THE FUNDAMENTAL TECHNOLOGIES FOR OPEN B2B – A SURVEY

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SUMMARY

B2B is a strong multidisciplinary research field with many constituent disciplines and technologies. This paper deals with the B2B interoperability in the sense of open component and framework standards. In particular, underlying network technologies, protocols, the components and concepts of Web intelligence, and the frameworks for B2B interoperability are described. All technologies described are covered by an overview of relevant standards. Concluding remarks emphasize a critical overview of the current state of B2B openness and future directions in research and standardization in terms of fundamental technologies described here. The most of discussed issues are of wider interest for many e-applications.

Keywords: *B2B, interoperability, standards, Web services, Web intelligence, ontologies*

1. INDRODUCTION

The growth of the Internet and Web has changed a lot. Numerous organizations started to use the Web as a way for doing business. The idea of exchanging business data between business partners using computer networks is nothing new and it was implemented since the 1970ies. The framework used was Electronic Data Interchange (EDI) based on international standards X.12 and UN/EDIFACT, both aimed to minimize the cost, effort, and time for processing paper-based business documents. Despite standard-based specifications, initial popularity and many promises, EDI failed to take widespread usage due to its complex and expensive implementation. A lot of money for EDI implementations has invested by big enterprises without ability to conduct a much of their business electronically because many of their partners, mostly Small-to-Medium Enterprises (SMEs) stayed away. The world of EDI business was open only for a very limited number of companies that were able to pay expenses for hardware, software, skilled personnel, the deployment of proprietary networks, etc.

Web use in business transactions is a way out from the bottleneck caused by EDI failure as well as a new business opportunity known today as *electronic commerce (EC)*. There is no universally accepted definition of EC. It depends on the various perspectives [33] such are communications, business processes, services, online operation, collaboration and community. However many people think about EC as an emerging concept that describes the process of buying, selling, or exchanging data, services and products over the Internet.

EC may be classified by the nature of transactions or by the business models [33]. By nature of transactions, we may distinguish B2B (business-to-business), B2C, B2E, C2B, C2C, G2C, etc., where C, G and E stands for customers, government and employees respectively. Today, most of EC are usually B2B. Various new business models are also established thanks to the e-business concept. Some well-known are "find the best price", "name your price", group purchasing, supply chain management, on-line tendering and auctions, etc.

B2B assumes unlimited number of participants each of which may have own scenario [18]. By default, doing something over the Internet involves various heterogeneous environments (operating systems, protocols, speeds, etc.). Dealing with a wide variety of business scenarios and applications necessary augments the total heterogeneity of the system. Many heterogeneous applications must be integrated both within and outside an enterprise into a single coherent environment where the interactions among a vast variety of organizations (here and after business entity, *be*) should be handled seamlessly and dynamically.

The rest of the paper is organized as follows. In section 2 the requirements for B2B openness and general framework are given. Section 3 gives a short overview of general Internet technologies standards that may be applied to the given framework. The main section discusses the major areas of Web development, especially the technologies for knowledge-based Web for B2B. Each section gives an overview of technology being discussed, the standard efforts and development trends. Finally, concluding remarks bring critical facts and forecast on the given subject.

2. THE OPEN B2B FRAMEWORK

Let us suppose that two business entities (*be1* and *be2*) are going to establish an automatic business process over the Internet. Let us also assume that both have well suited business applications at the top of the layered architecture of the underlying technologies and protocols [17] as shown in Figure 1. They will probably discover that their platforms do not match expectations, many discrepancies between their applications are existed, and despite high technology deployment they must do a lot behind the digital walls. In addition, many other obstacles may appear from time to time, such as overcrowded communications, virus attacks, etc. Such complex challenges are topics of many

research fields. They include, but not limited to, Internet and communications technologies, Web, intelligent agents, security and privacy, middleware, B2B frameworks, standardization, etc. This paper deals with some of the most important technologies and research trends in terms of existing and future standards that should allow the full maturity of open B2B interactions. In order to save space the security standards and issues are not covered here, but they may found elsewhere [18], [29].

The framework shown in Figure 1 is a component based framework [9], [32]. The platform itself is multi-layered and multi-dimensional [17]. Components are software modules that can be developed and delivered independently and then combined to form larger systems. In general, strong decoupling of the components of a framework is required, each component may consists of one or more open subcomponents, and relationships and interfaces between components should be precisely defined.

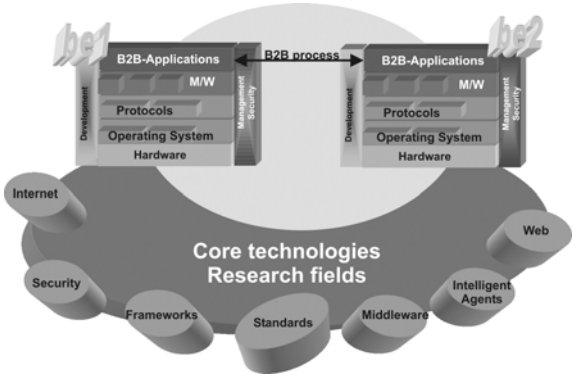

Fig. 1 The B2B reference framework, core technologies and research fields

Various B2B integration efforts that are described in, for example, [4], [6], [24], [51], etc. and the main rules and achievements of open systems [17] are generally should included into the wide open framework.

B2B specific applications are on the top of the framework. On the other side, the bottom layers consist of different hardware platforms, various operating systems and communications protocols. *Core components* that should allow interoperability between B2B applications in heterogeneous distributed environments are at a middleware layer . The role of a *middleware* (M/W) is to make uniformity between bottom layers, which are different by default, and various applications that are different by nature (e.g. by B2B business models). Various middleware platforms, which may also have their own protocol stack, are proposed and are in use [18]. These provide distributed file system services, naming, messaging, resource sharing, etc.

The term *open systems* exists almost twenty years, but there is not yet a widely accepted comprehensive definition. They vary from the wrong simple equality with ISO OSI (Open Systems Interconnections), followed by non proprietary, vendor neutral, interoperable, standard-based, extensible, scalable, etc, to many variations of "Portability + Scalability + Interoperability (PSI, [16]+ Standards". The discrepancies come from the different points of view of standards, if they are de jure only, de facto, or both. Additional problems are influenced by vendors which usually spoil standard specifications in order to add new features, etc.

The first attempt to define a comprehensive platform consisting of standard components has done by X/Open, originally known as X/Open *CAE (Common Application Environment).* X/Open CAE is a set of standards for providing a complete support system for the development and running of application software in a full open environment, based on the PSI features of such applications. In order to define CAE, X/Open adopted and adapted individual standards, both de jure and de facto and then put them into one cohesive and comprehensive super-standard known as the *X/Open Portability Guide (XPG).* X/Open also introduced the term branding in terms of open systems, so the vendors who claimed that are deliver open systems must approve the conformance to XPG. After the merge of X/Open and Open Software Foundation into The Open Group (TOG), the CAE has known as TOG Technical Standards [43]. The goal of this paper is an investigation which of existed and oncoming technologies may be used to form a common application environment for EC and therefore the appropriate framework.

