milestone. It is defined as combination of zero or more events and zero or one condition. A sentry, as criterion, is satisfied when the event(s) has (have) occurred, and the condition has evaluated to “true”. Sentries express dependencies between plan items. If sentry is satisfied, plan item is enabled (entered) or terminated (exited). For example: completion of one task satisfies the sentry that enables the start of the other.

Figure 1. Case model as UML class diagram
Source: Own elaboration based on [5]
As mentioned above, planning is a run-time effort. It is regulated by planning table that defines scope of planning. Planning table comprises set of elements that can be considered for planning stage or task, rules that regulate their applicability and references to roles that are authorized to use the elements to their “discretion”.

3.3. Notation

The CMMN notation provides for the depiction of the behavioural elements of a case (i.e. elements of a plan). Case plan is depicted using a “folder” shape with the name of the case. All elements of case plan model are located within boundaries of case plan shape. Because of declarative nature of CMMN relative positions of shapes have no meaning. Every type of plan item has individual shape assigned to it. A stage is depicted by a rectangle shape with angled corners whereas task is a rectangle with rounded corner. Depending on type and/or parameters, task shape can have some additional symbol placed in upper left corner (e.g. “hand” symbol denotes non-blocking human task). Composite elements (e.g. stages) can take collapsed or expanded form. Discretionary items are outline with dashed lines. Plan items may have associated sentries. Sentry can be used as entry (shallow “diamond” shape) or exit criterion (solid “diamond” shape). When allowed, “diamonds” can be placed as decorator anywhere on the boundary of a plan item shape. Rectangle with half-rounded ends gives a picture to milestone. An event listener is depicted by a double line circle shape with an open centre so that markers can be placed inside to indicate variations of an event listener. Certain dependencies between elements (e.g. when one task depends on completion of other task) can be expressed by connectors. The shape of the connector object is a dotted line.

A stage or a human task can have a planning table. A planning table is symbolized by a “table” shape composed of six cells with the centre bottom cell containing a marker indicating if the discretionary items are visualized or not. The planning table symbol can only be placed as a decorator on the boundary of a stage or a human task.

Figure 2 illustrates process of paper writing modelled with CMMN. Paper writing is undoubtedly intensive knowledge work. It can be handled in different ways. Process has two milestones (draft completed and document completed) that have to be reached. Many tasks (e.g. seek comments) or even stage (i.e. review draft stage) is left to the discretion of the author – case plan and both stages have expanded planning tables. Prepare draft stage with write text task is mandatory. This stage has defined repetition rule what is symbolized by repetition decorator (three bold, black bars). It can be altered by further research or graphic creation. Process will be finished when document is created or the deadline is reached.
4. Summary and conclusion

Although knowledge work is based on using knowledge, creativity and experience in handling unpredictable and unrepeatable cases, it can be guided and assisted by case management systems. Cases as essential proceedings can be modelled and executed to certain extent. Knowledge workers should be able to define at least “documents” that case is assumed to require or produce, the roles that perform the work and non-exhaustive and maybe only preliminary list of activities that might be relevant in the context of the case. CMMN with its tasks, event listeners, milestones and planning tables offers appropriate tool for this type of modelling. Modelling itself can help knowledge worker to think out his or her tasks to eliminate everything that hampers their performance. Moreover creating the model is first step in implementation of case management system which conducting “rou-
“tine” activities allows knowledge workers to concentrate on crucial and creative ones. User is not obliged to predict thoroughly the entire case proceeding, but she or he is rather expected to model some main episodes of the case which provide basis to create and execute case instances. CMMN follows evolutionary paradigm. It assumes that during execution with gaining experience user will be able to reveal and define more plan elements and the rules that regulate their applicability and behaviour, and then to incorporate them iteratively into case model. Building on variety of concepts CMMN represents universal solution that provides interoperability (XML Model for Interchange, XML Schema) and execution semantics.

REFERENCES


INFLUENCE OF MODERN TECHNOLOGIES ON INTERNATIONALIZATION OF SMALL AND MEDIUM ENTERPRISES

JOANNA KOS-ŁABĘDOWICZ
Department of International Economic Relations

This paper describes ways in which small and medium enterprises (SME) can apply modern information and communication technologies, threats and chances connected to such application, potential barriers stopping use of modern technology and ways such solutions may be used during internationalization of SMEs.

Keywords: small and medium enterprises, SME, Internet, modern technology, internationalization

1. Introduction

Internationalization steadily becomes an important factor in competitiveness of enterprises, regardless of their size and area of interest. Small and medium enterprises (commonly abbreviated to SME) often begin their business with their eyes set on global market and utilizing global-oriented strategies. They often see – and take advantage of – opportunities to work across political borders, resulting in not only significant increases in revenues, but in exchange of knowledge and know-how. Such exchanges invariably prove profitable to all parties involved, increasing their ability to compete with companies not involved in the network.

Internationalization of SME can take various forms: it often involves export of goods, creation of international alliances and development of company branches abroad.
Information and communication technologies simplify and boost development for all kinds of enterprises, yet in case of small and medium enterprises, the influence is far better visible. Activities such as searching for new markets become easy, companies find various economical barriers reduced, which in turn decreases costs of international operations. It is a subject of vital importance for both companies that can increase their competitive ability, as well as for the consumers, who gain access to wider array of products, services and information – all due to Internet access. It is also worth mentioning that in spite of significant advantages that new technologies provide for SME, those solutions are not free of flaws and they do have their own barriers and limitations [1].

2. The process of internationalization of SME

Internationalization of an enterprise is a gradual process. The company actions and activities becomes more and more international, knowledge of external markets grows, as does its experience in conducting deals abroad. Cultural barriers become less problematic and cause fewer problems as experience grows, leading to lower risks – both real and perceived – associated with the process of internationalization [1].

Definitions of internationalization of a company differ between various publications, but they all have a common trait: most authors see it as gradual process, progressing in discernable steps. Example of such step-based model could be a situation where company progresses from selling on its own marked, then moves to taking minor orders from abroad, then starts taking on major orders from other countries and finally ends up as experienced exporter on large scale [2]. Current version of Uppsala model (the 2009 revision) emphasizes importance of cooperation and creation of a network between companies in order to facilitate exchange of experiences, reduce physical distance to new markets, lower the risks associated with entering new markets and increase chances of success for cooperating companies [3]. A common issue, often mentioned in professional literature, is the significant difference between high-tech SME (HTSME) and SME in traditional branches of industry. HTSME operate on very fast-changing, turbulent and unstable markets, where windows of opportunity are usually very short and require significant flexibility to take advantage of. Considering factors common to high-tech markets, like narrow specialization, short-lived products and low internal demand (especially significant in case of small courtiers), HTSME should focus on international markets – or even the global market – from the start (the so-called “born global” concept) [4, 5].

There are four paths of access to international markets [6]:

- penetration into international markets through practicalities (for example by extending connections already present),
- gradual entering to markets that are closest in geographical sense,
- dynamic penetration when market conditions become convenient,
- dynamic penetration by early adaptation of new technologies.

Two former approaches are examples of gradual approach, whilst two latter are more organic and are most useful in companies that utilize e-commerce solutions [7].

When it comes to discussing the issue of internationalization of SME, it is very important to remember that SME are not small version of corporations. There is a significant difference in available resources, fields of activity, methods of management and overall abilities between an SME and a corporation. Those differences result in a different way internationalization will progress in both cases. Of course, there is no reason the process may not be similar – depending on approach the owner or managers (in case the owner is not actively managing the company) take, the internationalization of SME might be as complicated as internationalization of a corporation. The inherent weaknesses of SME are – in the first place – inability to gather experience and develop in any significant way on the primary market before expansion and difficulties in identification of possible expansion targets and choice between markets to expand to. The greatest advantages SME have over the corporations in the process of internalization are: ability to quickly react to market changes and customers demands, greater flexibility and closer relations to customers – which in the end translates to better handling of niche markets and competitive advantage in comparison to larger companies [8]. The main barriers that make SME internationalization difficult are, among others:

- high cost of internationalization, including analysis of new markets, legal consultation cost, cost of translating documentation, adaptation of the products to market requirements, travel costs,
- higher business and financial risk,
- existing regulations and legal limitations, bureaucracy,
- difficulties in capital acquisition, payment delays,
- tariffs,
- insufficient management and marketing skills,
- difficulties in accessing necessary information and knowledge,
- difficulties in finding partners and representatives on the new markets

The aforementioned difficulties, often encountered by SME during the process of internationalization can vary in intensity and specifics, depending on company’s country of origin. Differences can manifest due to variety in size of the market of origin (large vs. small) and its degree of development (developing vs. developed) [9]. It is important to remember that the Internet by itself does not provide any universal solution to aforementioned barriers in internationalization. Nonetheless, with proper application, the Internet becomes a useful tool, allowing many barriers to be reduced or removed, speeding up the process considerably.
3. Modern technologies in hands of SME

SME existing in turbulent and ever-changing economical environment can gain substantial advantage with implementation of modern information and communication solutions. Globalization and technological progress cause change in expectation of both the customers and business partners and force the introduction of modern technology in daily work of the company. One of the main advantages SME gain due to implementation of modern information and communication technology is the access to information infrastructure that could be compared to infrastructure normally available only to large enterprises. Application of modern technology increases company’s capability of both internal and external communication in the degree available only to large companies – until recently. Improved communication with recipients, suppliers, business partners, even rivals, can result in adding new value to products and services and, what is even more important in age of information, allows trade of concepts and intellectual property. The small businesses, due to their size, are extremely adaptable. This attribute results in ability to gain a competitive advantage due to being able to apply the Internet as a tool faster and more flexible than a large company would be able to. The increasing range of available solutions gives SME a chance to make use the opportunities offered by information systems[10].

Most commercial applications of the internet consist of information exchange tools (ie. e-mail, chat, videoconference, EDI systems), WWW sites used for information acquisition or transaction facilitation and creation of company’s own WWW site. Application of the Internet in enterprise’s daily work will be dependant of company’s area of expertise and the product it is manufacturing: it can be expected that IT companies will be far more willing and able to use the Internet than their non-IT counterparts. Least degree of application of e-business solutions can be seen in public sector, education and non-profit sector. The most popular and commonly used Internet tool is the website, a tool of great information capacity and a platform allowing use of other communication tools[11]. The website is most often a base for marketing communication, a tool for on-line promotion and a way to present the company on the outside. It is often a way to show plans, goals and ideas that should be associated with the company [12].

The Internet-based tools, such as aforementioned websites and communication tools, can be used to achieve various goals, such as [13]:

- Increase in efficiency of company’s activities:
  - Promotion of the products,
  - Creation of new selling channels,
  - Reduction of costs,
  - Decrease in distribution time,
  - Simplification and improvement of customer service,
- Shaping and perfecting image of the company and the brand,
- Creation and upkeep relationships with business partners,
- Acquisition of market data,

- Transformation of company’s organization schema:
  - Learning the new technologies and their applications,
  - Experimentation with new organizational structures,
  - Customer relations management

- Redefinition of the way organization works:
  - Availability of new possibilities regarding the products,
  - Ability to apply new business models

The research shows that the Internet and Internet-based technologies are of great importance to development of SME in countries both developed and developing. Table 1 shows most commonly encountered uses of the Internet by Australian SME, according to annual Sensis report [14], along with results of research done by McKinsey Institute, concerning use of Internet by SME in developing countries with special emphasis on the technologies that have the greatest influence on increase of SME revenue [15].

**Table 1. Internet usage by SMEs**

<table>
<thead>
<tr>
<th>Current uses of the Internet by SMEs (Australia)*</th>
<th>Benefits of Internet for entrepreneurs (aspiring countries)</th>
<th>Technologies leading to higher revenue and lower cost of goods sold (aspiring countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Communication via email</td>
<td>- Increased reach to more customers</td>
<td>- Electronic messaging</td>
</tr>
<tr>
<td>- Searching for information about products and services, reference information or research data</td>
<td>- Ease of doing business-related research online</td>
<td>- Social networks</td>
</tr>
<tr>
<td>- Internet banking</td>
<td>- Reduced cost of doing business</td>
<td>- Web site</td>
</tr>
<tr>
<td>- Searching for suppliers of products or services</td>
<td>- Increased access to investors</td>
<td>- Online marketing</td>
</tr>
<tr>
<td>- Promotion of the company</td>
<td>- Ability to register business online</td>
<td>- Cloud</td>
</tr>
<tr>
<td>- Streamlining communications with customers and staff</td>
<td>- Increased access to investors</td>
<td>- E-business solutions</td>
</tr>
</tbody>
</table>

* Includes only activities reported by more than 60% SME


Introduction of information and communication solutions in SME is not a simple and risk-free process. SME encounter numerous difficulties, barriers and
limitations in introduction of e-business solution in their business model. Table 2 presents some of the problems SME might encounter in an attempt to introduce information technologies in their operations [16].

<table>
<thead>
<tr>
<th>Category</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural</td>
<td>- Fear of IT and resistance to change</td>
</tr>
<tr>
<td></td>
<td>- Trust and quality of support to companies</td>
</tr>
<tr>
<td></td>
<td>- Commitment of time by SMEs</td>
</tr>
<tr>
<td>Financial</td>
<td>- High initial set-up cost</td>
</tr>
<tr>
<td></td>
<td>- Additional cost due to the change</td>
</tr>
<tr>
<td>Technical</td>
<td>- Weak skills base</td>
</tr>
<tr>
<td></td>
<td>- Security/privacy issues</td>
</tr>
<tr>
<td>Access</td>
<td>- Lack of training opportunities and networking</td>
</tr>
<tr>
<td>Knowledge</td>
<td>- Ownership of data, intellectual property</td>
</tr>
<tr>
<td>sharing</td>
<td></td>
</tr>
<tr>
<td>Awariness</td>
<td>- Lack of awareness of potential of ICT</td>
</tr>
<tr>
<td></td>
<td>- Lack of proven best practice examples</td>
</tr>
</tbody>
</table>


SME that become early adopters of information technologies have a significant chance of gaining great competitive advantage comparable to advantage gained by companies that enter a given market first. The basic incentives to implement information technology early are, among others: lower costs and comparatively low risk, improvement of relations with providers and recipients, better control over distribution process and improvement of products’ marketing.

4. Modern technologies and SME internationalization

Internet and modern communication and information technologies connected to it should be of great interest to enterprises that are planning to internationalize their business. The geographical distances and political borders steadily become of less importance due widespread Internet accessibility, mainly due to simplifying the contact between organizations and making it far faster than it has ever been in history. Using the Internet to communicate is a significant asset to an SME that is trying to become an international company; it is not only a way to lower – or even eliminate – traditional barriers SME face in entering external markets, it is also a signal to potential partners that the company is both modern and flexible.
Using both Internet and e-commerce, SME can comparatively easily access new customers and external markets while still maintaining a presence on company’s market of origin, even in absence of any significant knowledge about the external markets. Another factor that makes the internationalization process easier is the adaptation of real-time communication over the Internet in the form of Voice over IP (VoIP), often extending to videoconferences. This manner of communication has a significantly lower cost that traditional forms of long-distance communication and adds to elimination of geographical barriers between the company and its customers and providers.

A research conducted among British industrial SME allowed for mapping of areas in which the Internet can simplify the process of internationalization of a company. The researchers analyzed three groups of SME; the selection was based on Research & Development spending, the groups were named low-tech, medium-tech and high-tech. The main subject of the research was the degree the Internet was used in the company and how big is its influence on the internationalization process. The results are shown in Table 3. The research have clearly shown that the Internet have the greatest value for high-tech SME, especially in the area of market research, customer relation management and increasing company’s share in worldwide business networks, a process which results in acquisition of new business partners and providers. In case of low-tech and medium-tech enterprises, the Internet is mainly used to maintain existing business relations and reduction of cultural barriers in acquisition of new customers and agents. In conclusion, the more the SME utilizes the Internet and associated modern technology – including the communication and presentation tools – the greater the influence on the internationalization process. In other words, the more tech-savvy the company is, the greater role the Internet plays in both its daily operations and long-term plans – including plans of internationalization [17].