3. THE UNDERLAYING NETWORKS

Doing business over a network is a very sensitive matter that requires special attention to network availability, reliability, trustworthiness, security and many other network features. Recent data provided by Internet Systems Consortium show that there are more than 285 millions of hosts connected to the Internet by July 2004. That is one hundred times more than ten years ago. IETF was predicted that the Internet address space would become an increasingly limiting resource. Thus, the work for the next generation IP was started [3]. The formal name of the new protocol is *IPv6 (Internet Protocol version 6).* Ipv6 supports an extremely large address space that is 2^{96} times the size of the IPv4 address space. Even pessimistic mathematics estimated that this would provide 1,564 addresses for each square meter of the surface of the planet Earth [15].

At the same time, the backward compatibility with the existed IPv4 is provided. Special attention has also given to new services such as support for multimedia and real time applications by allowing special handling of such packets over the IPv6 routers. In addition, new generation of routing protocols at the TCP/IP stack have been appeared. All of these are tested by an experimental network, 6bone. Recently, IETF has announced a plan for a multi-year phase-out of the 6bone and its address allocation until June 2006 [10] that means that

6bone test era is going to be replaced with IPv6 regular deployment.

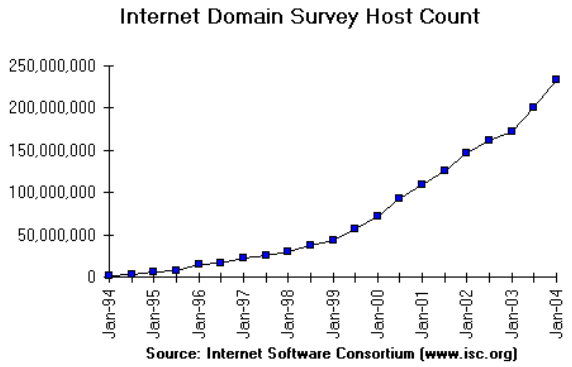

Fig. 2 The growth of the Internet

SOAP (Simple Object Access Protocol, the protocol especially intended for EC has also added to the TCP/IP protocol suite. SOAP is a lightweight protocol intended for exchanging structured XML data in a distributed environment [45]. SOAP specifies exactly how to encode a HTTP header and an XML file so those programs can call each other and exchange data. It defines a message formats and describes a variety of message patterns, including, but not limited to, RPC, asynchronous event notification and forwarding via SOAP nodes. A variety of protocols such as HTTP, SMTP and FTP or not, may support SOAP messages. SOAP is a part of a wider initiative known as Web Services [49], which we will be discussed later.

"All optical networks", another issue of faster Internet, is playing an important role in order to establish fast and reliable B2B communications. Various standard technologies are deployed, FDDI, ATM, SONET/SDH. Fiber Channel, etc., to form the appropriate local or global backbones that are able to operate on Mbps or Gbps data rates. In addition, new fiber-based implementations such are FTTC and FTTH [16] bring fiber to the curb or to the home, allow SMEs (Small-to-Medium Enterprises) to be a partner with equal opportunity to participate. Potential EC players who have difficulties due to the lack of the optical infrastructure (e.g. in development countries), may stay in touch using ISDN and associated standard modem technologies known as xDSL.

The area of the *nomadic computing* (also known as pervasive, ubiquitous, mobile, wireless, etc.) is an emerging research field over the decade [19], [37]. Millions of people, business people, researches, ordinary people, etc., wear their portable computers of different type (personal digital assistants, notebooks, laptops, etc.) and seek for the Internet connection anywhere in the world. Such unpredictable connections are characterized with many specific requirements and attributes ranging from variable bandwidth and latency to resource replication or foreign language involvement. Anyway, the ultimate goal is to provide services in both the local and wide are environments with performances achievable in fixed environments. Many efforts have already done or they are underway for providing appropriate infrastructure and protocols. These include mobile IP, wireless LANs, 3G global satellite networks, etc.

Mobile IP [31] is an extension of IPv4 that allows transparent routing of IP datagrams to mobile nodes in the Internet. Three functional entities are defined. There are mobile node, home agent and foreign agent. A host or router that changes its point of attachment from one network or subnetwork to another is defined as *mobile node*. *Home agent* and *foreign agent* are routers on a mobile node's home network and a mobile node's visited network, respectively. Home agent tunnels IP datagrams for delivery to the mobile node when it is away from home and maintains current location information. While a mobile node is registered on a visited network, foreign agent provides routing and delivering services. The home address is administrated in the same way as permanent address. During the mobility state of the mobile node, a care-of address is associated with in order to keep the current point of attachment. The care-of address must be an address to which datagrams can be delivered via traditional IP routing.

Different approach is used by cellular networks and *wireless LANs (WLANs)* that keep the same address for mobile users. ANSI/IEEE standard 802.11 [ANSI/IEEE, 1999] for WLAN defines protocol and compatible interconnection of data communication equipment via the radio or infrared signals in a local area network using the carrier sense multiple access protocol with collision avoidance (CSMA/CA). Nine services are defined by this standard, six of which are used for delivery, three for control and security.

According to estimates by Gartner Group, in 2004, at least 40% of B2C EC will be initiated from smart phones supported by WAP [34]. *WAP (Wireless Application Protocol)* stack consists of the six layers starting with wireless bearers, then WDP, WTLS, WTP and WSP, and ending with WAE, where the previous acronyms stand for wireless–datagram protocol, transport layer security, transport protocol, session protocol and application environment, respectively. WAP 2.0, supports Internet protocols into the WAP environment as well as several enhanced services.

None of the above standard technologies and protocols for nomadic computing have not reach yet full performances and required quality of services thus the many research work is still underway. In the area of IEEE.802.11 examples include, but not limited to, advanced media access schema as proposed by Infrared Data Association (IrDA) [35], the possibilities for higher data rates in WLANs are analyzing [38], etc. 2.5G and 3G wireless systems are supported by EDGE (Enhanced Data Rates for GSM Evolution), WCDMA (Wideband Code Division Multiple Access) and TDMA (Time Division Multiple Access) [26]. These are coordinated by 3GPP (Third Generation Partnership

Project), a collaboration agreement that brings together a big number of standards bodies.

4. THE MIDDLEWARE LAYER

By default, B2B systems are both heterogeneous and distributed, which cause their strengths and weaknesses. That is why we are needed to define an appropriate middleware in an EC framework. In addition to general-purpose middleware components, such as Web itself, two sublayers should be carefully considered depending on the subject of integration: the layer of the content exchange and the layer where the business processes cooperate as shown. At the *content layer* semantics and structural heterogeneity issues are resolved as well as the transport binding to specific transport protocols either statically at development time or dynamically at runtime. A business process is defined as a set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships [4]. Unlike content layer where the business entities should agree on data formats, data models and languages, at a *business process layer* partners are concerned with the automatic conversional interactions. In order to allow such level of interoperability there are several important things that should be done before. First of all the digital jungle of today's Web should be clean up.

The pool of the human knowledge, as the Web described by the inventor Tom Berners-Lee, the Web has changed in recent years from the easy-to-swim pool (using HTML+URL+HTTP) to a digital jungle with more than three billions, often hard-to-find, documents as per data given in [5]. In order to simplify the navigation across the Web and across the particular site, and to improve interoperability between e-applications and between customers and applications as well, several technologies have been developed or specified for further research. In general, the topics are concentrating on languages, portals, Web services, and Web intelligence.

4.1. Supporting languages

In the area of supporting languages, *XML*, the standard recommended by W3C in 1998 [39], takes an important role in overcoming the limitations of HTML. XML is especially designed for Web-based applications with many implementations to specific application areas. Unlike HTML that deals with the visual presentation of a document, XML mainly concentrates on data, thus the data parameterization, object hierarchy, data validation and other data features may be included in XML data formats. Many authors agree that XML gives to data portability what Java did for application portability. In addition to XML there are plenty of XML schema languages, the some representatives of which are defacto standard *XML DTD (Document Type Definitions)*, *SOX (Schema for Object-Oriented XML)*, Microsoft's *XDR (XML Data Reduced)*, *RELAX NG* [53] now standardized by ISO, Schematron, etc., the overview and comparisons of which can be found elsewhere [1], [21].

Developers of the application-specific markup languages are able to define a set of domain-specific tags that carry the semantics of the data. An example is remote method invocation implemented by *XML-RPC (Remote Procedure Call)* [52]. XML-RPC represents a framework for transmitting method calls and the resulting responses between processes across hosts using standard XML encoding. An example of XML-derived languages for EC is *ebXML (e-business XML)* the specification of which is under the joint effort of UN/CEFACT (UN Centre for Trade Facilitation and Electronic Business) and OASIS [42]. It should be considered as an EC framework [12] rather than just another domain-specific markup language.

In addition, several special-purpose languages but independent of application domain, have been developed. These include XSL, XLink, SVG, SAML, etc. *XSL (eXtensible Stylesheet Language)* allows visual attributes to be added in XML documents, e.g. fonts or colors. *XLink (XML Linking Language)* is intended for defining links between resources. *SVG (Scalable Vector Graphics)* is a W3C recommendation for a language intended for describing two-dimensional vector and mixed vector/raster graphics in XML [46]. *SAML (Security Assertion Markup Language)* is a recent OASIS effort to define a framework for exchange security information between online business partners [42].

4.2. Web design and usability

Another important goal for an enterprise being involved in electronic business is to *webify* its business using portal technologies. An enterprise *portal* allows the dynamics contents to be served for customers according to their interest. Unlike static information provided by classic Web pages that are changed from time to time and sometimes hard-to-find, portals are updated constantly and mainly serve for business. Special kind of portals is used for representing a group of business subjects that have something in common (e.g. car industry). Such portals are known as *vortals* (vertical industry portals). Once webyfied, a business strongly depends on applied technologies Enterprise portals must be carefully designed mainly driven by business goals but also by the observations of the potential user behavior, technical opportunities, etc. The challenges and issues in enterprise portal development include content management, knowledge management collaboration, security, relationship management, each of which has own subtopics [14]. There are no efforts for defining a general standard framework for portal development. Instead, many component standards related to core technologies described in this paper should be applied. However, some efforts for portal server

standardization are underway [28], [36]. These include but not limited to *IBM WebSphere* Portlet, *JSR (Java Specification Request)* 168, *Jetspeed, GridSphere*, etc.

From the design point of view, many authors emphasize the importance of Web site usability [25], [27]. Web usability can be defined in terms of several criteria such as ability to locate desired information, to know what to do next, to do so with minimal effort, the treatment of returning customers, the way of data presentation, etc., as pointed in [25]. A bad Web design may cause unrecoverable loses in potential sale making visitors bored, frustrated or even afraid of buying because they are not able to find what they are look for or because they do not understand the process. Despite the big technology improvement and many accumulated experience designers sometimes forget some important principles of human-computer interaction. For example, unclear purpose of something, things that mean nothing for visitors, too much information at once, the limitations to express customer questions in a natural way, etc., represent some of the main design errors in 2003 [41]. In summary, the business goals and cognitive science are most important players in portal design.

4.3. Web services

Another important effort for cleaning digital jungle mentioned before is represented by the *Web services* initiative coordinated by W3C [49]. The working group defines a Web service as a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format. Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. The simplest definition can describe a Web service as an interface that describes a set of operations (self-contained and self-describing modular applications) that can be published and then automatically discovered and invoked across the Web. Three major standardization initiatives are submitted to the W3C: SOAP, that is described earlier, WSDL and UDDI. *WSDL (Web Services Description Language)* is an XML-based language used for describing Web services independent of concrete network deployment and data formats. *UDDI (Universal Description, Discovery and Integration)* provides a mechanism for clients to find Web services either to publish a service description or to obtain a needed service.

The concept is based on the loosely coupled reusable software components which can be bring together at the time of service invocation. Service providers define services offered using WSDL and publish such services by UDDI. A service customer (program looking for a service) uses UDDI to consult UDDI registry and to inquire about a needed service. If such a service exists SOAP is used for message exchange. The Web services protocol stack is layered just above the TCP/IP stack and may use any of the fifth-layer protocols, HTTP, FTP, e-mail, etc. Although Web services are not able to provide full open B2B interoperability they should be considered as enablers for implementing that goal. There are estimations that worldwide spending on Web services-based software projects will reach $11billion by 2008 [20].

Several specialized languages are also under development based on Web services. Examples include *WSFL (Web Services Flow Language)* [50,], XLANG and *BPEL4WS (Business Process Execution Language for Web Services)* [40]. BPEL4WS, positioned to be the Web services standard for composition, combines the best of both WSFL (support for graph oriented processes) and XLANG (structural constructs for processes). This combination may support the implementation of any kind of business process in a natural manner.

4.4. Towards Web intelligence

A way out from the digital jungle mentioned before should be achieved by the implementing of the *Semantic Web* [2]. Instead of hyperlinked HTML documents presented in HTML, the semantic Web should be based on knowledgeable machine-readable data that is much easier to find, access, present and maintain. The stack of knowledge technologies that build the semantic Web starts with minimum knowledge of data (XML) and ends with maximum knowledge about domains, processes, etc. (ontologies).

XML may describe the structure of the data but it does not support any mechanism of telling something about data, its meaning and use are remaining hidden. To give meaning to data, a more powered mechanism is used, known as *RDF (Resource Description Framework)* [44]. RDF allows creating metadata, the data about data that provides information about Web resources. In RDF terminology all the things have their own identifiers on the Web. The simplicity of RDF is represented by collections of triples, each consisting of a subject (a resource or strings), a predicate (attribute) and an object (a resource). A set of such triples is called an RDF graph. Thus using RDF triples we may describe resources denoted by subjects and objects and their relationships indicated by attributes. In order to define domain specific properties and classes of resources to which those properties may apply an RDF schema is used.

RDF and RDF schema alone are not able to bring all the knowledge required for full open B2B interoperability because they not support the logical semantics of the resources. The higher degree of knowledge may be reached by *ontologies*, popularly known as a silver bullet for knowledge management [8]. Ontologies provide a machine processable semantics of information sources that can be communicated between applications and humans,

the goal highlighted in any B2B interoperability research. Ontologies are also a backbone technology for establishing semantic Web as well as the intelligent Web [18].

Ontology is a formal explicit specification of a shared conceptualization [13]. Three keywords are dominant here, the shared conceptualization, explicitly and formality. Shared conceptualization refers to an abstract model of some thing (e.g., a service, a product) that describes the relevant concepts of that thing and that can be shared among different users (people, other services, etc.). Such concepts must be explicitly defined including the constraints of their use while the formality refers to machine-readable form of the ontology.