Despite of the obvious advantages the application of Internet grants in the process of internationalization of SME, there are several potential problems and disadvantages that must be considered before drawing final conclusions. Utilizing the Internet as distribution and marketing channel (replacing traditional export) will not increase the sales by itself. The company must conduct normal marketing activity at the same time – of course, those activities can be conducted using the Internet channels as well – and provide post-selling services (service that normally – in the classic, non-Internet model – would be rendered by the agent or trade office). Replacing the agents entirely by Internet-based trade may result in increase of distance between the customer and company, in worst case – disassociation of the product and the company in the eyes of the customers. Such situation may result in loss of customers, lessened knowledge about markets and – in the end – incomplete or erroneous picture of the target market [18].
Table 3. Internet usage and the influence of the Internet on internationalization

<table>
<thead>
<tr>
<th>Level of technology of SMEs</th>
<th>Internet usage</th>
<th>Influence of internet usage on internationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High-technology SMEs</strong></td>
<td>Web site</td>
<td>Supporting communication with worldwide customers</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
<td>Intelligence gathering</td>
</tr>
<tr>
<td></td>
<td>Video-conferencing</td>
<td>Making new personal customer contacts</td>
</tr>
<tr>
<td></td>
<td>Search Facility</td>
<td>Providing product information for customers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Responding to pre-sales customer information requests and pre-sales production consultation for customized offerings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication with agents/distributors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Investigating potential foreign suppliers</td>
</tr>
<tr>
<td><strong>Medium-technology SMEs</strong></td>
<td>Web site</td>
<td>Supporting communication with international customers</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
<td>Product promotion</td>
</tr>
<tr>
<td></td>
<td>Online technical support</td>
<td>Making direct contact with prospective customers</td>
</tr>
<tr>
<td></td>
<td>Online tracking order</td>
<td>Providing product information for customers</td>
</tr>
<tr>
<td></td>
<td>Advertising and promotion</td>
<td>Responding to pre-sales customer information requests and pre-sales production consultation</td>
</tr>
<tr>
<td></td>
<td>Search facility</td>
<td>Reducing communication barriers and social and cultural distance with international customers</td>
</tr>
<tr>
<td></td>
<td>Video-conferencing</td>
<td>Communication with agents</td>
</tr>
<tr>
<td></td>
<td>Newsletters</td>
<td>Cost savings in travelling</td>
</tr>
<tr>
<td><strong>Low-technology SMEs</strong></td>
<td>Web site</td>
<td>Supporting communication with customers in Europe</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
<td>Providing online marketing material</td>
</tr>
<tr>
<td></td>
<td>Online product catalogue</td>
<td>Providing pre-sales product information</td>
</tr>
<tr>
<td></td>
<td>Online ordering system</td>
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<tr>
<td></td>
<td>Announcements</td>
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<tr>
<td></td>
<td>Newsletters</td>
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<tr>
<td></td>
<td>Customer satisfaction feedback</td>
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</table>


Many businesses tend not to include in their estimates that using Internet to compete on new market means that they will encounter a whole new group of companies that already use Internet and that competition may be even greater that
on their domestic market. SME should take into consideration an uneven availability of the Internet in various countries – obviously, the Internet has the greatest presence in developed countries, while in their developing counterparts, access is often limited both in quantity (to urban areas or even to the wealthy minority) and quality (due to weak connections or governmental control). This factor heavily influences the applications of Internet in expansion to developing countries.

Taking the above mentioned issues into account, SME that choose to apply modern technology in the process of internationalization must carefully consider the pros and cons, deciding in which degree are they going to use traditional methods of internationalization, and in which degree will they support – or replace – them with the Internet-based tools, moving their activity to the virtual world.

5. Conclusion

The internationalization processes of SME and large corporations are significantly different. Nonetheless, the SME version can be complicated as well, and encounters many difficulties typical for the SME sector, like limited access to resources and financing, lack of proper qualifications, etc. Implementation of modern information and communication technology can simplify the process to a great degree, but not without inherent risk. SME accessing the modern markets with application of new technologies must be aware of larger competition and change of conditions defining the company behavior. Research mentioned in this paper show that SME apply the Internet and associated technology to varying degree. The variety is often based on their market of origin and area of industry they operate in. The area in which SME apply the new technologies – with special regard to the Internet – is obviously wider in case of high-tech companies. Application of information and communication technology in the process of internationalization is prevalent in such areas as customer service, business-to-business relations, creation of new relations, acquisition of market information and online sales. New technologies simplify the process of SME internationalization, nonetheless the enterprises must be aware of limitations and risk connected to different market conditions and increased global competition coming from other companies.

REFERENCES


THE ANALYSIS OF INFORMATION SYSTEM IN LOCAL GOVERNMENT UNIT – THE PROPOSAL OF RESEARCH METHODOLOGY

ANNA MUSIÓŁ - URBAŃCZYK, BARBARA SORYCHTA - WOJSCZYK

Politechnika Śląska, Wydział Organizacji i Zarządzania, Instytut Zarządzania i Administracji

The information system in a local government unit should ensure an adequate flow of information to ensure the efficient and effective management of the unit. All organisations should take care of the quality and quantity of available information. This objective can be achieved by the continuous diagnosis and assessment of the functioning information system to draw meaningful conclusions, to identify actions for its improvement in order to make the system an effective support for managerial processes and adequate tool to the needs of the activity of a local government unit.

In the article the authors proposed the research methodology of the analysis of the information system in a local government unit. The proposed research methodology is based on questionnaire surveys, which allows a thorough diagnosis of the information system in local government units to identify the deficit in the tools applied in these units and to identify actions to improve the system.

Keywords: information system, local government unit, research methodology

1. Introduction

Changing internal and external circumstances of business activity need to be adapted in company’s business processes by effective management both in the short term and in the long term perspective. Effective management is determined
by the adequate and detailed information about the organisation and its environment. The commune is a special kind of a company which is influenced by the dynamic environment. The adequate flow of information in the commune is one of the key factors determining the effective and efficient management. The sustainable and effective development in the commune needs the process of creating an adequate information system, which is determined by the unique past and present business processes according to applicable laws and regulations. Thus, the important issue is the detailed analysis of an information system in the commune and its permanent evaluation in order to make it adjusted to the needs of the commune’s activity. In this context, it is difficult to imagine a modern and well-functioning commune without the effective information system and the computer system properly adopted to its needs.

Modern organisations realize more and more projects that play an increasingly important business role not only in companies but also in the public sector. Projects are tools for the strategy implementation of the organization. Any organization, including the local authority, has a specific objective to be achieved. The main way to implement the strategy into operational actions is the transformation of the strategy into the appropriate set of projects and programmes. A set of projects and programmes and other activities related to the work carried out in the organization is referred to as the projects portfolio. Efficient and effective management of the projects portfolio’s implementation is made possible by providing the access to information and the proper information flow at each stage of implementation. The appropriate quality and quantity of information in the process of portfolio management in a local government unit contributes to the effective implementation of its strategy.

In the article the authors proposed the research methodology in the range of the analysis of the information system in relation to the whole functioning of a local government unit and the analysis of the information system in the range of projects portfolio management. The proposed research methodology is based on the research questionnaire, which enables a detailed diagnosis of information systems of local government units and the identification of the deficit in the tools used in these units. As a result it will help to identify actions improving functioning of the information system.

2. Information system in a local government unit

2.1. The definition of an information system

The quality of the management system is determined by the quality of the information system as a key tool to realize effective decision-making processes.
One can assume that the building of the functional information system leads to the efficient management of the organization.

There are various definitions of an information system. The definition depends on the objective for which the system is needed or on the discipline concerning its user. The information system is defined as a communication system of organisation that integrates the elements of the management system [7]. The management system in an organization is a set of activities covering the entire cycle of management processes to achieve the objective efficiently and effectively. According to [6], [7], the information system can be defined as a multilevel structure allowing the user to process the input information into the output information using procedures and models. As a result of the output information, decisions are made more effectively. The information system can be defined as "a specific nervous system of the organisation that integrates the elements of the management system" [9]. This statement emphasizes the priority function of an information system i.e. the support for efficient management process in the organisation.

The role of an information system for efficient management is emphasized, inter alia, in [5], in which it is stated that "the degree of efficiency of communication among organisation’s elements, between organisation’s elements and the environment, and the whole organisation and its environment is a direct link with the efficiency of the entire organisation". The information system of management is "an organised set of people, procedures, processes, databases and devices used to provide information for managers and decision makers" [5]. The information system is an element of the management system which enables the implementation of management processes. The information system is connected with organisation’s activity including inputs, outputs, information flow and processing. The analysis of the information system should take into consideration the following functions [15]:

- the function of downloading input information (documents, messages) and information storage in a sustainable way (files, directories or archives),
- the function of information processing, calculation of indicators characterising organisation’s activity, transferring the processed information to the organisation’s outputs,
- the function of supporting a decision making process by operations on indicators (reasoning on the basis of stored information).

At present, the emphasis is put on the speed of information delivery, its availability and processing ability. These requirements bring the situation that more and more elements of organisation’s information system is computerized. And as [9] reported, in the future there will be no differences between the concept of "the information system" and "the computer system" concerning management
information systems, because there will be no information systems without hardware.

Taking into account the relationships between the information system and the management system, we can say that the information system is the element of a management system. The information system makes management processes possible to be realised, because the information enable making decisions. The system as "the separate part of the information system which is computerized from the point of view of its objectives " is the most detailed term.

2.2. The structure of an information system in a local government unit

The description of an information system is the result of the analysis of business processes and information flows within the company. The analysis of the information system gives the picture of a current state, which is characterized by the following elements [15]:

- statutes, resolutions, orders, directives, decisions determining organisation’s objectives and conditions for the formation of an organisational structure, competence and communication links;
- business regulations and documents necessary to perform the functions of individual organisational units;
- ways of communication between individual organisational units;
- ways of communication between the environment and organisational units in conjunction with realised tasks.

The description worked out with making use of this method contains the elements concerning the organization - the list of tasks, an organizational structure and specific elements - functions of individual units, documents. The following necessary step is to organize and systematize of the generated description. It is connected with the introduction of standardized signs and hierarchy of analysed object’s elements.

The analysis presented in the article concerns the information system of local government units. However, later in the article considering the information system in local government units (communes, districts, provinces) we mean the office of these units (i.e. commune office, district office, voivodeship office). The courthouse (including the town office, the commune office), which is the organisational unit of communes, whose core activity is the support of mayor in the implementation of the commune’s resolutions and commune’s tasks determined by state law and teams of material and personal resources in a local government unit to ensure technical and organisational support. The commune office consists of departments, equivalent organisational units and independent organisational units. The organisational structure and functioning rules of a commune office are defined in the regulations issued as the mayor’s ordinance. The office operates according to
generally applicable law, the commune statute, the city statute and other council’s resolutions, ordinances and other legal acts in the area of organisation, issued by the mayor. The management system of a commune council is based on management control standards issued by the Minister of Finance. The key tool for forming management of the office are organisational ordinances. The mayor is the head of a commune council. The organisation and work orderliness at the office and related rights and obligations of an employer and employees are determined by regulations and other legal acts. Similar tasks are realised by departments in the office created by the mayor who defines the range of their tasks. Departments are managed by heads, except for the Civil Registration Office, which is managed by the manager and independent units led by supervisors. In the range of departments the mayor can create independent units and positions. Tasks realised by commune office are supervised, monitored and controlled. For this purpose, there are terms specified in the legal regulation in the area of commune’s organisation, using the following tools:

- an organizational chart reflecting the division of responsibilities in the commune office,
- systems for monitoring tasks’ realisation and their objectives, functioning at the operational and strategic level,
- risk management,
- financial audit carried out particularly in the form of self-control and functional and institutional control,
- management system audits conducted by the internal auditor according to the Public Finance Act,
- the review of management system, implemented in the form of annual surveys based on the current monitoring results and the target review, fixed by the mayor or a person designated by him.

Projection and development of software solutions supporting management processes require different methods of analysis and modelling of the information system [3]. In general, the concept of the information system in an organisation should be identified making using of typical elements of the system analysis. Taking into consideration such an approach the whole procedure of the model construction should begin with a thorough analysis and verification of sets of appropriate inputs and outputs of the system. The analysis should take into account the functional structure of the organisation, which includes existing information inputs and outputs of the system. As a basis for the analysis of the information system of a functioning organisation should be the research undertaken by using a formal procedure. According to the classical method of the information system analysis, the diagnosis procedure should include the following steps [13]:

1. The determination of the characteristics of the enterprise’s organisational structure taking into account the division into functional units.
2. The development of the description of the organisational structure.
3. The development of the information system model of the analysed object and the further analysis and verification of information links.
4. The impact assessment of information links on decision-making processes in an enterprise and the identification of changes opportunities.

The research conducted by Grochowski and Kisielnicki in 2000 [7] was concentrated on improving the functioning of the Białystok Town Office and resulted in the proposal of the office information system (Fig. 1). The objective of the system was to ensure efficient information flow and consequently faster decision-making.

![Diagram of information relationships in the Białystok Town Office](source: [7])

**Figure 1.** Information relationships in the Białystok Town Office

Source: [7]

3. Assumptions and objectives of the research

The issue of information systems is often undertaken by many researchers. Most often, however, they engaged in business information systems (A. Gumiński, W. Zoleński, J. Kisielnicki, S. Senczyna, K. Wodarski, A. Kozmiński, W. Piotrkowski, G. Morgan). There are a small number of studies - particularly in Poland - concerning information systems in local government units.

Local government units are obliged under the law to realise a lot of tasks, and one of them is to work out and implement development strategies. The Act of 6th December 2006 on the principles of development policy clearly indicates the
principles of development policy and procedures for cooperation between them [the Law of 5 June 1998 on Regional Government, as amended. d. (Journal of Laws 1998, No. 91, item. 576)]. In accordance with Art. 4 of the Act, policy development should be carried out on the basis of the development strategy using programmes that lead to achieve the objectives.

Achieving the vision of the development and the implementation of strategic objectives require the preparation and realisation of projects. Working out the system for managing a projects portfolio in a local government unit can make this process effective. Such a system cannot be separated from the information system of a local government unit. It should be properly integrated with the existing information system. To make it possible it is necessary to analyse:

- channels of communication between departments,
- channels of communication between a local government unit and the environment,
- organisational regulations, statutes and other documents relating to the tasks of organisation,
- competences of individual organisational units (departments, independent units, authorities of these units).

Efficient planning and effective management of the realisation of programs and projects is essential to ensure the success in the effective implementation of strategies of local government units. To ensure the effectiveness of this process it is necessary to make the information flow efficient and as a result faster and better decisions. The literature study in this area, and preliminary case study in selected local government units show that a large part of the information is collected traditionally or in stand-alone, not in network computers. The cooperation between organisational units is weak and there is indirect realisation of individual tasks, and are long decision-making terms. Therefore, it is necessary to undertake the study in order to analyse the information system in selected local government units to work out the computer system supporting projects portfolio management.

The achievement of the main objective can be possible by realising the following steps:

- the identification of the information system elements in a local government unit,
- the diagnosis of a functional range of implemented IT solutions in selected areas of management in a local government unit,
- the definition of roles and relationships of the information flow between departments in a local government unit,
- the diagnosis and analysis of information flow in the process of project management,
- the identification of decision-making competences in the range of project and projects portfolio management,
the determination of the deficit in the applied tools in local government units,
• the development of the model of the information system of projects portfolio management in local government units.

The research will be conducted in the area of Silesia Voivodeship in selected offices of local government units (communes and towns with county rights).