Early efforts to provide portability and openness of ontologies are represented by Ontolingua [13] and KIF [ANSI draft NCITS.T2/98-004]. Ontolingua is a system for describing ontologies, syntax and semantics of which are described in KIF. *KIF (Knowledge Interface Format)* is a language designed for use in the interchange of knowledge among disparate systems. Although the Ontolingua is a very high power tool, there is no control of its power, so the other efforts are also take place such as OIL, DAML and OWL.

OIL (Ontology Interface Layer) is a layered approach to a standard ontology language where each layer above adds functionality and complexity to the layer below [47]. It exploits three roots, description logics, frame-based systems and Web languages. In that way OIL combines the widely used modeling primitives from frame-based systems with the formal semantics and reasoning services supported by description logics and with XML- and RDF-based syntax.

As a consensus of European and American efforts there is a dialect of OIL, know as DAML+OIL. The goal of *DAML (DARPA Agent Markup Language)* is to provide markup language understandable by both human and machines. Finally, W3C is working on *OWL (Web Ontology Language)* intended to be used when the information contained in the documents needs to be processed by programs [48]. OWL goes beyond all previously described technologies in terms of expressing meaning and semantics of something on the Web. The novel effort is representing by *OWL-S (OWL for Web services)*, the aims of which are clearly explained as follows [23]:

- *Web service discovery* that allows declarative advertisements of service properties and capabilities that may be used for automatic service discovery.
- *Web service invocation* by a computer program or agent that is seeking for a service. It provides a declarative, computer-interpretable API that includes the semantics of the arguments to be specified when executing a Web service and the semantics of that is returned in messages when the service succeed or fail. A software agent should be able to interpret this markup to understand what input is necessary to invoke the service, and what information will be returned. OWL-S, in conjunction with domain ontologies specified in OWL, provides standard means of specifying declaratively APIs for Web services that enable this kind of automated Web service execution.
- *Web service composition and interoperation* allows the automatic selection, composition, and interoperation of Web services to perform some complex task, given a high-level description of an objective.

When we talk about intelligence on the Web and electronic commerce, the research area of *intelligent agents* could not be avoid. Intelligent agents are of wide interests over the decade [7], [22], [30], etc. There is no precise definition of intelligent agents. However, in a wide sense we may define intelligent agents as software components capable to perform tasks on behalf of their owners (clients) autonomously. They may be classified by their degree of intelligence, by mobility features and by their autonomy [30]. The intelligence varies by the degrees of understanding and self-learning that are crucial to understand the orders and perform given tasks. Autonomy of an agent may be judged by its possibility to interact with the environment (a program, other agents, owner, etc.) and make decisions where to go, when to go and what to do there (*3w space, where, when, what*), as shown in 3w diagram in Fig. 3.

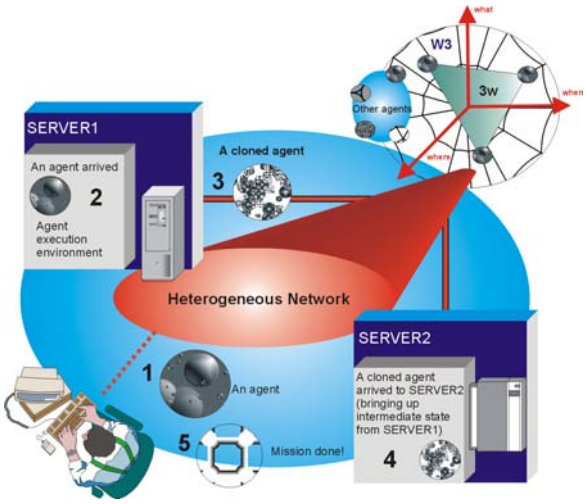

Fig. 3 Model of remote programming [16]

There are also several types of agents depending on their role, motivation, way of work, etc., such are collaborative, mediators, reactive, mobile, hybrid, heterogeneous, etc. All of them are useful for a specific support of e-applications, but two of them, mediators and mobile agents, are of particular interest for EC. Mediators are use in agent-mediated electronic commerce in order to establish a special kind of EC middleware capable to act in distributed heterogeneous environment.

Mobile agents can be considered as pieces of code with defined tasks which are executed somewhere on the network and then return the requested results to the client as shown in Fig. 3 with five steps. They are fundamental technology for so-called *remote programming)*, that allows a client to delegate a task to an agent. Computation by delegation allows the client and server to interact without using the network once the agent has arrived on the server. In addition, after processing the data on the remote server, an agent can decide, or it can be a part of its dedicated task, to compress the answers before shipping them back. The implications are obvious. The traffic across the network reduces significantly. For example, nomadic clients using laptops can reach the data they want while at the same time holding their mobility at the required level; wireless users can have the ability to access data they need regardless of the bandwidth limitations; the possibility of errors is reduced, and so on.

Very important feature of mobile agents is their ability to communicate with other agents. To do that some kind of *ACL (Agent Communication Language)* should be deployed. The standardization process for ACL is under the *FIPA (Federation of Intelligent Physical Agents)* responsibility with numerous already issued documents that are downloadable at http://www.fipa.org.

However mobile agents by nature are suspicious and may have problems with trust and security, but the foundations of mobile agent research and intelligent agents in general are of big importance in the field of EC.

An emerging framework that is based on above intelligent technologies is the *WSMF (Web Service Modeling Framework* [51]. WSMF is centered on two complementary principles: strong de-coupling of the various components that realize a B2B application and strong mediation service that should allow fully P2P (peer-to-peer) communications between business entities. To solve issues above WSMF defines four different main elements: ontologies, goal repositories, web services descriptions and mediators. Ontologies provide a shared and common understanding of a domain and they are used here to define the terminology that is used by other elements of WSMF. *Goal repositories* describe the objectives that a client may have asking for a Web service. *Mediators* should solve various P2P incompatibilities such as data formats, business logics, service invocation, message exchange etc. Web services descriptions should allow the distinctions between internal an external processes and the external complexity of a Web service as well.

Another general approach for creating and composing sophisticated distributed systems capable of integrating services across distributed heterogeneous virtual environments is represented with the emerging *grid computing* and proposed open architecture. The name of the proposal is *OGSA (Open Grid Service Architecture)* [10] that combines concepts and technologies from the Grid and Web services communities. Grid computing has originally been intended for high performance resource sharing. OGSA tends to align Grid technologies and Web services to obtain standards-based distributed service systems that support the creation of the sophisticated distributed services required for open B2B. OGSA requires only minor extension to existing technologies and represents a natural evolution of Web services.

The successor of the OGSA for the subject matter is the *WSRF (Web Services Resources Framework)* [54]. WSRF defines a generic and open framework for modeling and accessing resources using Web Services. This includes mechanisms to describe views on the state, to support management of the state through properties associated with the Web Service, and to describe how these mechanisms are extensible to groups of Web Services.

4.5. The Summary of B2B openness

The given overview of available technologies allows us to full a general B2B framework shown in Figure 1. In the operating system arena three dominant systems are widely recognized, UNIX, Linux and Windows. On the layer above there are plenty of network protocols that may meet application requirements as well as the local network environments (technology, speed, etc.) Some of them are shown in Figure 4. The middleware layer is the place where the problems are complicated. By definition at this layer all heterogeneity of the layers bellow must be hide from the application, but at the same time all discrepancies between applications over the network should also be hidden. At the bottom of this layer many of existed second generation middleware may be deployed but they can't meet full B2B interoperability [18].

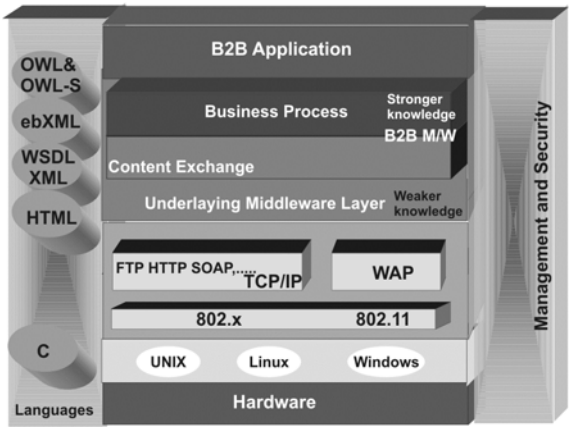

Fig. 4 The summary of the open B2B framework

Enabling technology	Some major initiatives	Responsibility	Interoperability			Some major constrains
			Communication layer	Content layer	Bussiness process layer	
XML-based	XML-RPC ebXML RosettaNet	XML-RPC CEFACT, OASIS RosettaNet	HTTP, RPC SMTP/HTTP HTTP email	XML XML, core components XML, Dictionaries	 CPA PIPs	No semantics Limited semantics Limited to IT industry
Web Services	WS	W3C, UDDI	SOAP	WSDL	WSFL XLANG BPEL4WS	Limited semantics by choreography
WSMF	WSMF	SWSI	SOAP	not precisely defined	RDF OWL	Still under development

Tab. 1 Some major attributes of the existing frameworks

Following the stack of knowledge at the content M/W, XML and WSDL together with choreography languages such as BPEL4WS may satisfy interoperability at the content layer. ebXML is a step forward, but there is no power to control all the knowledge needed for full interoperability between business processes. Finally, the OWL is a tool that may meet all the requirements. The frameworks described earlier may be compared by several criteria such as enabling technologies, interoperability and their constraints as shown in table 1. In terms of full openness the communications at the business process layer are essential.

5. CONCLUSION

After twenty years of open systems we may agree that many important technologies have developed, the initial goal to connect isolated islands of information has been reached, but for advanced applications such as B2B we are still on the move to reach full maturity of open systems. In general, the technologies under development may be divided into two groups, the general purpose technologies such as Internet, Semantic Web or security where the main goals address better performances in open communications, and B2B specific technologies where the main goals concentrate on the automatic interoperability between business processes. Unlike the first group where the technologies are mostly adding to each other, do not overlap at most, the second group experienced a lot of competition and even overlapping. Thus we may highlight two bottlenecks in current B2B openness: the overlapping standards and the lack of full semantic interoperability. However, recent research trends make promises that we may reach the full B2B openness in a reasonable time. Together with excellent capabilities of upcoming Internet backbone and Semantic Web it may make a very powerful technology framework for open B2B in the near future.

In the meantime, there may be a question which framework is better to use than other. The answer is not relay on technology, but mostly depends on the business goals, the number of partners, business models, etc., of a business entity that asks. If it has a relatively small number of partners and if there is a long-time relationship between them, then the semantics is not so important, they may establish a business scenario in advance. Unfortunately, in a dynamic heterogeneous environment, such as B2B, there is more likely that business partners are loosely coupled and that are not able to establish their business in advance, so the some kind of semantic must be deployed.

Although the issues and standards covered in this paper do not fit all available standards, some of the core important technologies for open B2B are discussed. Many of the standards and trends described above are not dedicated for EC only; these may be deployed by any e-application. B2B is just one of the chains on the way from small “e” (e-mail) to big “E” (E-Society).

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BIOGRAPHY

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LOKALIZÁCIA POZÍCIE CHYBY ESTIMÁCIE POHYBU

(LOCALISATION OF MOTION ESTIMATION ERROR POSITION)

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SUMMARY

This paper presents the analysis of errors produced by block matching motion estimation methods with lower computational cost (fast search algorithms). We try to find an answer on the question what model of distortion can be used and which motion vectors are founded as fault (corrupted by noise). We consider the vector fields obtained by using of full search algorithm (FSA) as lossless data. We take the vectors of movement obtained by using 2D logarithmic (2D log) search procedure as data corrupted by noise. The results of analysis can help optimize post processing of motion vectors in endeavouring to reduce computational cost or regularize vector fields.

Keywords: *motion estimation, block matching, motion vector*

1. ÚVOD

Účelom estimácie a kompenzácie pohybu je redukcia redundancie spôsobenej medzisnímkovou koreláciou pohybujúcich sa objektov [1], [6]. V perspektívnych systémoch s vysokou schopnosťou kompresie (videokodeky H.261, H.263, MPEG-1, MPEG-2, MPEG-4 a H.264 [2], [3]), v ktorých nachádzajú široké uplatnenie algoritmy priradzovania blokov, resp. blokovej podobnosti (Block Matching - BM) [4], [5], [6].

V dôsledku limitácie vyplývajúcej zo snahy dosiahnuť vysokú vernosť predikovaného obrazu BM algoritmy vnášajú tzv. efekt blokov, ktorý je dôsledkom nedostatočnej spojitosti medzi estimovaným a skutočným pohybom v obraze. Pre čiastočné potlačenie tohto nedostatku je možné v ďalšom kroku zrealizovať zrovnomernenie alebo vyhladenie estimovaného vektorového poľa [1]. Pri následnom spracovaní vektorového poľa za účelom zlepšenia výsledkov metód BM je vhodné zohľadňovať nie iba priestorovú spojitosť, ktorá by mohla byť dosiahnutá aplikáciou priestorových filtrov vektorov ale aj zohľadnením miery podobnosti blokov prípadne štatistickými vlastnosťami chýb vektorov.

Tento príspevok je zameraný na analýzu jednej z často spomínaných metód s redukovaným počtom prehľadávacích krokov a to dvojrozmernú logaritmickú metódu (2Dlog) z hľadiska odhadu a lokalizácie potenciálne možnej chyby estimácie vektora pohybu.

2. PRÍČINY CHÝB 2DLOG METÓDY

Dôležitou podmienkou správneho nájdenia vektora posunutia 2Dlog metódou (ale aj iných BM metód s redukovaným počtom prehľadávacích krokov) je kvadrantová monotónnosť [7] hodnôt kritéria podobnosti.

Príklad nájdených vektorov pohybu zo sekvencie "Stanica" je na obr. 1, na ktorom je znázornená snímka s nájdenými vektormi pohybu. Čierne vektory sú vektory nájdené 2Dlog metódou pre subbloky s rozmermi (Block size - BS) BS = 16x16 [OP] a predpokladané maximálne posunutie dm = 13 [OP] v každom smere. Biele vektory sú vektory pohybu nájdené metódou s úplným prehľadávaním (Full Search – FS), s tými istými parametrami BS a dm a sú viditeľné pre tie subbloky, v ktorých sa nezhodujú s vektormi získanými 2Dlog metódou. Tmavšou úrovňou jasu je v obrázku zvýraznený jeden zo subblokov, v ktorom nie je zhoda medzi 2Dlog vektorom (čierny) a FS vektorom (biely).