4. The research procedure

Based on the literature study and web/desk research the authors suggest that the proposed research methodologies in the range of information systems analysis in local government units do not meet the research purpose and the research object. And this is the reason why the authors propose the research procedure which is described below. The research are to be undertaken in six stages. The research procedure is shown in table 1 and includes the description of the research stages and proposals of methods and research techniques.

<table>
<thead>
<tr>
<th>Stage</th>
<th>The range of the stage</th>
<th>Methods, research techniques</th>
<th>Research tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Working out theoretical assumptions based on the study of literature and source documents</td>
<td>web/desk research research of documents, observations.</td>
<td>development, research reports, legal acts, websites regulations and resolutions.</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Working out the survey questionnaire. Pilot studies.</td>
<td>case studies, interviews</td>
<td>survey questionnaire</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Structured interviews based on survey questionnaire.</td>
<td>method of individual cases surveys, interviews.</td>
<td>survey questionnaire (interview)</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Working out research results.</td>
<td>statistical methods, the method of analysis and logic construction.</td>
<td>spreadsheet, computer program Statistica</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Working out the general model of information system in a local government unit.</td>
<td>Modelling method, mapping.</td>
<td>model, process map.</td>
</tr>
<tr>
<td>Stage 6</td>
<td>Working out the model of information system of projects portfolio management in a local government unit.</td>
<td>Modelling method, mapping.</td>
<td>model, process map.</td>
</tr>
</tbody>
</table>
Stage 1. Working out theoretical assumptions based on the literature study and source documents. The stage includes the analysis, using the technique desk/web research, of different types of data sources, websites, documents, ordinances, resolutions concerning the information systems, and legal acts determining functioning of local government units. From the perspective of this research a particular attention should be paid to such documents of a local government unit as:

- the statute,
- the organisational regulation,
- the book of quality management,
- the development strategy,
- the long-term investment plan,
- other documents.

The analysis of this kind is an exploration and enables to identify:

- input and output information,
- information flow path in a local government unit,
- information processing,
- problems of information systems,
- competences of departments, units, local government unit’s authorities in the area of information collecting and processing.

Stage 2. Working out the survey questionnaire. Pilot studies. Based on the research problem in this stage research objectives will be determined. The survey (interview) questionnaire will be worked out to undertake the pilot structured interviews in selected local government units. The main aim of the pilot studies is to get the knowledge how the questionnaire reflects determined research problems and enables the achievement of research objectives. The result of this stage will be modified and supplemented questionnaire with missing questions.

Stage 3. Structured interviews based on survey questionnaire. The research will be conducted in the form of structured interviews using a questionnaire. For each of the questions contained in the questionnaire will be additionally asked questions that enable a broader view of the studied problem. Working out of a survey questionnaire is one of the most important steps in the proposed research procedure. In the questionnaire on one hand there should be few questions, but on the other hand, there should be enough questions to give the full knowledge of the analysed problem. Moreover, the questionnaire should include a conscious and logical layout of questions [1]. Following this principles the research questionnaire will consist of two parts. The first part of survey questionnaire includes questions about the state of management systems in a local government unit. The important item is the integrated management system. Questions concern whether there are integrated solutions or they are planned to implement, and what problems
encountered in the system implementation or the system functioning. The second part of the survey questionnaire concerns the system of projects portfolio management in a local government unit. Researchers intend to meet the general criteria which are critical in the process of construction the projects portfolio and find out if the creation of this portfolio is formalized through procedures. Problems emerging in planning and realising of projects portfolio will be analysed.

The research analyses will also concern such issues as follows:
- applied project management methodology (project management procedure in commune office),
- IT tools used in the process of project management,
- the creation of project’s team,
- developing a project schedule (including the preparation of Work Breakdown Structure),
- analysis of project’s budget,
- project’s risk management,
- project’s realisation control,
- employees competences in project management in a commune,
- knowledge transfer in project management.

**Stage 4. Working out of research results.** Spreadsheet and computer program Statistica will be applied to work out the research results. The analysis of survey results will enable to determine problems and deficits in the information systems in the range of used tools in selected areas of the management in local government units and in the range of projects portfolio management.

**Stage 5. Working out the general model of an information system in a local government unit.** The information and results derived from undertaken research in previous stages will enable to work out the general model of an information system in a local government unit in the form of process’s map.

**Stage 6. Working out the model of an information system of projects portfolio management in a local government unit.** The analysis of results of the second part of questionnaire research will enable to work out the model of the information system of projects portfolio management in a local government unit, which will be the element of the integrated information system of a local government unit.

**5. Conclusions**

A properly functioning information system of a local government unit should ensure an efficient information flow within the unit to enable faster and better decisions. The cooperation between organisational units is the key factor.
The information system in a local government unit, like in enterprise’s information system, must be completely subjected to the continuous analysis and evaluation of its performance. It should provide the adaptability and the ability to expand service functionalities of the system related to the needs of the system’s user.

Local government units plan and realise plenty of projects which derive from the development strategy. Efficient and effective realisation of these projects require the access to suitable information to make right decisions. The information system in a commune should be adjusted to these needs.

The undertaken research will enable to diagnose the information system in the range of selected areas of management in communes and towns of Silesian Voivodeship and to work out projects portfolio management system in local government units.

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[11] Regulation of the Minister of Internal Affairs of 19th December 2012 on the modalities for the transfer of data between public records and notification of the assignment of PESEL.


This paper presents the changes in the global IT market over the last 6 years. The main purpose of the research is to establish (using multidimensional data analysis tools) a ranking of worldwide providers of advanced analytical tools used to support complex management processes in large corporations.

Keywords: IT market, advanced analytics software, analytic application, data warehouse, business intelligence

1. Introduction

Using of IT tools in the management processes began in the second half of the twentieth century. Initially, these were separate products for each department in the company. The evolution of management information systems is described in many publications (e.g., [4], [5], [9], [10]). Already in 1960, under the cooperation of the Case and IBM companies, the first system of MRP (Material Requirements Planning) was designed, and since 1972 such systems have become the primary support in many manufacturing companies. In 1972, five German engineers established SAP company, and in the second half of the seventies, Oracle Corporation and SAS Institute were created, which currently together with IBM and SAP, are the main global suppliers of software supported management process. Starting from
the year 2000, after the emergence of the concept of EAS (Enterprise Application Suite) i.e. integrated packages for businesses, the rapid development of the business process management software market has taken place. This acceleration can be illustrated (see Figure 1) by changes in annual revenues of the SAS Institute (a company specializing in creating software for data storing and decision making based on its own system SAS) proudly presented on its website: http://www.sas.com/company/about/statistics.html. Revenue from the Business Analytics area, as defined by IDC (International Data Corporation), represent over 80% of the company’s revenues in the recent years.

In the period 2000-2007, the majority of large companies with foreign capital in Poland implemented or were well advanced with the implementation of MIS systems together with Business Intelligence (BI) type of tools. In the case of banks, it has had a visible impact on the achieved results. More information on this can be read in the papers [4], [5] and [14]. Thus, it can be assumed that from 2007 onwards there is already a mature software-supported management market with experienced and stable suppliers.

![Figure 1](http://www.sas.com/company/about/statistics.html)

**Figure 1.** (Left) SAS Company annual revenues beginning from the establishment of the company. (Right) SAS revenues in 2006-2012 against annual expenditures on information technology (excluding expenditure on telecommunications) in Poland and the world. Source: http://www.sas.com/company/about/statistics.html and own calculations on the base of [3], [7] i [8]

World information technology expenditures have grown an average of 3.1% annually since 2006. Figure 1 clearly shows that they exceed the 2008 level while in Poland they are still below this level. The growth is not uniform and the structure of expenditures is changing.

Table 1 (the left part) shows the world information technology expenditures in 2006-2012 broken by type of products (Hardware – H, Services – Serv, Software – S) and year. In the middle part of Table 1, expenditure structure in each year and throughout the period is shown. The right part contains respectively: the expenditure structure in the period 2006 - 2012 broken down by type of products (the last
The overrepresentation ratios are defined by the following formula:

\[ h_{ij} = \frac{s_{ij}}{s_{j}} \quad i = 1, \ldots, k, \quad j = 1, \ldots, n, \]  

where \( s_{ij} \) and \( s_{j} \) mean, respectively, the \( j \)-th coordinate of the structure stored in the \( i \)-th and the last line of the middle part of Table 1. It is easy to see that the ratios \( h_{ij} \) have the identical interpretation in relation to the vertical parts of this table. It follows from the following equality:

\[ h_{ij} = \frac{s_{ij}}{s_{j}} = \frac{r_{ij}/r_{++}}{r_{j}/r_{++}} = \frac{r_{ij}/r_{j}}{r_{++}/r_{+}} = \frac{r_{ij}/r_{j}}{r_{++}/r_{+}} \quad i = 1, \ldots, k, \quad j = 1, \ldots, n, \]  

where \( r_{ij} \) means revenues from the sale of the \( j \)-th group of products in the \( i \)-th year, and \( r_{+j} \) revenues from the sale of the \( j \)-th group of products over the entire period and \( r_{++} \) total sale revenues.

Table 1. (Left) World information technology expenditures in 2006-2012. (Middle) The expenditure structures in each year and for the whole period 2006-2012. (Right) Over-representation rates of expenditure structures in the subsequent years in relation to the structure of the whole period 2006-2012.

<table>
<thead>
<tr>
<th>Year</th>
<th>H</th>
<th>Serv</th>
<th>S</th>
<th>Total</th>
<th>H</th>
<th>Serv</th>
<th>S</th>
<th>Total</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>289</td>
<td>686</td>
<td>186</td>
<td>1162</td>
<td>2006</td>
<td>0.249</td>
<td>0.590</td>
<td>0.160</td>
<td>1.00</td>
</tr>
<tr>
<td>2007</td>
<td>318</td>
<td>761</td>
<td>209</td>
<td>1288</td>
<td>2007</td>
<td>0.247</td>
<td>0.591</td>
<td>0.162</td>
<td>1.00</td>
</tr>
<tr>
<td>2008</td>
<td>350</td>
<td>814</td>
<td>223</td>
<td>1388</td>
<td>2008</td>
<td>0.252</td>
<td>0.567</td>
<td>0.161</td>
<td>1.00</td>
</tr>
<tr>
<td>2009</td>
<td>336</td>
<td>782</td>
<td>219</td>
<td>1337</td>
<td>2009</td>
<td>0.251</td>
<td>0.585</td>
<td>0.164</td>
<td>1.00</td>
</tr>
<tr>
<td>2010</td>
<td>353</td>
<td>821</td>
<td>232</td>
<td>1406</td>
<td>2010</td>
<td>0.251</td>
<td>0.584</td>
<td>0.165</td>
<td>1.00</td>
</tr>
<tr>
<td>2011</td>
<td>404</td>
<td>848</td>
<td>268</td>
<td>1520</td>
<td>2011</td>
<td>0.266</td>
<td>0.558</td>
<td>0.176</td>
<td>1.00</td>
</tr>
<tr>
<td>2012</td>
<td>424</td>
<td>874</td>
<td>285</td>
<td>1583</td>
<td>2012</td>
<td>0.268</td>
<td>0.552</td>
<td>0.180</td>
<td>1.00</td>
</tr>
<tr>
<td>Total</td>
<td>2479</td>
<td>5566</td>
<td>1622</td>
<td>9684</td>
<td>Total</td>
<td>0.256</td>
<td>0.577</td>
<td>0.160</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: own preparation on the basis of [3], [7] and [8]

Figure 2 presents the overrepresentation maps illustrating the expenditure structure in the world and in Poland. An overrepresentation map is a rectangle, divided by the lines parallel to its sides, into \( n \) horizontal and \( k \) vertical parts, giving a total of \( n \times k \) rectangles, shaded with the intensity of the shade determined by the overrepresentation ratio values (Formula 1). More about the over-representation maps one can read, for example, in the works [15], [16].

The map in the middle part of Figure 2 is the graphical presentation of Table 1. The width of the columns is determined by the structure in the last line of the Table 1, so the width of the columns indicates the 2006-2012 expenditure structure broken by type of products. The width of the lines is determined by the expenditure structure broken by year.
The overrepresentation map in the left part of Figure 2 is the graphical presentation of the world IT expenditures structure (including telecommunication), and the map in the right part of Figure 2 represents the IT expenditures structure in Poland.

Figure 2. Over-representation maps illustrating the structure of information technology expenditures in the world, including the telecommunication expenditure T (Left) and excluding the telecommunication expenditures (Middle) and in Poland (Right)

Source: own preparation based on [3], [7] and [8] using the application GradeStat (http://gradestat.ipipan.waw.pl/)

In sum, Figure 2 shows that the telecommunication spending constitutes more than half of a global spending on IT, but it’s share is decreasing in favor of spending on software and hardware. In contrast, the annual expenditures in nominal terms, excluding the year 2009, are increasing. Comparing the maps in the middle and the right of Figure 2, it can be seen that the expenditure structure in Poland is very different from the world expenditure structure. In Poland, more than half of the expenditure in the considered period is spent on hardware. This means that a significant change in the expenditure structure can be expected in the coming years.

2. Software supporting management processes

Currently, it is difficult to imagine a large corporation, which does not use either basic systems recording operations with customers and company's own economy in the wide sense or advanced analytical software to support the widely understood management processes. Moreover, with high probability it can be assumed, that companies have comparatively good systems concerning the automatic registration of operations with customers and company's own economy. However, in the area of using Business Analytics (BA) software to support management processes there is still a large variation. This is particularly true in developing countries.
IDC company divides the market of BA software into the three primary segments:

- **Performance Management and Analytic Applications (PM&AA):** Financial performance applications, Supply chain analytic applications, Workforce analytic applications, CRM applications, Service operations analytic applications, Production planning analytic applications.

- **Business Intelligence Tools (BI):** Query, reporting, analysis tools, Advanced analytic tools, Contents analysis, Spatial information analytic tools.

- **Data Warehouse Management Platform (DW):** Data warehouse management, Data warehouse generation – processes data generation, transformation, loading, data quality.

Changes in the structure of BA software suppliers’ 2005 – 2012 revenues according to the three categories mentioned above (PM&AA, BI, DW) are shown in Figure 3 in the form of the overrepresentation map. Analyzing Figure 3 one can see that the revenues from the sale of these products are growing quite quickly (in consecutive years lines become wider and wider). The structure of revenues broken by product is also changing (changes in gray color intensity of individual cells shows the overrepresentation of cells from a particular year relative to the average for the whole period).

As follows from Figure 3, the share of BI tools revenues is decreasing in relation to the other categories in the period 2005-2012. Business Intelligence tools appeared on the market quite a long time ago. Revenues of BI tools suppliers in the period 1994-2012 are presented in Figure 4, from which it can be seen that the sale of BI tools was growing at over 15% a year at the end of the last century.

![Figure 3. Overrepresentation map illustrating the structure of the revenues from the sale of BA tools in the period 2005-2012](http://gradestat.ipipan.waw.pl/)

Source: own preparation based on [17], [18] and [19] with using the application GradeStat (http://gradestat.ipipan.waw.pl/)
3. Business analytics tools market

The Business Analytics (BA) tools market is the market already operating for several years, and therefore it can be considered as the mature market. Some big players offering a wide range of products as well as many niche players offering single products operate in this market. It is worth to mention that large corporations choose as suppliers mainly the world-known players which are well assessed by product positioning global companies. One of the most known such companies is Gartner Inc. listed on the American Stock Exchange NYSE under the symbol IT. It operates also in Poland. Another no less –known company is the International Data Corporation (IDC), a leading global provider of market information and IT advisory services and solutions. Based on the reports of this type of companies, the global BA market picture can be easily submitted, in terms of both the software quality and the market share of the individual major players.

In principle, there are six large suppliers of BA tools that can meet the needs of large corporations handling huge data volumes: IBM, SAP, Oracle Corporation, SAS Institute, Teradata, and Microsoft. However, this does not mean that it is the only option. A large number of niche players operate at the market. These are more flexible and can provide tools that are better adapted to the requirements of the purchaser. Currently, the market continues to grow strongly, being accompanied by market reshuffling: the new niche players appear at the market, and some other are absorbed by the global giants. These changes are well illustrated by two Gartner Magic Quadrants assessing BI software suppliers in 2007 and 2013 (see Figure 5). It is worth noting that earlier IBM was not found among the major providers of such tools, and it is not presented at 2007 Magic Quadrant. After the acquisitions
of very valuable niche players (Cognos and SPSS), IBM was assessed by a research group Gartner Inc. as one of the best companies.

Figure 5. Gartner Magic Quadrants presented the assessment of BI software suppliers

In the case of Data Warehouse Management Platform tools, the situation is more stable. Changes in the assessment of DW tools suppliers were investigated on the base on Magic Quadrants assessing these suppliers. Five global giants (IBM, Microsoft, Teradata, Oracle, SAP) have appeared in the upper right quadrant during the whole period, wherein the corporation SAP is presented in a strategic partnership with the corporation Sysbase (SAP and Sysbase have signed an agreement on strategic partnership). For the period before 2009, the Sysbase assessment was taken as the assessment of the partnership. Since 2010, in the upper right quadrant of the Magic Quadrants has appeared EMC corporation, which took over the company Greenplum in that year. Earlier assessments of Greenplum placed it close to the upper right quarter. In addition, in 2010 disappeared the well assessed company Neteza, as a result of its acquisition by IBM.

Figure 6 illustrates changes in the assessment of major firms in the years 2006-2012. The assessment is based on Magic Quadrants. Namely, it is assumed that the point in Magic Quadrant is equivalent to the point in the square [0,1]×[0,1] and the assessment is defined as: \[1 - \frac{d((x, y), (1,1))}{2^{0.5}}\], where \(d\) is the Euclidean distance. The information needed for positioning of individual firms was derived from reports published in the first quarters of each year. In sum, in the period 2006-2012 suppliers presented in Figure 6 were worth of recommending.
In the Business Analytics area, the increasing role begin to play advanced analytical technologies, which also allow to manage and exploit the large volumes of data. This means that the BA area begins to be more widely understood, namely in addition to the advanced analytical procedures it covers also the techniques for efficient processing of very large volumes of heterogeneous data: new area, called Big Data is arising. There is no uniform definition of the concept of Big Data. For many authors this term means exponential growth of data and issues connected with the collection and rapid access to the large and heterogeneous data sets (eg. non-relational data) in order to exploit the information contained therein. Some others place greater emphasis on advanced techniques for extracting information from a large set heterogeneous data. This is probably why many large corporations seek interdisciplinary specialists with:

* programming skills,
* knowledge of the technical platform for collecting and processing large heterogeneous data
* specialized preparation in various fields with particular focus on the knowledge of the mathematical methods of information processing and statistical methods.

Suppliers have already responded and sell tools under the banner Big Data. In 2011, revenues under this heading received quite a lot of companies [13]. In 2011, total revenues of Big Data market achieved $5,2 billion. Table 2 presents the list of 15 companies with the greatest Big Data market share and the list of 15 niche suppliers who only sell products (or sell majority of products) under this heading. It is worth noting that the list of the 15 companies with the highest market
share does not include Microsoft and Oracle companies. More about Big Data market one can read in [6].

Table 2. (Left) Big Data revenues of companies with the greatest market share and (Right) companies with the greatest share of Big Data revenues in the total revenues

<table>
<thead>
<tr>
<th>No</th>
<th>Company</th>
<th>Revenues ($ M)</th>
<th>Market Share (%)</th>
<th>Revenues ($ M)</th>
<th>Total (M)</th>
<th>Big Data Rev. Share in Total Rev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IBM</td>
<td>953</td>
<td>18.60%</td>
<td>16000</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Intel</td>
<td>765</td>
<td>14.53%</td>
<td>54000</td>
<td>1.4%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>HP</td>
<td>523</td>
<td>10.05%</td>
<td>126000</td>
<td>0.4%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fujitsu</td>
<td>285</td>
<td>5.56%</td>
<td>50700</td>
<td>0.6%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Accenture</td>
<td>273</td>
<td>5.33%</td>
<td>21900</td>
<td>1.2%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CSC</td>
<td>160</td>
<td>3.13%</td>
<td>16200</td>
<td>1.0%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Dell</td>
<td>154</td>
<td>3.00%</td>
<td>61000</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Seagate</td>
<td>149</td>
<td>2.91%</td>
<td>11600</td>
<td>1.3%</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>EMC</td>
<td>138</td>
<td>2.69%</td>
<td>19000</td>
<td>0.7%</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Teradata</td>
<td>120</td>
<td>2.34%</td>
<td>22000</td>
<td>5.2%</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Amazon Web Serv.</td>
<td>116</td>
<td>2.26%</td>
<td>650</td>
<td>17.8%</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>SAS Institute</td>
<td>115</td>
<td>2.24%</td>
<td>2700</td>
<td>4.3%</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Capgemini</td>
<td>111</td>
<td>2.17%</td>
<td>13200</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Hitachi</td>
<td>110</td>
<td>2.13%</td>
<td>10000</td>
<td>1.1%</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>SAP</td>
<td>85</td>
<td>1.66%</td>
<td>17000</td>
<td>0.5%</td>
<td></td>
</tr>
</tbody>
</table>

Source: own preparation on the base of [13]

4. Concentration of the business analytics software market

One of the key elements influencing the purchase of tools by a large corporation is the size and long term-market position of the supplier. Using IDC reports, the evaluation of concentration changes in business analytics software market in the past few years was performed. For this purpose, the simple indicator of CR4 (meaning the sum of the market shares of the top 4 brands in the industry) was used. Usually the following classification of the market (industry) is applied:

- competitive market - the concentration ratio CR4 <40%,
- oligopoly - the concentration ratio CR4 ≥ 40% (tight oligopoly when CR4> 60%, loose oligopoly when 40% ≤ CR4 ≤ 60%).

Figure 7 shows the oligopoly character of the business analytics software market. Moreover, the BA concentration ratio is slowly growing over the reporting period. Only in the case of Data warehouse management platforms, the concentration ratio is decreasing. Taking into account the increasing use of the data processing centers services by small and middle-sized companies, the concentration may be even deeper.
5. Ranking of the business analytics tools suppliers

Nearly every large company has used the software supporting management for several years. The biggest diversity is in the BA tools area. Some companies are associated with a single supplier and another part uses the tools from different suppliers. Using standard methods of multidimensional comparative analysis the ranking of six major suppliers of this software was established taking into consideration 13 variables:

✓ the average positioning of Gartner Inc. from the years 2006, 2009 and 2012 concerning BI, DW and Advance Analytics Software - the average of the sum of the coordinates in three Magic Quadrant identified with a square [0,1] x [0,1] - weight = 1,
✓ the percentage change in 2012 position compared with to 2006 position in Magic Quadrant identified with a square [0,1] x [0,1] for BI, DW and Advance Analytics - weight = 0.5
✓ the current (from 2013) positioning of Gartner Inc. concerning Integrated Marketing Management and Data Quality Tools Software – weight = 1,
✓ the average market share in the years 2006, 2009 and 2012 for PM&AA, BI, DW and Advance Analytics tools according to IDC reports - weight = 1
✓ the 2011 revenues from the Big Data tools sale (according to [13]) - weight = 1

As a result of calculation the ranking of six leading companies was obtained. It is presented in Table 3 – the value of the synthetic index \( W \) indicates the big advantage of IBM.
Table 3. Ranking of the six largest BA tools suppliers according to the value of the synthetic index W that uses 13 variables

<table>
<thead>
<tr>
<th>Company</th>
<th>W</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM</td>
<td>0.6479</td>
<td>1</td>
</tr>
<tr>
<td>SAS</td>
<td>0.4831</td>
<td>2</td>
</tr>
<tr>
<td>Oracle</td>
<td>0.4593</td>
<td>3</td>
</tr>
<tr>
<td>SAP</td>
<td>0.4356</td>
<td>4</td>
</tr>
<tr>
<td>Microsoft</td>
<td>0.3153</td>
<td>5</td>
</tr>
<tr>
<td>Teradata</td>
<td>0.2266</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: own preparation based on Gartner and IDC companies reports

6. Summary

Today, practically every large company, especially financial institutions, use widely understood MIS tools that have been implemented for several years and that are continually developed and improved.

On the basis of available on the Internet materials from local conferences for users of software provided by the international scale companies, one can find out that starting from 2000, the majority of banks and other financial institutions began gradually implement software supported management system (virtually in all areas of the corporation), including the BA tools.

The conducted analysis shows that only in the case of IBM, company may rely on one supplier. In other cases, individual business areas require the use of tools from different suppliers.

If the corporation has the appropriate specialists (i.e. having (i) the ability of programming, (ii) knowledge of the technical platform for the collection and processing of large heterogeneous (non-relational) data and (iii) the various fields of knowledge with particular focus on the mathematical methods of information processing and statistical methods), it can implement solutions using niche suppliers which is certainly a cheaper and more flexible option.

REFERENCES


ANALYSIS OF REASONS FOR CITIZENS LOW INTEREST IN E-GOVERNMENT SERVICES IN POLAND:
E-FILING CASE STUDY

JOANNA PAPIŃSKA-KACPEREK

Department of Computer Science, Management Faculty, University of Lodz

E-government aim to create cheaper and more effective administration is getting to be important element in the operational strategy of all countries. The authorities spent funds on implementation of e-government services and the effectiveness of these investments will be appreciated only when it is possible to reduce the expenditure on handling traditional procedures. E-filing tax systems are the most advanced e-government services, however not everywhere have been accepted in the equal form. This article will present the results of a study setting out the reasons for not submitting electronic tax declarations in Poland. The survey was conducted in the tax offices in April 2012. The objective of this article is to find the main reason which inhibit readiness to use this e-government service.

Keywords: e-services, e-government, e-filing, theory of attitudes

1. Introduction

Electronic or digital service is a service delivered via electronic channel (medium) or device consisting of sequence of activities which are executed - not necessarily all - by software applications and includes processing on digital resources. These taken actions then result in getting the additional value by the customer. There were bodies on the market benefited from the preparation of the relevant software and devices in order to implement and realize the projects connected with offering of the digital services. First digital services included
Internet access, email, or hosting. After that e-commerce and e-banking services, various kinds of Internet payments and the web promotion were offered. E-services turned up in our everyday payments and the web promotion were offered. E-services turned up in our everyday routines. There are not only in the mentioned above financial and trade sector, but also in culture, transport, education, health care and in the public life. Digital services are offered by the public administration on state and local level. E-government as the integrated activities, aim to create cheaper and more effective administration, is getting to be important element in the operational strategy of all countries. E-government is a sign of a modern state. Its advancement demonstrates how seriously states consider the new methods of communication between the authorities at various levels and citizens or enterprises. ICT deployment has also economic sense and therefore the authorities should take extra care in order to make all e-government services more popular. Moreover there were some money spent on implementation of these services and the effectiveness of these investments will be seen only when it is possible to reduce the expenditure on handling traditional procedures. It happens with substantial increase in demand for digital services.

The market offers lots of e-services, but they are used to a various extend. The longer they have been available, the more customers they have gained. Surely it is the reason why the most popular are those related to electronic communication, e-commerce and e-banking, which have been delivered for at least several years. The Eurostat statistics show much lower interest and usage of the e-government services than usage of e-commerce or e-banking. In some countries it is even double lower [7].

<table>
<thead>
<tr>
<th>Country</th>
<th>On-line purchase/sales</th>
<th>In order to search for information</th>
<th>In order to download the official forms</th>
<th>In order to send completed forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithuania 2010</td>
<td>7%</td>
<td>18%</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>Sweden 2011</td>
<td>53%</td>
<td>57%</td>
<td>36%</td>
<td>32%</td>
</tr>
<tr>
<td>Poland 2010</td>
<td>20%</td>
<td>18%</td>
<td>13%</td>
<td>6%</td>
</tr>
<tr>
<td>Austria 2010</td>
<td>32%</td>
<td>35%</td>
<td>21%</td>
<td>12%</td>
</tr>
<tr>
<td>UK 2010</td>
<td>60%</td>
<td>33%</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td>France 2010</td>
<td>42%</td>
<td>30%</td>
<td>22%</td>
<td>17%</td>
</tr>
<tr>
<td>Finland 2010</td>
<td>41%</td>
<td>47%</td>
<td>36%</td>
<td>28%</td>
</tr>
</tbody>
</table>

E-government is another category of Internet services as e-commerce and e-banking already known, accepted and popular. However, the citizen’s attitude is not the same towards them, what is for now a barrier difficult to overcome.
social or mental barrier may appear to be much more difficult than the technical ones. Nowadays, when Internet access is provided in many countries for the majority of citizens, the aim is to improve the bandwidth connection, but the promotion and education of potential users is more important. Having Internet connection has undoubtedly caused gaining of competences, often called digital competences. But it does not explicitly give rise to using any services available online, including electronic government services, by all citizens. Josef Makolm [8] proposed three categories of digital services success implementation factors: technological, political and cultural. All these factors have to be in place concurrently in order for a country to experience high levels of e-take-up of government services. Technological category includes the preparation of the efficient system by its operator or author as well as gives possibilities and abilities to take advantage of them by their users. Political factors (i.e. procedural and legal) are standards and regulations to ensure the correct and legal operation of the system. Cultural then affect the behaviour of all the peoples involved in the process i.e. customers and employees of the company providing the service. They apply to social imagination, communication style and attitude toward new methods of activity. The acceptance of the service described as the qualities of the perspective users to use the certain system personally depends on these factors. When access to the new communication technologies is widespread in many countries, and when the most important regulations were prepared, this last factor is becoming the most important one.

2. Background

The success and acceptance of e-government initiatives, such as sending out electronic forms, petitions and complaints, voting online and settling the tax depend on the willingness of citizens to accept these services. Statistics show that Internet access to 20 basic public services, selected and monitored by the European Commission, reached in Europe in 2010, 82% [4]. Unfortunately Poland belonged to the countries in which the discrepancy between supply and demand on the electronic government service was the largest, especially in the sector of services for citizens [3].

The objective of this study is to find the main reason which inhibit readiness to use e-government service. But these services are used by such a small percentage of users that it would be extremely difficult to generalize or compare the results of their research and conclude anything on their basis (Table 2, Polish Central Statistical Office GUS data). For this reason, it was decided to examine one of the most popular e-government services in all the countries.
Table 2. Use of Internet in contacts with public administration in Poland

<table>
<thead>
<tr>
<th>The percentage of people who use the administration pages to:</th>
<th>2008</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search for information</td>
<td>14,0%</td>
<td>25,0%</td>
<td>20,9%</td>
</tr>
<tr>
<td>Download the official forms</td>
<td>15,5%</td>
<td>18,7%</td>
<td>14,4%</td>
</tr>
<tr>
<td>Send filled forms</td>
<td>7,7%</td>
<td>9,8%</td>
<td>8,8%</td>
</tr>
</tbody>
</table>

Source: own preparation, data from [9]

According to the EU reports, the most activities related to e-government in the member states focus on delivering of governmental services, designed to make administration more efficient and effective. It was also noted that in the last decade, EU countries first set up services that generate income for government. Examples of such policy are electronic systems to file the tax returns, which are the most advanced e-service in all EU and OECD countries.

Hence it was considered that the attitude of citizens to public digital services can be examined on the example of electronic, annual income tax declaration sent by individuals and used regularly once a year. In most countries, many citizens just use this one, although it does not mean that it is absolutely a large percentage (Table 3).