Na obr. 2a sú znázornené všetky hodnoty kritéria MAD (Mean Absolute Difference), ktoré sú vypočítané FS metódou pre zvýraznený subblok z obr. 1 (tmavší štvorec s rozmerom 16x16 [OP]). Počet týchto hodnôt je $(2d_m + 1)$x$(2d_m + 1)$, t.j. 27x27 hodnôt. Z obr. 2a je zrejmé, že hodnoty kritéria MAD nevykazujú monotónnosť. Pozícia globálneho minima kritéria MAD korešponduje so skutočným vektorom pohybu. Na obr. 2b sú hodnoty kritéria MAD znázornené ako úrovne sivej, pričom biely bod (v úplne čiernej oblasti) indikuje polohu minima. Biely vektor v obr. 2b je hľadaný vektor posunutia, ktorý nájde FS metóda. Čiernymi čiarkovanými vektormi je znázornený postup hľadania vektora pohybu 2Dlog metódou, pričom čierny vektor vyjadrený súvislou čiernou tučnou čiarou je výsledný nájdený vektor 2Dlog metódou pre zvýraznený subblok z obr. 1. Z obr. 2 je zrejmé, že 2Dlog metódou bol nájdený nesprávny vektor pohybu v dôsledku konvergencie procesu hľadania k miestu lokálneho minima a nie k miestu globálneho minima.

Obr. 1 Snímka zo sekvencie "Stanica" s vektormi pohybu, nájdenými FS metódou (biele) a 2Dlog metódou (čierne)
Fig. 1 Frame from the image sequence "Railway station" with motion vectors founded by FS method (white) and 2Dlog method (black)

Inou príčinou možných chýb nájdených vektorov pohybu je medzisnímkový šum v obraze (spôsobený vlastnosťami obrazového snímača, odleskami, zmenou osvetlenia, atď.). Ďalšou príčinou môže byť skutočnosť, že iba časť pravouhlého subbloku je podrobená pohybu a zvyšná jeho časť je tvorená statickým pozadím (resp. časť subbloku je statické popredie a časť pohyblivé pozadie).

Vizuálne posúdenie nájdených vektorov pohybu a zohľadnenie príčin možných chýb, generovaných metódami s redukovaným počtom prehľadávacích krokov, naznačuje impulzový charakter chýb [8] (hodnoty impulzového šumu nenadobúdajú iba extrémne hodnoty -salt and peper, ale hodnoty z celého rozsahu). Akceptovaním impulzového modelu (1),

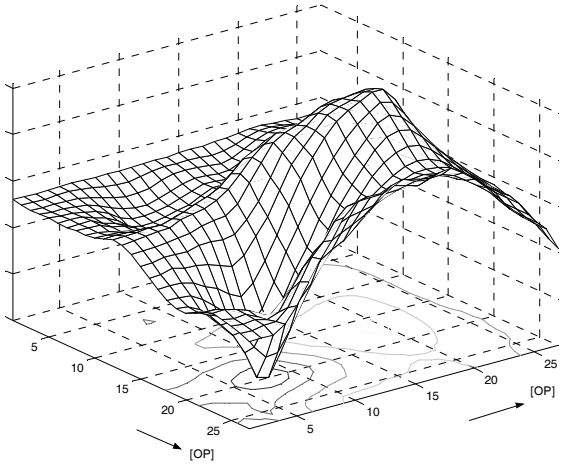
$y = (1 - ef)s + ef.š$,

$$ef = \begin{cases} 1, \textit{ pravdepodobnosť } P_{ef} \\ 0, \textit{ inak} \end{cases} \qquad (1)$$

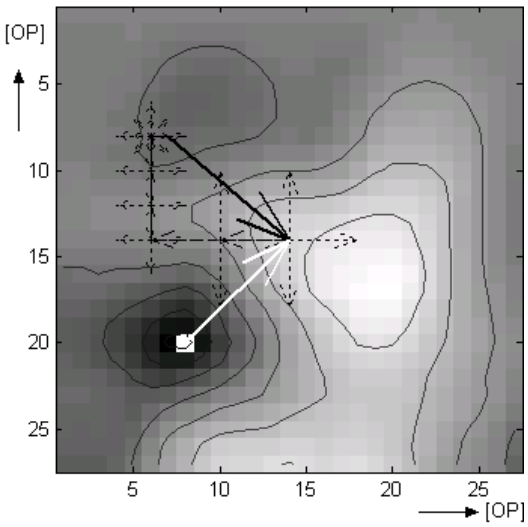
môže byť *ef* pre zložky vektorov pohybu vyjadrená v tvare :

$$ef(i,j) = \begin{cases} 1, \text{ak } [\mathbf{U}_{FS}(i,j) \neq \mathbf{U}_{2Dl}(i,j)] \cup \\ \quad \cup [\mathbf{V}_{FS}(i,j) \neq \mathbf{V}_{2Dl}(i,j)] \\ 0, \text{inak}, \end{cases} \qquad (2)$$

kde symbol $\cup$ reprezentuje logický operátor OR (logický súčet), $\mathbf{U}_{FS}$ a $\mathbf{U}_{2Dl}$ sú súbory (matice) horizontálnych zložiek vektorov pohybu pre celú, rovnakú snímku, nájdených FS alebo 2Dlog metódou a podobne $\mathbf{V}_{FS}$ resp. $\mathbf{V}_{2Dl}$ sú súbory vertikálnych zložiek vektorov pohybu pre celú a tú istú snímku, nájdených FS alebo 2Dlog metódou.



a)



b)

Obr. 2 a) Hodnoty MAD, b) hodnoty MAD vyjadrené ako úrovne sivej a postup hľadania vektora posunutia 2Dlog metódou (čierne čiarkované vektory)
Fig. 2 a) Values of MAD, b) values of MAD shown as gray levels and 2Dlog search procedure (black dashed vectors)

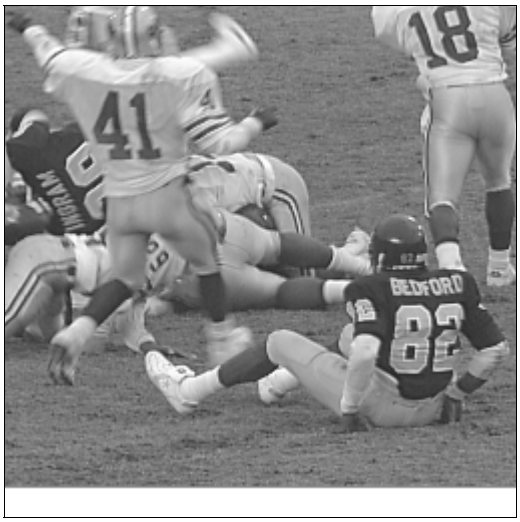
3. ODHAD FUNKCIE CHYBY

Pri diagnostike impulzového rušenia je dôležitým bodom detekcia samotných impulzov. V prípade známeho signálu bez rušenia a signálu s rušením je možné hodnoty impulzového šumu detekovať jednoduchým porovnaním hodnôt týchto dvoch signálov (najpresnejšie – prakticky však obtiažne) alebo detektormi impulzov [9].