Table 3. Use of electronic tax declarations according to OECD, data [10]

<table>
<thead>
<tr>
<th>Country</th>
<th>Beginning</th>
<th>E-filing 2004 (%)</th>
<th>E-filing 2007 (%)</th>
<th>E-filing 2009 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>2002</td>
<td>3</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>2005</td>
<td>-</td>
<td>0,4</td>
<td>3</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2004</td>
<td>0,5</td>
<td>No data</td>
<td>1</td>
</tr>
<tr>
<td>Estonia</td>
<td>2000</td>
<td>59</td>
<td>85</td>
<td>92</td>
</tr>
<tr>
<td>Finland</td>
<td>2006</td>
<td>0</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>France</td>
<td>2001</td>
<td>4</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>Lithuania</td>
<td>2004</td>
<td>14</td>
<td>No data</td>
<td>71</td>
</tr>
<tr>
<td>Latvia</td>
<td>2008</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Hungary</td>
<td>2003</td>
<td>3</td>
<td>31,5</td>
<td>30</td>
</tr>
<tr>
<td>Portugal</td>
<td>2000</td>
<td>24</td>
<td>64</td>
<td>80</td>
</tr>
<tr>
<td>Poland</td>
<td>2008</td>
<td>-</td>
<td>-</td>
<td>1,4</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2004</td>
<td>-</td>
<td>4</td>
<td>77</td>
</tr>
<tr>
<td>Sweden</td>
<td>2002</td>
<td>15</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>UK</td>
<td>2000</td>
<td>17</td>
<td>33</td>
<td>73</td>
</tr>
</tbody>
</table>

50
In Poland, individuals can send electronic declarations from 2008. In the first year of implementing e-Deklaracje (Polish e-Taxation system), only holders of qualified digital signature could use it. The procedure also required the dispatch of the paper notice to the relevant head of Tax Office, informing about the intention of sending the electronic PIT form (Personal Income Tax). It was done by 419 people only. In 2009, when the most popular PIT-37 could be sent without digital signature verified by the qualified certificate and without written notice, tax authorities received more than 89 thousand declarations from taxpayers. From this year the forms may be signed with the electronic signature unverified by any certificate, but ensuring the authenticity of the settlement. This signature is based on the following set of information about the person who e-files a tax return: tax identification number NIP, name, surname, national identification number PESEL, date of birth, the amount of income referred in the settlement of tax return for previous year (or zero value if none of the settlements was filled). This possibility has been made available only just in April 2009, at the end of the settlement period. In 2010 five electronic forms were prepared to file without digital signature. Increased number of electronic PIT forms was meant to encourage taxpayers and over one million of declarations were expected.) It was reckoned that the lack of fairly expensive digital signatures was the main cause of not exploiting the existing possibility of electronic case handling. However, it turned out that this was not the only reason. Offices received only almost 320 thousand forms from 355 thousands of taxpayers. The Ministry of Finance’s expectations came true in 2011: nearly 1.2 million taxpayers sent e-declarations. The system is still being improved and it is getting easier and more convenient to use: since 2011, an electronic correction of PIT without a digital signature can be submitted, and the spouses who file joint tax returns do not need to notify about it. Since 2012, identification data – i.e. NIP number does not have to be specified.

Statistics show that after several years of operation of this service in Poland, still not a large percentage of the population decided to test it. In Poland in 2012, four years after implementing of the service, over 2 million taxpayers have sent e-declarations, what constitutes 8% of the population. Four years after introducing the service Estonia has achieved a better result, which accounted for 59%, Portugal 24%. However there are countries with slower adoption pace: e.g. in Bulgaria only 3% of taxpayer’s population uses e-filling [10]. In Lithuania in 2006 - 2 years after services introducing, 46% of citizens used the service, and even 71% in 2009. One of the reasons for such rapid acceptance of the digital services in Lithuania and Estonia was to provide citizens with electronic ID cards, by which the taxpayers can authenticate themselves. Higher rates have been achieved in countries where forms were partly or entirely prepared by government tax authority [7, 10]. This approach was first applied in the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) as well as in Estonia and Lithuania, then in other countries.
(Chile, Slovenia, South Africa, Spain and a bit later in Australia, Belgium, France, Portugal and the Netherlands. A lot of countries are going to introduce such a service, Poland is among them. Such a solution was planned to introduce in 2013, but in 2012 the deadline for projects like: e-Podatki and e-Deklaracje 2 was prolonged until March 2015.

In 2013, a month before the end of accepting the declarations, it was already known that the service was used by 10% of taxpayers and at the end they reached the result over 3.5 million e-declarations. The question, which should be answered, is: does little interest of the potential audience show that the service is not needed? Or does it indicate that it is not well prepared and requires much more work or better propagation?

In many countries, the research into the factors that affect the decision to take up the e-filing systems [2, 6, 11], and obstacles [5] are conducted. The results are not consistent, because systems in individual countries differ. In many countries, the tax offices fill out forms, not everywhere access to the e-file system is free, not everywhere strong authentication is required. Not all tax authorities have a policy of tax incentives or extending deadline for making tax return. These factors influence the behaviour of potential users and the extent of use.

3. Research model

Taxpayers who do not file annual tax returns over the Internet were the subjects of the undertaken studies. Citizens, who did not take this possibility in that particular year, make the tested population. Because one of the reasons for this matter may be the lack of computer skills and not using the Internet, it was decided to carry out paper questionnaires.

It is not possible to draw a representative sample of those taxpayers, who do not file of electronic declarations PIT, since there is no database of such taxpayers. Numerousness and structure of the examined population is usually known 1st May of each year. Therefore, it was decided to use non-probabilistic selection method based on the availability of those under examination [1]. However, it was attempted to retain certain features of probability selection: it was decided to select voivodeships and then large and small villages out of them (layered model), moreover every 10th taxpayer standing in the queue in the course of the examination was asked for participation.

Majority of published studies also used the non-probabilistic selection based on the availability of respondents. In many cases respondents were graduates of one field of study, one or two Universities, the participants of special courses or public event therefore, the results may be less representative [2, 6, 12].

Four voivodeships were drawn, and big and small towns within them. The research was conducted in 11 offices, which agreed: 8 in big cities (Gdynia,
Wrocław and Łódź) and 3 in small (Włocławek, Poddębice and Oleśnica). Survey was carried out in tax offices at the time of the tax returns submission, during the highest turnout i.e. in the last decade of April 2012. 360 people took part in questionnaire. 341 completed forms were taken into account in order to develop the results.

4. Analysis

Almost all surveyed taxpayers were aware of possibility of using electronic forms (320 people, 94%), and almost 50% knew somebody who benefited from this service (18% knew one person, 28% several people, 4% more than 10).

People who took part in the study are the other digital services’ users. Most respondents use e-mail and e-banking services, and the least number of respondents use blogs. The details are shown in Table 4. Up to 62% of those surveyed (but 40% were not so sure) declared that next year would try to take advantage of electronic services to send their tax returns.

<table>
<thead>
<tr>
<th>Digital service</th>
<th>The percentage of users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email</td>
<td>82%</td>
</tr>
<tr>
<td>Social networking sites</td>
<td>59%</td>
</tr>
<tr>
<td>Blog</td>
<td>17%</td>
</tr>
<tr>
<td>Electronic auctions as a seller</td>
<td>26%</td>
</tr>
<tr>
<td>E-Commerce and e-auctions-as a buyer</td>
<td>64%</td>
</tr>
<tr>
<td>Social purchasing</td>
<td>21%</td>
</tr>
<tr>
<td>E-banking</td>
<td>71%</td>
</tr>
<tr>
<td>E-Government</td>
<td>20%</td>
</tr>
</tbody>
</table>

Respondents gave their own description of several dozens of causes because of which they have so far not tried to send electronic declarations. These are grouped in 24 categories in Table 5. Some mentioned up to 3 maximum, and 54 could not give any reason. Only 9 people did not choose any suggestion regarding the next question, in which some ready proposals were offered, amongst them: fear of the Internet medium, fear of using the Internet to communicate with the office, inability to authenticate, inability to confirm sending e-declarations, somebody’s own bad experience or his friends or this described in media.

53
Table 5. Causes of non-using the e-Deklaracje, given spontaneously

<table>
<thead>
<tr>
<th>Category of causes</th>
<th>Participation in the trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit</td>
<td>10.30%</td>
</tr>
<tr>
<td>Technical problems</td>
<td>9.40%</td>
</tr>
<tr>
<td>The old method preferences</td>
<td>8.20%</td>
</tr>
<tr>
<td>At the opportunity</td>
<td>7.30%</td>
</tr>
<tr>
<td>Other reasons</td>
<td>6.50%</td>
</tr>
<tr>
<td>Lack of knowledge about details</td>
<td>5.90%</td>
</tr>
<tr>
<td>Someone else filled the PIT</td>
<td>5.30%</td>
</tr>
<tr>
<td>Lack of time to get to know it</td>
<td>4.10%</td>
</tr>
<tr>
<td>Software problems</td>
<td>4.10%</td>
</tr>
<tr>
<td>Need for clarify the problem</td>
<td>3.80%</td>
</tr>
<tr>
<td>Need for credentials</td>
<td>3.20%</td>
</tr>
<tr>
<td>Safety regulations</td>
<td>2.60%</td>
</tr>
<tr>
<td>Lack of digital skills</td>
<td>2.60%</td>
</tr>
<tr>
<td>The first tax-return</td>
<td>2.30%</td>
</tr>
<tr>
<td>Lack of interests in the service</td>
<td>2.10%</td>
</tr>
<tr>
<td>Unwillingness to get to know the service</td>
<td>2.10%</td>
</tr>
<tr>
<td>Lack of e-signature</td>
<td>2.10%</td>
</tr>
<tr>
<td>Fear of the Internet</td>
<td>1.80%</td>
</tr>
<tr>
<td>Inability to authenticate</td>
<td>1.50%</td>
</tr>
<tr>
<td>Traditionally faster</td>
<td>1.20%</td>
</tr>
<tr>
<td>Traditionally easier</td>
<td>0.90%</td>
</tr>
<tr>
<td>Due to additional charge to tax payment</td>
<td>0.90%</td>
</tr>
<tr>
<td>Problems of others with the system</td>
<td>0.60%</td>
</tr>
<tr>
<td>Due to tax overpayment</td>
<td>0.60%</td>
</tr>
</tbody>
</table>

In the study group can be assumed that they all have a passive attitude towards the service because they did not have benefited from it. A very small group admitted that they had a problem with installing the necessary program, so they intended to use the system, but there was not enough motivation or competence, or there was lack of support to complete it to the end. Quite a lot of people seemed to be aware of the benefits that the application of the e-declarations can bring however, habits, fear or laziness were stronger.

Almost 20% reported the preference of the traditional method as their reasons. Nearly 9% reported lack of eagerness, time, and interest in the service, therefore, not seeing enough of the service benefits, they do not want to make an effort and
try to find out something more about the electronic settlement. And more than 6% of respondents reported a lack of information on this topic.

Study group seldom heard about the problems of other taxpayers, which could discourage them, and almost half of them knew at least one person, who filed electronic PIT. This matter can be looked at less optimistically: since the study group did not hear about problems, so their acquaintances probably have not had bad experiences, although that was still not a stimulus to try. Quite a lot of people used the services of accountancy offices, which have prepared paper forms, that is, why in Poland these kinds of institutions do not encourage to change the old way of the PIT preparation.

The respondents did not report directly lack of available reference materials. It is known that one can find them, but maybe if they were better advertised, the level of knowledge of the service would be higher and the irrelevant causes would not be given.

In order to further analysis division was made regarding the spontaneously given respond into 4 categories: technical, procedural, cultural and cognitive - related to lack of knowledge. Technical factors include problems connected with a lack of technical opportunity for using the service e.g. due to the lack of Internet connection, the computer or application. Sometimes problems can be subjectively technical, e.g. when someone did not use the service because of not having the program that could be easily downloaded from the e-Declarations webpage, what objectively is the lack of knowledge. Procedural factors are regulations which unable to use the system. Here also, some of the reasons are subjectively procedural, e.g. filing of the first in one’s life income-tax return. Cultural causes result from public imagination, the communication style and the citizens’ attitude towards the new method of operation. Cognitive factors are a consequence of the lack of knowledge and competence how to use the computer system.

Values in the table do not add up to 100% because other causes were omitted, apart from that some people gave a couple of reasons.

Only lack of printer and a failure of Internet connection were considered as subjectively technical problems. However, it can be assumed, that most of the reasons given was easy to defeat, e.g. in the case of having old or too slow computer surely a friend’s computer could be used. Moreover to send the declaration does not need special parameters.

From the list of issues connected with the software, inability to cope with a Web browser was recognized as subjective, as it is the basic tool, particularly in the context of the popularity of WWW services. Having trouble installing a new version of the plug-in or the program actually could cause an obstacle.
Table 6. Aggregation of reasons for not benefiting from the e-Declaration system

<table>
<thead>
<tr>
<th>Type</th>
<th>Subjectively</th>
<th>Objectively</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural</td>
<td>Fear of the Internet 41%</td>
<td>Fear of the Internet 40%</td>
</tr>
<tr>
<td></td>
<td>Habit</td>
<td>Habit</td>
</tr>
<tr>
<td></td>
<td>Lack of interests in the service</td>
<td>Lack of interests in the service</td>
</tr>
<tr>
<td></td>
<td>The old method preferences</td>
<td>The old method preferences</td>
</tr>
<tr>
<td></td>
<td>Traditionally faster</td>
<td>Traditionally easier</td>
</tr>
<tr>
<td></td>
<td>Traditionally easier</td>
<td>Unwillingness to get to know it</td>
</tr>
<tr>
<td></td>
<td>Unwillingness to get to know it</td>
<td>Lack of time to get to know it</td>
</tr>
<tr>
<td></td>
<td>Lack of time to get to know it</td>
<td>Problems of others with it</td>
</tr>
<tr>
<td></td>
<td>Problems of others with it</td>
<td>At the opportunity</td>
</tr>
<tr>
<td></td>
<td>Traditionally faster</td>
<td>Traditionally easier</td>
</tr>
<tr>
<td></td>
<td>Traditionally easier</td>
<td>Unwillingness to get to know it</td>
</tr>
<tr>
<td></td>
<td>Unwillingness to get to know it</td>
<td>Lack of time to get to know it</td>
</tr>
<tr>
<td></td>
<td>Lack of time to get to know it</td>
<td>Problems of others with it</td>
</tr>
<tr>
<td></td>
<td>Problems of others with it</td>
<td>At the opportunity</td>
</tr>
<tr>
<td>Procedure</td>
<td>Need of credentials 21%</td>
<td>Someone else filled the PIT 10%</td>
</tr>
<tr>
<td></td>
<td>Due to tax overpayment</td>
<td>Need to clarify the problem</td>
</tr>
<tr>
<td></td>
<td>Due to tax payments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Someone else filled the PIT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need to clarify the problem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The first tax-return</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of information needed to authenticate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of digital signature</td>
<td></td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>Lack of digital skills 9%</td>
<td>Lack of digital skills 22%</td>
</tr>
<tr>
<td></td>
<td>Lack of knowledge about details</td>
<td>Lack of knowledge about details</td>
</tr>
<tr>
<td></td>
<td>Due to tax overpayment</td>
<td>Due to tax overpayment</td>
</tr>
<tr>
<td></td>
<td>Due to tax payments</td>
<td>Due to tax payments</td>
</tr>
<tr>
<td></td>
<td>Need of credentials</td>
<td>Need of credentials</td>
</tr>
<tr>
<td></td>
<td>Traditionally faster</td>
<td>Traditionally faster</td>
</tr>
<tr>
<td></td>
<td>Lack of information needed to authenticate</td>
<td>Lack of information needed to authenticate</td>
</tr>
<tr>
<td></td>
<td>Lack of digital signature</td>
<td>Lack of digital signature</td>
</tr>
<tr>
<td></td>
<td>Lack of ability to solve simple technical problems</td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td>Security 17%</td>
<td>Security 16%</td>
</tr>
<tr>
<td></td>
<td>Technical problems</td>
<td>Technical problems</td>
</tr>
<tr>
<td></td>
<td>Software problems</td>
<td>Software problems</td>
</tr>
</tbody>
</table>

Each of the listed reasons in table 6 can be assigned to one of the 3 components of attitudes (emotional, cognitive, and behavioural) [12] together with an indication of whether there is a chance for a quick persuasion to change the
attitude, what is an attempt to use the system. Tested taxpayers can be divided into two groups: very difficult to persuade whose resistance demonstrates mainly through the emotional component. And those, whom should be fairly easy to explain what their e.g. false belief consists in, regarding their inability of submitting an electronic form PIT.

The emotional factor demonstrates a lack of interests and concerns. The first group should include also those who could not give a reason of not using the system. Presumably, that will be extremely difficult to influence on the attitude change in this case. What can help in that matter is the advertisement aimed at the emotions where famous and popular people will appear, or bringing up the subject of the electronic tax settlement in popular TV shows and TV series.

It will be much easier to apply the persuasion techniques in relation to those who had cognitive defect occurred, i.e. they subjectively believe that there are some e.g. technical or formal obstacles but if it is explained that this is not the case – it can be assumed, that in the near future they attempt to use the system.

We need to be aware of the fact, that those who are the most resistant to a new way of activity, can change their attitude only through the influence on behavioural component, like implementing of mandatory sending e-form. Then everything what is possible should be done to show that the system is really worth using, even though when the duty is abolished. Not so many countries have decided on mandatory use of e-system of taxes by their citizens. Potential users are persuaded by media campaigns, policy incentives (tax relieves, faster tax refunds, longer periods for collection of the e-declarations, decreased demand for income data) and direct support (free software, online help).

Services for the mass user should be very well prepared, because many people do not read the instructions and relay on the context-sensitive help. Observing the Polish operation of the e-Deklaracje have noted numerous weaknesses, happily repaired - sometimes in the same year. In 2011, many taxpayers could have been deterred when it turned out that the full procedure was not completed, because they recognized reference number as the official acknowledgement of receipt (UPO). The taxpayers whose forms were wrong and rejected by the system (they did not notice this fact) as the consequence did not submit them. Those taxpayers have been finding out about it only after receiving information about failure of fulfil their obligations.

In this case taxpayers were partly to blame for, but the system could actually suggest that they should wait for the official acknowledgement of receipt UPO – what was fixed in 2012. In 2013 the authors of the system did not take into consideration that the new versions of Web browsers did not allow to open the interactive forms. It could discourage those who were convinced that they had had a bad image of the system, and we should not allow these to happen.
5. Conclusions

Conducted questionnaire study showed that people performing the obligation to file tax return in paper form, have digital experience and, therefore, have access to the Internet, and by using the electronic services, they acquire practice in the field of the new ICT application in many areas. Despite this, those respondents and unfortunately still majority of Polish taxpayers choose the traditional method.

Distinguishing between obtained responses to cultural, technical, cognitive and procedural factors, it turned out that 40% of spontaneously given reasons belong to the cultural, which is associated with tradition, fear of the Internet, lack of being inquisitive enough. Procedural reasons are in the second place in the perception of surveyed group. In third place are technical related to the software or equipment problems, and in the last one cognitive. However, the analysis of the responses obtained, leads to the conclusion that objectively in second place there are reasons related to lack of knowledge about procedure of sending the electronic tax return, in the third are technical problems, and only in the last procedural.

Therefore, citizens are aware of existing service, they have digital experience, there is no obstacles to the Internet access, applications and the methods of authentication, but despite having all this, and they prefer to use the service in the traditional way. What could be worrying is, that there was a lack of eagerness to find more accurate information, so taxpayers do not see any benefits in the service and their attitude to a new proposal is passive.

The task for government should be a better understanding of the potential group of users and popularizing how to use the service. Also stronger emphasis on the benefits resulting from usage of the e-Deklaracje system would be advantageous. Practical examples and giving the argument list will dispel concerns learnt in the study. This will make potential users be aware of the fact that the new way of action is worth testing, what means changing the attitude.

A group of taxpayers who have not yet benefited from the system is not homogeneous, two sectors can be distinguished in it: more and less resistant. In most cases, the reason for non-acceptance is a defect in the cognitive or emotional area - first one is easier to overcome through the application of persuasive methods. However, administration may also convince how to use the new services by making it easier for the entire procedure, do not let users discourage themselves e.g. just at the beginning while facing the problems with installing necessary software or with opening the files. Therefore, it is essential to know what the structure of the potential users group is and address the appropriate messages and actions for each of its sectors.
REFERENCES

ANALYSIS OF IT PROJECTS IN THE MODELS OF ENTERPRISE VALUE BUILDING. A SUMMARY OF RESEARCH BETWEEN 2010–2012

BARTOSZ WACHNIK

Warsaw University of Technology, Faculty of Production Engineering, Institute of Organisation of Production Systems

The research results presented here refer to the issues linked to the role of information technologies in enterprise value building models that can be found in the current economic structure. The scope of this article is to present an analysis of the data collected in an annual research cycle and the resulting conclusions, describing management support IT projects in three groups of enterprises, representing three models of enterprise value analysis, i.e. the value chain, the value shop and the value network. The essence of the research is to present a distribution of management support IT systems, the size of the projects, chosen application implementation strategies and the method of IT project investment economic evaluation in specific enterprise groups.

Keywords: models of enterprise value building, IT Project, Effectiveness, IS investments

1. Introduction

Currently, the subject literature is dominated by three models of enterprise value analysis, i.e. the value chain [7], the value shop and the value network [10]. In enterprises functioning according to M.E. Porter’s model, the end-product value is obtained through processing raw materials into final products. The enterprise value analysis by M.E. Porter [7] is mostly used in manufacturing companies.
C.B. Stabell and O.D. Fjeldstad [10] have proven that M.E. Porter’s value analysis is not sufficient and it does not cover all types of enterprises that presently function within the structure of our economy.

In the value shop model, value is most often built through resolving individual customer tasks. According to C.B. Stabell and O.D. Fjeldstad, the difference between the value shop and the value chain lies in the fact that in the value chain, an enterprise conducts a fixed number of operations in order to deliver a standard product in big quantities, while in case of the shop the activities performed and the resources used are adjusted to a specific, often unique problem that needs to be solved. Enterprises functioning according to the value shop model are, for example, consulting firms, architects, design studios and accounting firms.

In the value network model, value is built through linking customers or mediating between them. It can be either a direct link (e.g. in telecommunications companies) or an indirect one (e.g. in banks). According to C.B. Stabell and O.D. Fjeldstad, management of an enterprise that builds its value based on the value network logics is focused on perfecting the quality and the number of links between customers. Examples of management tasks include the maximum usage of infrastructure capacity, finding innovative forms of service delivery and collection of payments, assessing the long-term customer value and identifying clusters and links between the networks.

Examples of enterprises functioning according to the value network are recruitment companies, real estate agencies, insurance companies, banks and telecommunications companies. The aim of this publication is an analysis of IT projects in three groups of enterprises that represent three models of enterprise value analysis, including the IT project typology proposed by the author [13]. The article presents chosen data analyses collected in an annual research cycle and the resulting conclusions, describing management support IT projects among enterprises representing three models of enterprise value analysis, i.e. the value chain, the value workshop and the value network. In this case, the research objective is to analyse effective design, solution delivery and the usage and influence of information technology in the three groups of enterprises. The opening chapters of the paper discuss the role of information technologies in the models of enterprise value building, research assumptions and the method used. Subsequently, the results of research on IT projects in the enterprise value building models are presented and the crucial conclusions formed.

2. The role of information technologies in enterprise value building models

The general concept of enterprise value management originates from research [8] presenting the concept that through maximising the profits of shareholders, the benefits of all the parties linked to the enterprise are maximised. Managing
enterprise value means directing the enterprise so that the management activities and processes are aimed at maximising its value while considering the best interest of the owners and the capital they engage. The subject literature describes that the economic value of an enterprise is equal to the sum of its discounted operating net cash flow stream, which means that each factor influencing the flow can potentially shape the enterprise value. The impact of these factors derives from long-term strategic decisions and current operational decisions. The essence of value management [1] is the process of decision-making through focusing on the most important factors shaping enterprise value, known as generators or value drivers. In the subject literature, there is a predominant classification of value generators [8] based on three main components, i.e. cash flows from operating activities, discount rate and liabilities. The division of value generators into two groups [2] is particularly noteworthy: Main drivers: Free cash flows, Value increase period, Capital cost: Lower level drivers: Return on capital employed, Intellectual capital.

In the literature, there is no single binding definition of intellectual capital [12] and additionally the expression “intellectual capital” takes on many different forms. According to T.A. Stewart [11], intellectual capital is intellectual material: knowledge, information, intellectual property and experience that can be used for creating wealth. Another definition (L. Edvinsson, M.S. Malone) [4] says that intellectual capital is knowledge, experience, organisational technology, customer relations and professional skills that allow a company to achieve a competitive edge. Intellectual capital in a modern enterprise are patents, trademarks, practical experiences, management’s vision, the accumulated knowledge of the whole company and its specific employees, customer relations and business models supported by tools using modern technology. On the basis of literature research, indicates that the predominant approach is defining three major components within intellectual capital: human capital, structural capital and customer capital (relational). An important input of management support information systems into the development of intellectual capital is collecting and processing data, information and knowledge existing in different forms in an organisation and making them available to the users depending on their needs.

3. Research assumptions and the method used

The choice of research subject matter stemmed from the belief that the character of management support information system project implementation could depend on the group of enterprises that represent three different models of enterprise value analysis, i.e. the value chain, the value shop and the value network. The method and characteristic of realisation in these types of projects necessitates specific functional requirements for systems and a level of business-IT alignment. Understanding the views and the cognitive maps of companies’ top management is
of crucial significance to the description of the prevailing logics of action within the scope of management support IT projects implementation among a wide spectrum of enterprises in Poland. It is important from the perspective of research on effective enterprise value building with the use of IT in Polish economic conditions, with a growth of GDP on the level of 4.3% in 2011 and a seasonally unadjusted GDB growth by 2% in 2012. The research was conducted on an inter-regional scale, with companies located in Mazovia and Lower and Upper Silesia. Questionnaires were collected from 160 enterprises who answered questions about 210 completed IT projects in the period between 2011 and 2012. In the year 2012 in Poland there were 75,789 active enterprises with 10-49 employees, 15,694 enterprises with 50-249 employees and 3,107 enterprises with more than 250 employees. In the conducted research on the analysis of IT projects, the questionnaire questions corresponded with chosen attributes of the proposed typology of IT projects [13]. The enterprises qualified for the research complied with the following criteria: 80 to 1000 employees, the company has its own IT department, the minimum turnover of 40m Polish zloty, it’s around 10 m EUR. The enterprises included companies that have a wide autonomy in their IT strategy realisation, with both Polish and foreign capital. Table 1 presents the structure of the examined IT projects.

<table>
<thead>
<tr>
<th>The number of enterprises</th>
<th>The value chain</th>
<th>The value shop</th>
<th>The value network</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of enterprises</td>
<td>45</td>
<td>50</td>
<td>65</td>
<td>160</td>
</tr>
<tr>
<td>The number of projects</td>
<td>68</td>
<td>55</td>
<td>87</td>
<td>210</td>
</tr>
</tbody>
</table>

The selected companies achieved good or average results in their industry – so they are neither leading nor marginal companies. The enterprises selected for the research belonged to the small and medium-sized enterprise group. The research was aimed at reaching people directly or indirectly engaged in the implementation of management support IT projects. The respondents were company owners, directors, members of the board, financial directors or IT directors. After completing questionnaire research, the author carried out an in-depth analysis based on completing workshops, i.e. a series of meetings with chosen company representatives in order to verify the answers and conduct additional interviews. The author carried out 7 meetings in the ‘value chain’ enterprise group, 12 meetings in the ‘value shop’ enterprise group and 13 meetings in the ‘value network’ enterprise group. The workshops were aimed at conducting a deeper analysis of the logics of action in the analysed enterprises.
4. Analysis of IT project in models of enterprise value building

Table 2 presents the structure of two types of IT projects, i.e. the project of building an IT system developed from scratch and an IT system pack adaptation project divided by three enterprise groups representing the value chain, the value shop and the value network.

Table 2. The structure of IT project types divided by three enterprise groups

<table>
<thead>
<tr>
<th></th>
<th>The value chain</th>
<th>The value shop</th>
<th>The value network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building an IT system from scratch</td>
<td>34%</td>
<td>58%</td>
<td>61%</td>
</tr>
<tr>
<td>A standard IT system pack adaptation project</td>
<td>66%</td>
<td>42%</td>
<td>39%</td>
</tr>
</tbody>
</table>

Table 3 shows the size structure of management support IT projects divided by three enterprise groups representing the value chain, the value shop and the value network. The size of an IT project has been defined on the basis of three criteria, i.e. the number of end users, the number of key users and project duration. None of the enterprise groups has conducted a big or a large IT project. All three enterprise groups have a higher percentage of small IT projects.

Table 3. The size structure of management support IT projects divided by three enterprise groups representing the value chain, the value shop and the value network

<table>
<thead>
<tr>
<th>Project size</th>
<th>The value chain</th>
<th>The value shop</th>
<th>The value network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microprojects – number of end users 1-5; number of key users 1-2; duration up to 3 months</td>
<td>37%</td>
<td>36%</td>
<td>25%</td>
</tr>
<tr>
<td>Small projects – number of end users 5-20; number of key users up to 5; duration 3-6 months</td>
<td>44%</td>
<td>49%</td>
<td>52%</td>
</tr>
<tr>
<td>Medium-sized projects – number of end users 20-100; number of key users up to 10; duration 6-12 months</td>
<td>19%</td>
<td>15%</td>
<td>23%</td>
</tr>
<tr>
<td>Big projects - number of end users up to 1000; number of key users 50-100; duration 2-3 years</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Large projects - number of end users over 1000; number of key users 100; duration 4-6 years</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 4 and Figure 1 present the structure of strategy types that lead IT system implementations divided by three enterprise groups representing the value chain, the value shop and the value network. The group of companies belonging to the value chain model is dominated by the market survival strategy, while in the group
of companies belonging to the value shop model the platform for changes strategy prevails. In the group of companies from the value network model, the strategy of achieving saltatory innovation is predominant. In the enterprise group belonging to the value chain model, the same number of respondents chose the saltatory innovation strategy and the platform for changes strategy. In case of companies belonging to the value shop model, the lowest number chose the strategy of achieving saltatory innovation, while in case of the value network model, the market survival strategy was the least popular choice.

**Table 4. IT system implementation strategy structure divided by three enterprise groups representing the value chain, the value shop and the value network**

<table>
<thead>
<tr>
<th>Strategy type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market survival strategy.</strong></td>
<td>Strategy linked to the enterprise’s survival on the market treats an IT system implementation as a tool allowing the company to survive on the market.</td>
</tr>
<tr>
<td><strong>Achieving saltatory innovation.</strong></td>
<td>Strategy linked to the need to achieve innovations saltatorily treats an IT system implementation as a tool allowing to quickly achieve a single process innovation.</td>
</tr>
<tr>
<td><strong>Platform for changes strategy.</strong></td>
<td>Platform for changes strategy treats an IT system implementation as a platform for introducing permanent, step changes in enterprise organisation and management during the period of the system lifecycle in the enterprise.</td>
</tr>
</tbody>
</table>

**Figure 1.** The structure of respondents’ answers to the questions concerning an IT system implementation strategy structure divided by three enterprise groups representing the value chain, the value shop and the value network. Source: own study (See Table 4)

Table 5 and Figure 2 show the structure of an IT project investment model divided by three enterprise groups representing the value chain, the value shop and
the value network. Both the chain value model enterprise group and the value network group are dominated by the original investment model. In the case of companies from the value shop group, the interim model is predominant. Cloud computing proved to be still the least popular investment model in the three groups.