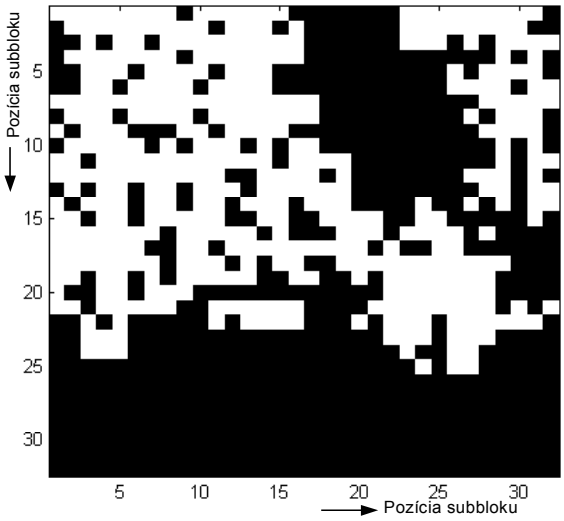
Veličina $ef(i,j)$, definovaná vzťahom (2) je vlastne funkcia s binárnymi hodnotami. Svojou hodnotou "1" indikuje pozíciu subbloku, v ktorom sa niektorá zo zložiek vektora pohybu získaného 2Dlog metódou nezhoduje s príslušnou zložkou vektora pohybu získaného FS metódou. Daný vektor je tak považovaný za hodnotu impulzového rušenia.

Na obr. 4 sú znázornené ako binárny obraz hodnoty funkcie $ef(i,j)$ (biela znamená hodnotu "1",

čierna "0"), získané zo snímok sekvencie "Football" (obr. 3) pre 2Dlog metódu s parametrami estimácie BS = 8x8 [OP] a d_m = 10 [OP].



Obr. 3 Snímka zo sekvencie "Football
Fig. 3 The frame of sequence "Football"



Obr. 4 Funkcia chyby $ef(i,j)$ pre snímky zo sekvencie "Football" (biela⇔"1", čierna⇔"0")
Fig. 4 Error function $ef(i, j)$ for frames of sequence "Football" (white⇔"1", black⇔"0")

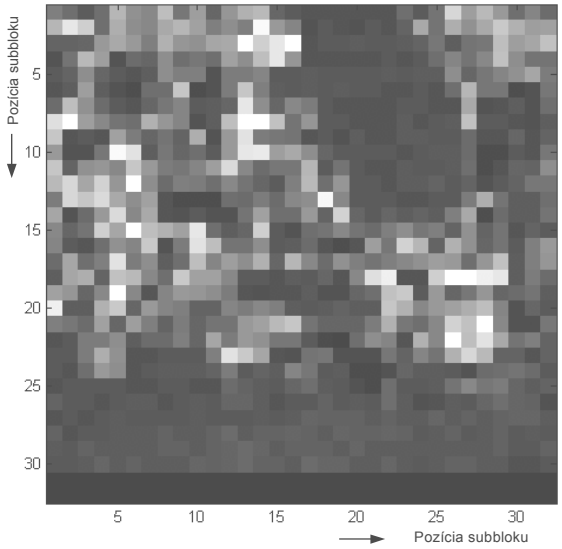
Takéto hľadanie hodnôt funkcie $ef(i, j)$ je však nepraktické, pretože vyžaduje poznanie vektorov pohybu získaných FS metódou (výpočtovo najnáročnejšia).

Užitočnou mierou úspešnosti nájdenia vektora pohybu $\vec{V}_B$, so zložkami (u_B, v_B), pre subblok $B(i,j)$ s pozíciou (i,j), je hodnota kritéria MAD_B s posunutím (u_B, v_B). Hodnota MAD_B sa vypočíta:

$$MAD_B(i,j,u_B,v_B)=\frac{1}{M.N}\sum_{m=1}^{M}\sum_{n=1}^{N}\left|X_k(m,n)-X_{k-1}(m+u_B,n+v_B)\right| \quad (3)$$

kde M, N sú rozmery subbloku v pozícii (i,j), $X_k(m,n)$ sú hodnoty obrazových prvkov snímky k a $X_{k-1}(m+ u_B,n+ v_B)$ sú hodnoty predchádzajúcej snímky z vyšetrovanej oblasti s posunutím o nájdený vektor (u_B, v_B). Táto hodnota nemusí byť pri metódach s redukovaným počtom prehľadávacích krokov minimálna. V takom prípade je možné predpokladať že vektor $\vec{V}_B$ je odhadnutý nesprávne, t.j. zaťažený šumom.

Na obr. 5 sú ako úrovne sivej (od 0 po 256) znázornené hodnoty $MAD_B(i, j, u_B, v_B)$ pre všetky hodnoty pozície subblokov (i, j), získané zo snímok sekvencie "Football" pre 2Dlog metódu s parametrami estimácie BS = 8x8 [OP] a d_m = 10 [OP]. Rozsah hodnôt $MAD_B(i, j, u_B, v_B)$ (pôvodne výrazne menší ako 256) bol kvôli zlepšeniu viditeľnosti normovaný na 256 úrovní.



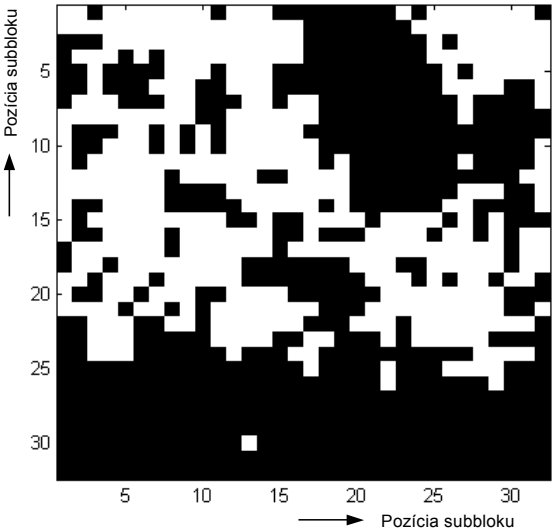
Obr. 5 Hodnoty funkcie $MAD_B(i, j, u_B, v_B)$ normované na 256 úrovní (svetlejšia-väčšia hodnota, tmavšia-menšia hodnota)
Fig. 5 The values of function $MAD_B(i, j, u_B, v_B)$ normalized to 256 levels (lighter-higher value, darker-lower value)

V prípade, že hodnoty $MAD_B(i, j, u_B, v_B)$ sa považujú za mieru úspešnosti nájdenia vektora pohybu $\vec{V}_B$, je možné vhodným stanovením prahu T_2 odhadnúť binárnu funkciu $ef_E(i, j)$ pre pozície subblokov (i, j), ktorá má podobný tvar ako funkcia $ef(i, j)$. Pre zistenie hodnôt funkcie $ef_E(i, j)$ však nie je potrebné poznať vektory pohybu zistené FS metódou. Hodnoty $ef_E(i, j)$ sa vypočítajú:

$$ef_E(i,j,u_B,v_B)=\begin{cases}1, \text{ak } MAD_B(i,j,u_B,v_B)>T_2\\ 0, \text{ak } MAD_B(i,j,u_B,v_B)\le T_2\end{cases} \quad (4)$$

Na obr. 6 sú znázornené ako binárny obraz hodnoty funkcie $ef_E(i, j, u_B, v_B)$ s prahom T_2=8 (biela znamená hodnotu "1", čierna "0"), získané zo snímok sekvencie "Football" pre 2Dlog metódu

s parametrami estimácie BS = 8x8 [OP] a d_m = 10 [OP]. Vizuálnym posúdením možno konštatovať značnú mieru podobnosti medzi funkciou $ef_E(i, j, u_B, v_B)$ (obr. 6) a funkciou $ef(i, j)$ (obr. 4).