Table 5. The structure of an IT project investment model divided by three enterprise groups representing the value chain, the value shop and the value network

<table>
<thead>
<tr>
<th>Investment model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud processing (virtualisation)</td>
</tr>
<tr>
<td>- A processing model based on using services delivered by external organisations. It means that the original investment, i.e. server and license purchase or the necessity to install and administer software, is eliminated.</td>
</tr>
<tr>
<td>Original investment model</td>
</tr>
<tr>
<td>- A model based on investment realisation, i.e. purchasing all the necessary equipment and software, as well as software installation and administration services, in the initial phase.</td>
</tr>
<tr>
<td>Interim model</td>
</tr>
<tr>
<td>- An interim model between the cloud-processing model and the original investment model, e.g. collocation service.</td>
</tr>
</tbody>
</table>

Figure 2. The structure of respondents’ answers to the questions concerning an IT project investment model divided by three enterprise groups representing the value chain, the value shop and the value network. Source: Own study (See Table 5)

Table 6 and Figure 3 present the structure of project groups that completed selected IT projects divided by three enterprise groups representing the value chain, the value shop and the value network. All three groups are dominated by the model of a mixed project group, consisting both of enterprise employees and external consultants.
Table 6. The structure of project groups that completed selected IT projects divided by three enterprise groups representing the value chain, the value shop and the value network.

<table>
<thead>
<tr>
<th>Project groups</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal team</strong></td>
<td>Only the employees of the enterprise where the project is being completed</td>
</tr>
<tr>
<td><strong>External team</strong></td>
<td>Only the employees of the project supplier participate.</td>
</tr>
<tr>
<td><strong>Mixed team</strong></td>
<td>The project group consists of both of the enterprise’s employees (the so-</td>
</tr>
<tr>
<td></td>
<td>called key and end users) and external consultants.</td>
</tr>
</tbody>
</table>

Figure 3. The structure of respondents’ answers to the questions concerning investment model divided by project groups that completed selected IT projects divided by three enterprise groups representing the value chain, the value shop and the value network.

Source: own study (See Table 6)

Tables 7, 8 and Figures 4, 5 present the information concerning performing economic analyses of IT project investments from the ex-ante and ex-post perspective. In all three enterprise groups, a lack of ex-ante and ex-post economic analysis of IT projects prevailed. The main reason for failing to perform this type of analyses was a lack of interest on the side of the top management, as shown in Table 11 and Figure 6.

Table 7. Information concerning performing economic analyses of IT project investments from the ex-ante perspective

<table>
<thead>
<tr>
<th>Information on economic analysis performance in an IT project investment (ex-ante)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performed (ex-ante) economic analysis of an IT project investment</td>
</tr>
<tr>
<td>Lack of ex-ante economic analysis of an IT project investment</td>
</tr>
</tbody>
</table>
Figure 4. The structure of respondents’ answers to the questions concerning information on performing economic analyses of IT project investments from the ex-ante perspective. Source: Own study (See Table 7)

Table 8. Information concerning performing economic analyses of IT project investments from the ex-post perspective

<table>
<thead>
<tr>
<th>Information on economic analysis performance in an IT project investment (ex-post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performed (ex-post) economic analysis of an IT project investment</td>
</tr>
<tr>
<td>Lack of ex-post economic analysis of an IT project investment</td>
</tr>
</tbody>
</table>

Figure 5. The structure of respondents’ answers to the questions concerning information on performing economic analyses of IT project investments from the ex-post perspective. Source: own study (See Table 8)
Table 9. Main reasons hindering the performance of an economic analysis in IT projects

<table>
<thead>
<tr>
<th>Main reasons hindering the performance of an economic analysis in IT projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top management’s lack of interest in performing an analysis</td>
</tr>
<tr>
<td>Lack of knowledge and tested models allowing to perform an economic analysis</td>
</tr>
<tr>
<td>Difficulties with specifying the benefits (indirect and direct) and costs entailed by the completed projects</td>
</tr>
</tbody>
</table>

Figure 6. The structure of respondents’ answers to the questions concerning the main reasons hindering the performance of an economic analysis in IT projects. Source: own study (See Table 9)

5. Conclusions

The selected results of analysed material presented in this paper from research on IT projects in three enterprise groups, representing three value building models, conducted by the author in 2011 and 2012, allow us to formulate the following crucial conclusions.

First of all, companies representing the chain value model chose IT projects consisting of adapting a standard IT system pack most often, as opposed to two other company groups, i.e. from the value shop and the value network. In all three enterprise groups, IT projects consisting of adapting a standard pack were dominated by ERP and BI system implementations. It stems from two facts: firstly, the life cycle of an ERP system product enforcing upgrades, re-implementations, new implementations and secondly, in the period of stagnation and recession that we experienced in Europe between 2009 and 2011, many enterprises decided to implement BI class analytical systems for more effective monitoring and control of
their operational activity, especially the costs. The majority of them treated a BI system implementation as one of the important components of an informatisation strategy during the difficult times [3].

Secondly, analysing the size of completed projects, considering the number of end users, the number of key users and the project duration, none of the enterprise groups has conducted a big or large IT project. In all three enterprise groups, small IT projects prevail. Additional interviews with enterprise representatives indicated that most enterprises have already completed the majority of big IT projects and that they are not planning to carry out this type of project in the near future. Currently, enterprises from the three groups are focused on implementing highly specialised management support applications in narrow fields, e.g. for statistical analysis and recommendations for product and service price setting on the market, and calculating service charges, the so-called billing, within small-scale projects.

Thirdly, enterprises from each of the groups followed different strategies in completing IT projects. The value chain model enterprises completed their projects according to the market survival strategy. It results chiefly from two reasons, i.e. implementing financial-accounting modules within ERP systems, that are naturally obligatory in enterprise management, and implementing appropriate IT systems complying with e.g. value management standards in the “Life&Science” industry production, i.e. FDA, GMP. The value shop model enterprises completed their projects according to the strategy of treating an IT project as a platform for changes. Additional interviews with selected enterprise representatives have shown that managers often decided to perform a DMS application on, e.g. the SharePoint platform, that was intended as a customer service management system, arguing that they have not found a standard pack that could be adapted to their needs and that would meet their requirements. The majority of analysed DMS applications had the characteristics of new functionality development facilitation required for widening the range of provided services. The value network model enterprises completed their projects according to the strategy of achieving saltatory innovation. It results mostly from the fact that this enterprise group includes enterprises from the financial sector, as well as telecommunications and data transmission services operators. Enterprises from the value network model group dedicate less resources to infrastructure investment, transaction applications that allow them to standardise and automate a big group of activities, focusing on analytical applications, chiefly innovative transformation systems influencing enterprise business model change and allowing to gain competitive advantage.

Furthermore, enterprises from all three groups chose two dominating IT project investment models, i.e. the original investment model consisting in an original purchase of the necessary equipment, software and service licence and the interim model, between the original investment model and the cloud computing model. It is worth noticing the new cloud processing model among management
support IT systems. Apart from owners seeking savings, the development of the cloud processing model is also influenced by an increase in popularity of mobile Internet and mobile applications.

Moreover, enterprises from all three groups completed IT projects in a mixed team, i.e. the project group consisted of both enterprise employees and external consultants. Additional interviews with chosen enterprise representatives have proven that in case of developing an IT system from scratch, external consultants were engaged mainly as project managers or programmers competent in a given specialisation.

Finally, in all three enterprise groups, both from the ex-ante and the ex-post perspective, a lack of economic analysis of IT project investments is predominant. Importantly, both in the ex-ante and ex-post perspective, the highest number of companies not completing an economic analysis has been found in the group of enterprises from the chain value model and the lowest in the value network group. The indirect, significant reasons were a lack of interest in carrying out such analyses among top management and a lack knowledge of how such analyses are performed.

Additional interviews with chosen enterprise representatives have shown that the companies representing the value chain and the value shop functioned according to corporate governance rules on IT that recommend controlling and monitoring the effectiveness of implemented IT management support systems [9], as opposed to the enterprises from the value chain model that had not yet implemented corporate governance on IT and thus performed such analyses less often. Additionally, during the interviews, the respondents pointed out that enterprises less frequently performed these analyses from the ex-post perspective, i.e. after the implementation, as this type of analyses may indicate mistakes and errors in the choice of system, implementation partner or, finally, project completion.

To sum up, it is interesting that top managers of most enterprises in all three groups are not interested in answering the questions of how to measure economic effectiveness in IT system implementation projects and how to maximise the business value of IT technology investments, unless they are forced to do so by corporate governance on IT.

The author hopes that the research results presented in this paper may help achieve two goals, i.e. indicating the character and the role of IT projects completed in Poland in the groups of enterprises representing three enterprise value building models and thus allowing for a wider verification of knowledge in this area and contributing to a more effective realisation of mid and long-term aims included in strategies for creating an economy based on innovations, information, knowledge and trust in Poland.
REFERENCES


EVALUATION OF THE PAGERANK ALGORITHM EFFECTIVENESS

KAZIMIERZ WORWA, GUSTAW KONOPACKI

The Faculty of Cybernetics, Military University of Technology

In this paper the challenges in building good search engines are discussed. Many of the search engines use well-known information retrieval algorithms and techniques. They use Web crawlers to maintain their index databases amortizing the cost of crawling and indexing over the millions of queries received by them. Web crawlers are programs that exploit the graph structure of the Web to move from page to page. Paper analyses the PageRank algorithm one of these Web crawlers. The results of the impact of the PageRank parameter value on the effectiveness of determining the so-called PageRank vector are considered in the paper. Investigations are illustrated by means of the results of a some simulation experiments to analyze the PageRank algorithm efficiency for different density graph (representing analyzed part of www) coefficient values.

Keywords: Search engine, Crawling, PageRank algorithm

1. Introduction

One of the most popular services offered by modern Internet is www. Access to the Web resources is implemented mostly through search engines, whose functionality is growing. Users of the search engine form queries resulting in a list of websites containing the following keywords. Most of the search engines uses familiar, traditional algorithms and information retrieval techniques developed for searching a relatively small and thematically coherent collection, such as catalogs of books in the library. These methods are not effective enough for the needs of
Web search, which is a huge, much less consistent, very often changing its content and structure, and is spread over geographically distributed computers. For the purpose of searching the Internet is therefore required to improve the traditional information retrieval techniques or develop new ones. The research carried out in order to estimate the size of modern Internet shows that it consists of over one billion pages. Given that the average web page size is approximately 5-10 kilobytes size of the Internet can be estimated at tens of terabytes. The Internet is characterized by a very high dynamics of change in its size and structure. The research conducted by Lawrence and Giles [10] shows that the size of the Web has doubled in the last two years. Large is the dynamics of Internet content. In addition to the newly created pages, existing pages are constantly updated. Research carried out by Cho and Garcia-Molina [4] shows that about 23% of all the pages available on the Web is updated daily. Knowledge of the structure and size of the Internet and development of methods for Internet structure modeling is a number of ongoing studies [4].

There are two main reasons why the traditional information retrieval techniques may not be sufficiently effective in the exploration of the modern Internet. The first reason stems from the mentioned above very large size of the Internet and the very large dynamic changes in its structure and content. The second reason has to do with the existence of multiple systems describing the contents of individual Web pages, which can significantly impede analysis of their contents. A qualitative change in the efficiency of search algorithms on the Web was the result of the use of the results in their design analysis of the structure of links in the network. In particular, a link from page A to page B can be considered as a recommendation of the page B by the author of the page A. In recent years some new algorithms have been proposed based on the knowledge of the structure of Internet links. Practice shows that the effect of information retrieval algorithms of this class gives qualitatively better results than the results of the algorithms that implement the traditional methods and techniques of information retrieval.

Internet search engines use a variety of algorithms to sort Web pages based on their text content or on the hyperlink structure of the Web. This paper describes algorithms that use the hyperlink structure, called link-based algorithms: PageRank [12] and HITS [8]. The basic notion for these algorithms is the Web graph, which is a digraph with a node for each Web page and an arc between pages \( i \) and \( j \) if there is a hyperlink from page \( i \) to page \( j \). Given a collection of Web pages linking to each other, the HITS and PageRank algorithms construct a matrix capturing the Web hyperlink structure and compute a measures of pages popularity (ranks) using linear algebra methods.
2. The PageRank algorithm

In well-known study Brin and Page [3] have proposed an algorithm for determining the ranking of Web pages called PageRank, which uses the term "weight of page". According to this proposal the weight of page depends on the number of others Web pages that point to it. The value of the weight can be used to rank the results of the query. This page rank, however, would be little resistance to a phenomenon known as spam, because it is quite easy to artificially create multiple pages pointing to the page [1]. To counteract such practices PageRank algorithm extends the basic idea of citations, taking into account the importance of each page that point to the analyzed page. This means that the definition of page weights (PageRank) is cyclic: the importance of page depends on the weight of pages pointing to it and at the same time affect the validity of the pages to which she points. Web model proposed in the work of Brin and Page [3] uses the link structure of Web site to the construction of a Markov chain with transition matrix \( P \), whose elements are the probabilities \( p_{ij} \) of random events such that the user of page \( i \) indicates a link to the page \( j \). The irreducibility of the chain guarantees that the long-run stationary vector \( r \), known as the PageRank vector, exists. Mathematically, we can think of this network as a graph, where each page is a vertex, and a link from one page to another is a graph edge. In the language of PageRank, vertices are nodes (Web pages), the edges from a node are forward links, and the edges into a node are backlinks.

2.1. The idea of PageRank model

We first present a simple definition of PageRank that captures the above intuition before describing a practical variant.

Let the pages on the Web be denoted by \( 1, 2, \ldots, m \). Let \( N(i) \) denote the number of forward (outgoing) links from page \( i \). Let \( B(i) \) denote the set of pages that point to page \( i \). For now, assume that the Web pages form a strongly connected graph (every page can be reached from any other page). The basic PageRank of page \( i \), denoted by \( r_i \), is a nonnegative real number given by

\[
 r_i = \frac{\sum_{j \in B(i)} r_j / N(j)}{N(i)}, \quad i = 1, 2, \ldots, m. \tag{1}
\]

The division by \( N(j) \) captures the intuition that pages that point to page \( i \) evenly distribute their rank boost to all of the pages they point to. According to this definition, the PageRank of some page depends not only on the number of pages pointing to it, but also on their importance. The row vector \( r \) is called a PageRank vector and the value \( r_i \) is the PageRank of page \( i \).

Effective, practical way to find PageRank vector \( r \) is using the language and methods of linear algebra. Using the linear algebra the PageRank vector \( r \) can be found by solving either the homogeneous linear system
or by solving the eigenvector problem
\[ r = r \cdot A, \]
where \( r^T \) is a column transposed vector to the row vector \( r \), \( I \) is the identity matrix of order \( m \), \( 0^T \) is the column vector of all 0's, and \( A^T \) is a transposed matrix of a square matrix \( A = [a_{ij}]_{m \times m} \) which elements \( a_{ij} \) are defined as follows

\[
a_{ij} = \begin{cases} 
\frac{1}{N(i)} & \text{if page } i \text{ points to page } j, \\
0 & \text{otherwise}.
\end{cases}
\]

Both formulations are subject to an additional equation, the normalization equation \( r \cdot I^T = 1 \), where \( I^T \) is the column vector of all 1's.

Simple PageRank is well defined only if the link graph is strongly connected, where a graph is strongly connected when for each pair of nodes \((i, j)\) there is a sequence of directed edges leading from \( i \) to \( j \). One problem with solely using the Web’s hyperlink structure to build the Markov matrix is apparent. Some rows of the matrix may contain all zeros. Thus, such a matrix is not stochastic. This occurs whenever a node contains no outlinks. Many such nodes exist on the Web. In particular, there are two related problems that arise on the real Web: rank sinks and rank leaks [1]. A group of pages pointing to each other could have some links going to the group but no links going out forms a rank sink. An individual page that does not have any outlinks constitutes a rank leak. Although, technically, a rank leak is a special case of rank sink, a rank leak causes a different kind of problem. In the case of a rank sink, nodes not in a sink receive a zero rank, which means we cannot distinguish the importance of such nodes.

Page et al. [12] suggest eliminating these problems in two ways. First, they remove all the leak nodes with out-degree 0. Second, in order to solve the problem of sinks, they introduce a decay coefficient \( \alpha \), where \( 0 < \alpha < 1 \), in the PageRank definition (1). In this modified definition, only a fraction \( \alpha \) of the rank of a page is distributed among the nodes that it points to. The remaining rank is distributed equally among all the pages on the Web. Thus, the modified PageRank is [1]:

\[
r_i = \alpha \sum_{j \in B(i)} r_j / N(j) + (1 - \alpha) / m, \quad i = 1, 2, ..., m
\]

where \( m \) is the total number of nodes in the graph. Note that basic PageRank (1) is a special case of (5) that occurs when we take \( \alpha = 1 \).

Using the matrix \( A \), defined by (4), is insufficient for the PageRank algorithm because the iteration using \( A \) alone might not converge properly. It can cycle or the limit may be dependent on the starting vector. Part of the explanation for this is that
the matrix $A$ is not yet necessarily stochastic [6]. For example, if some page is a leak node then corresponding row of the matrix $A$ contains all zeros ($0$).

Thus, to ensure that matrix $A$ is stochastic, we must ensure that every row sums to $I$. It can be proved that from matrix $A$, we can obtain the stochastic matrix $S$ as follows [6]:

$$ S = A + (b^T \cdot I) / m, $$  

where $b^T$ is a column vector such that

$$ b_i = \begin{cases} 
1 & \text{if } \sum_{j=1}^{m} a_{ij} = 0, \text{ i.e., page } i \text{ is a leak node,} \\
0 & \text{otherwise.} 
\end{cases} \tag{7} $$

where $i=1, 2, ..., m$ and $I$ is a row vector of all $1$’s.

Given any stochastic matrix $S$ we can obtain irreducible matrix $G$ as follows [6]:

$$ G = aS + (1-a)E, $$  

where $0 < a < 1$, $E = (I^T \cdot I) / n$ and $I^T$, $I$ are, respectively, the column and row vectors of all $1$’s.

Because $G$ is stochastic (i.e., the entries in each column sum to 1), the dominant eigenvalue of $G$ is 1 [11]. Notice, also, that matrix $G$ is completely positive, i.e. all elements of $G$ are positive, although the probability of transitioning may be very small in some cases, it is always nonzero. The irreducibility adjustment insures that matrix $G$ is primitive, where a nonnegative, irreducible matrix is primitive if it has only one eigenvalue on its spectral circle [10]. The matrix irreducibility implies that the power method will converge to the stationary PageRank vector $r$. It can be shown that

$$ r = r \cdot G. $$  

2.2. Computational aspects of PageRank

Although PageRank can be described using equation (1), the summation method is neither the most interesting nor the most illustrative of the algorithm’s properties [1]. The preferable method is to compute the principal eigenvector of the stochastic and irreducible matrix $G$ defined by (8).

One of the simplest methods for computing the principal eigenvector of a matrix is called power iteration. In power iteration, an arbitrary initial vector is multiplied repeatedly with the given matrix, until it converges to the principal eigenvector [6]. The idea of power iteration algorithm to compute the PageRank vector $r$ is given below [1]:

1) $s \leftarrow$ initial vector;

2) $r \leftarrow s \cdot G;$
3) if \( \|r-s\| < \epsilon \) then end; \( r \) is the PageRank vector;
4) \( s \leftarrow r \);
5) goto 2,

where \( \| \| \) is the measure of difference of successive iterates and \( \epsilon \) is predetermined tolerance level (computational accuracy).

In order for the power iteration to be practical, it is not only necessary that it converge to the PageRank, but that it does so in a few iterations [1]. Theoretically, the convergence of the power iteration for a matrix depends on the eigenvalue gap, which is defined as the difference between the modulus of the two largest eigenvalues of the given matrix. Page et al. [12] claim that this is indeed the case, and that the power iteration converges reasonably fast (practically in no more than in 100 iterations). It is worth noting that in practice we are more interested in the relative ordering of the pages induced by the PageRank (since this is used to rank the pages) than the actual PageRank values themselves [1]. Thus, we can terminate the power iteration once the ordering of the pages becomes reasonably stable. Experiments [7] indicate that the ordering induced by the PageRank converges much faster than the actual PageRank.

When dealing with data sets as large as Google uses (more than eight billion web pages [5]), it is unrealistic to form a matrix \( G \) and find its dominant eigenvector. It is more efficient to compute the PageRank vector using the power method variant, where we can compute the PageRank vector \( r \) in \( k \) iterations, \( k = 1, 2, \ldots \), with the matrix \( A \) which elements are defined by (4) instead matrix \( G \) [6]:

\[
\begin{align*}
    r^{(k)} &= \alpha r^{(k-1)} A + [(\alpha r^{(k-1)} b^T + (1-\alpha)) / m] \cdot 1. \\
\end{align*}
\]

One of the benefits of using the above power method variant to compute the PageRank vector is the speed with which it converges. Specifically, the power method on matrix \( G \) converges at the rate at which a quantity \( \alpha^k \) goes to zero. This gives the ability to estimate the number of iterations required to reach a tolerance level measured by \( \|r^{(k)} - r^{(k-1)}\| \). The number of needed iterations \( k \) is approximately \( \log \epsilon / \log \alpha \), where \( \epsilon \) the tolerance level [9].

It is worth noting that the founders of Google, Lawrence Page and Sergey Brin, use \( \alpha = 0.85 \) and find success with only 50 to 100 power iterations [9].
3. Test the effectiveness of the PageRank algorithm

3.1. General assumptions

Using an iterative algorithm, in practice, according to the formula (7) is conditioned to its efficiency, which in this case is measured by the number of iterations to be done to accuracy that is required for elements of \( r \) vector for a fixed value of the \( \alpha \) coefficient. The independent parameters of simulation experiments were the number of Web pages and their links and the density of these links. In accordance with what has been said, a network of websites is mapped in the form of a directed graph without loops, where the arc shows the indication (the link) from one page to another, such as a linked thematically. As a measure of the density of links between Web pages for the simulation experiments the \( \lambda \) coefficient is assumed, hereafter referred to as the density coefficient adjacency matrix of the Web pages graph comprising \( m \) websites, determined from the following relationship:

\[
\lambda = \frac{\sum_{i=1}^{m} N(i)}{m^2 - m}.
\]

Experiments were performed on randomly generated adjacency matrix with a predetermined value \( \lambda \) coefficient. Due to the limited possibility of presentation of the results of experiments will be based at most 20 Web pages networks (20 dimensional adjacency matrix), which does not detract from the generality of observations and conclusions.

Experiments conducted to evaluate the effectiveness of an iterative algorithm of determining the \( r \) vector were aimed at:

- assessment of the number of iterations of the algorithm and the clarity of the resulting \( r \) vector depending \( \alpha \) values at a fixed value of the \( \lambda \) coefficient for the Web with a fixed number of pages,
- assessment of the number of iterations of the algorithm, depending on the values of the coefficients \( \alpha \) and \( \lambda \) for the Web with a fixed number of pages,
- assessment of the impact of coefficients \( \alpha \) and \( \lambda \) for the Web fixed number of pages on the number of iterations of the algorithm required to achieve of \( r \) vector of highest distinctness,
- assessment of the impact the accuracy of determining the elements of the \( r \) vector on the number of iterations of the algorithm.
3.2. Assessment of the number of iterations of the algorithm and the clarity of the resulting $r$ vector depending $\alpha$ values at a fixed value of the $\lambda$ coefficient for the Web with a fixed number of pages

The research was conducted with the following assumptions:

- 20 Web pages were considered,
- for considered Web the adjacency matrix is a description of a graph without loops, with the density values $\lambda = 0.1$.

Fig. 1 shows graphs of the PageRank coordinates of $r$ vector for three values of the coefficient $\alpha$, equal to 0.1, 0.5 and 0.99, respectively.

![Figure 1. Graphs coordinate values of the PageRank vector r for values $\alpha = 0.1, 0.5, 0.99$](image)

Analysis of the results of the research confirm the supposition any increased expressiveness assessment of Web pages by PageRank algorithm with increasing $\alpha$ coefficient, wherein the assessments expressiveness was measured using well-known in statistics, the coefficient of variation (ratio of the standard deviation of the coordinate vector $r$ to their mean value), as:

$$V_r = \frac{s_r}{\bar{r}}.$$  \hspace{1cm} (12)

The values of the variation coefficient of $r$ vector depending on the value of the $\alpha$ coefficient shows the Table 1.

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>0.1</th>
<th>0.5</th>
<th>0.99</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_r$</td>
<td>0.0816</td>
<td>0.3768</td>
<td>0.7528</td>
</tr>
</tbody>
</table>

Table 1. The values of the coefficient of variation of PageRank $r$ vector depending on the value of the $\alpha$ coefficient
The desired increase of expressiveness coefficient of the $r$ vector by increasing the value of the $\alpha$ coefficient results in undesirable exponential increase of the number of iterations of the algorithm of calculating the $r$ vector, as shown in Fig. 2.

![Figure 2. Plot of the number of iterations of the PageRank algorithm in the process of determining the $r$ vector for $\alpha$ values](source: own preparation)

For the experiment, the number $L$ of iterations PageRank algorithm depending on $\alpha$ values can be estimated with high accuracy by using the following relationship:

$$L = 5,6815 \cdot e^{0,107 \alpha}$$ (13)

3.3. Assessment of the number of iterations of the algorithm, depending on the values of the coefficients $\alpha$ and $\lambda$ for the Web with a fixed number of pages

Experiments were performed for adjacency matrices of fixed dimensions ($20 \times 20$) and changing values of $\lambda$ coefficient ranging from 0.1 to 0.9 in steps of 0.1 and for fixed values of $\alpha$ coefficient. The number of iterations needed to determine the $r$ vector for the assumed accuracy of its coordinates have been measured. The results are shown in Table 2.

Table 2 shows that the increase in the value of $\lambda$ coefficient of the adjacency matrix (increasing the number of links between the pages) will reduce the number of iterations of the PageRank algorithm to determine the $r$ vector desired accuracy for fixed $\alpha$ coefficient. Number of iterations of the algorithm varies exponentially for rare adjacency matrix ($\lambda = 0.1$) by changing the linear for the adjacency matrix.
of $\lambda = 0.5$, up to by parabola negative coefficient directional - for a dense matrix, i.e. for $\lambda = 0.9$. However, it seems that the actual Web networks are rather rare, characterized by the values of the coefficient $\lambda < 0.5$, therefore, to be expected in such cases, the exponential increase in the number of iterations of the PageRank algorithm to achieve the desired $r$ vector with increasing $\alpha$ values.

### Table 2. Number of iterations of the PageRank algorithm as a function of the $\alpha$ and $\lambda$ coefficients

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$\lambda$ coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>6  5  5  5  4  4  4  4  3</td>
</tr>
<tr>
<td>0.2</td>
<td>8  6  6  5  5  5  4  4  4</td>
</tr>
<tr>
<td>0.3</td>
<td>10  8  7  6  6  5  5  4  4</td>
</tr>
<tr>
<td>0.4</td>
<td>12  9  8  7  7  6  5  5  4</td>
</tr>
<tr>
<td>0.5</td>
<td>14  11  9  8  7  6  6  5  4</td>
</tr>
<tr>
<td>0.6</td>
<td>18  12  10  9  8  7  6  6  5</td>
</tr>
<tr>
<td>0.7</td>
<td>21  15  11  10  9  7  7  6  6</td>
</tr>
<tr>
<td>0.8</td>
<td>26  17  12  11  9  9  7  7  6</td>
</tr>
<tr>
<td>0.9</td>
<td>34  20  14  12  10  10  8  7  6</td>
</tr>
<tr>
<td>0.99</td>
<td>44  24  15  12  11  11  9  8  6</td>
</tr>
</tbody>
</table>

3.4. Assessment of the impact of coefficients $\alpha$ and $\lambda$ for the Web fixed number of pages on the number of iterations of the algorithm required to achieve of $r$ vector of highest distinctness

Evaluation of the impact speed for obtaining the highest expressiveness of the $r$ vector by the algorithm based on the change both the value of the $\alpha$ and $\lambda$ coefficients made indirectly through the distances analysis of $r$ vectors obtained for different values of the $\alpha$ coefficient from the vector which is characterized by the greatest expressiveness, i.e. the vector obtained for $\alpha = 0.99$. Among the known distance measures between numerical vectors in experiment selected 7 following, the most frequently used in practice: Euclidean, Chebyshev, Manhattan, Pearson, tangents, angular and exponential module. The research was conducted for the adjacency matrix of fixed dimensions (20 × 20) and selected values of $\lambda$ coefficient. Fig. 3 shows the changes in the Euclidean distances between the $r$ vectors and the vector with the highest expressiveness (for $\alpha = 0.99$) as a function of the $\alpha$ coefficient for the adjacency matrix of values with $\lambda$ coefficient equals to 0.1, 0.5 and 0.9.
Figure 3. Changes of the Euclidean distance of \( r \) vectors to the vector with the greatest distinctness (for \( \alpha = 0.99 \)) as a function of the \( \alpha \) coefficient for the adjacency matrix with \( \lambda \) coefficient equals to 0.1, 0.5 and 0.9

The waveforms similar to shown in Fig. 3 was also observed if the distance between \( r \) vectors was measured by using the other distance measures. Thus justified hypothesis that for the rare adjacency matrix (\( \lambda = 0.1 \)) the approximation of the \( r \) vectors (decreasing distances), calculated for increasing values of \( \alpha \) coefficient from the reference vector is much faster than for the denser of adjacency matrix. Based on the results of the experiment can be concluded that the dense adjacency matrix (\( \lambda = 0.9 \)) the \( r \) vector (for small values of \( \alpha \) obtained using a small number of iterations of the investigated algorithm) will be a good approximation of the high expressiveness \( r \) vector, obtained for the high value of \( \alpha \) coefficient, but at the expense of a larger number of iterations. This conclusion may have important practical significance when examined pages ranking algorithm would be used in large networks with highly dynamic changes in the density of the relationship between the Web pages.

4. Conclusions

Many of today’s search engines use a two-step process to retrieve pages related to a user’s query. In the first step, traditional text processing is done to find all documents using the query terms, or related to the query terms by semantic meaning. This can be done by a lookup into an inverted file, with a vector space method, or with a query expander that uses a thesaurus. With the massive size of the Web, this first step can result in thousands of retrieved pages related to the query.
To make this list manageable for a user, many search engines sort this list by some ranking criterion. One popular way to create this ranking is to exploit the additional information inherent in the Web due to its hyperlinking structure. Thus, link analysis has become the means to ranking. One successful and well-publicized link-based ranking system is PageRank, the ranking system used by the Google search engine [2].

From the foregoing considerations, it follows that there is possibility of practical achieve time savings associated with the ranking Web pages, by substituting the result (page ranking), obtained through the implementation of the PageRank algorithm, by the approximate ranking of these pages, based on the analysis of their input stages, i.e., the number of appeals from other pages.

REFERENCES