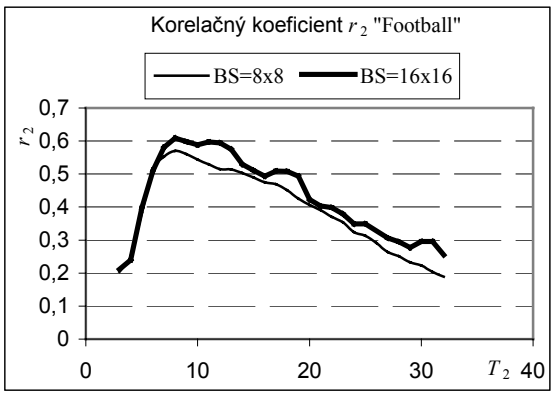


Obr. 6 Funkcia chyby $ef_E(i, j, u_B, v_B)$ pre snímky zo sekvencie "Football" (biela⇔"1", čierna⇔"0")
Fig. 6 Estimated error function $ef_E(i, j, u_B, v_B)$ for frames of sequence "Football" (white⇔"1", black⇔"0")

Pre kvantitatívne posúdenie podobnosti sa zvolil korelačný koeficient r_2 dvojrozmerných veličín, ktorý je definovaný:

$$r_2 = \frac{\sum_i \sum_j \left[ef(i,j) - \overline{ef}\right]\left[ef_E(i,j) - \overline{ef_E}\right]}{\sqrt{\left\{\sum_i \sum_j \left[ef(i,j) - \overline{ef}\right]^2\right\}\left\{\sum_i \sum_j \left[ef_E(i,j) - \overline{ef_E}\right]^2\right\}}} \quad (5)$$

kde $\overline{ef_E}$, resp. $\overline{ef}$ znamenajú stredné hodnoty.



Obr. 7 Graf závislosti korelačného koeficienta r_2 od hodnoty prahu T_2 ("Football", d_m = 10)
Fig. 7 Chart of correlation coefficient dependency r_2 from value of threshold T_2 ("Football", d_m = 10)

V grafe na obr. 7 sú znázornené závislosti korelačného koeficienta r_2 medzi $ef_E(i, j, u_B, v_B)$ a $ef(i, j)$ od hodnôt prahu T_2 pre snímky zo sekvencie "Football". Funkcia $ef_E(i, j, u_B, v_B)$ bola získavaná pomocou 2Dlog metódy s parametrami BS = 8x8 a 16x16 [OP].

4. ZÁVER

Z uvedených výsledkov vyplýva, že voľba prahu T2 vplýva na veľkosť korelačného koeficienta r_2. Charakter závislosti je pre rôzne hodnoty BS rovnaký ale po prekročení určitej hodnoty prahu prudko stúpne hodnota koeficienta r_2, pričom ďalším zvyšovaním hodnoty prahu hodnota r_2 pozvoľne klesá. Maximálne hodnoty r_2 sa dosahujú pre odlišné hodnoty T_2 v odlišných sekvenciách (charakter obrazu a miera aktivity). Hodnoty funkcie $ef_E(i,j)$ vykazujú pri vhodnej voľbe prahu T_2 dobrú zhodu s teoretickými hodnotami funkcie $ef(i,j)$. Táto skutočnosť umožňuje zaviesť modifikácie nielen 2Dlog metódy, ale aj iných algoritmov estimácie pohybu s redukovaným počtom prehľadávacích krokov, ktorými sa zvýši ich účinnosť a efektívnosť.

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VLASTNOSTI DVOJFÁZOVÉHO SYNCHRÓNNEHO MOTORČEKA S PERMANENTNÝMI MAGNETMI NA ROTORE PRI NAPÁJANÍ CEZ TRIAK Z JEDNOFÁZOVEJ SIETE

(BEHAVIOUR OF THE TWO-PHASE PERMANENT MAGNET SYNCHRONOUS MOTOR SUPPLIED BY A TRIACS FROM SINGLE-PHASE VOLTAGE)

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SUMMARY

A synchronous motor with ferrite permanent magnet rotor is a good solution for small pump applications. Strontium-ferrite based permanent magnets are attractive for application in electric machines due to several reasons. Their price is relative low. They are chemically inert, which make them suitable for application in aggressive environments. Strontium-ferrite magnets have high specific electric resistance, so they do not experience thermal problems due to eddy-current losses. On the other side, their low residual flux density imposes the need for special machine construction when high air-gap flux density is needed. It also has some drawbacks. The most important of them seems to be its inability to start directly on the mains, Permanent magnet motor has to by equipped with an electronic circuit for direct starting, which increases motor price. Another drawback is the torque ripple for the non- harmonic supply. This paper shown analytical calculation of the torque ripple of the small permanent magnet motor, which does a triac converter supply. The converter forms a two supply triacs in each phase of motor, connected on one-phase 50Hz mains.

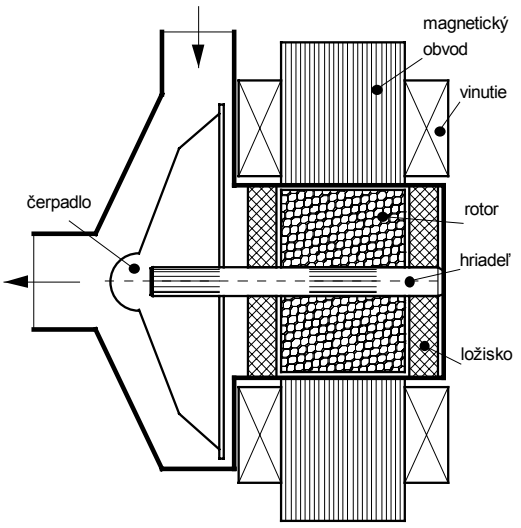
Keywords: *permanent magnets, synchronous motor, triacs supply, torque ripple*

1. ÚVOD

Malé vodné pumpy výkonu do 100 W majú veľké využitie v priemyselných, ale aj nepriemyselných aplikáciách. Príkladom sú chladiace obvody priemyselných zariadení, automobilový priemysel ale aj ústredné kúrenia, práčky alebo umývačky riadu. Ako pohonný motor slúži buď jednofázový asynchrónny motor pracujúci v otvorenej regulačnej slučke napájaný priamo z jednofázovej siete, alebo jednosmerný motor v prípade automobilov.

Obidva prvky, motor aj pumpa sú najčastejšie vyrábané ako samostatné prvky, pracujúce na spoločnom hriadeli. Nevýhodou je, že časom sa poruší tesnenie pumpy a dochádza k únikom kvapaliny. V prípade, že je motor a pumpa na jednom hriadeli, unikajúca kvapalina vniká do vzduchovej medzery motora a spôsobuje poruchu motora. Pre takéto prípady porúch sa rotor aj stator obaľuje antikoróznou látkou, ktorá chráni vinutie, ako aj plechy magnetického obvodu. Obalová látka však spôsobuje v motore jednak prídavné straty, ale aj na druhej strane vyžaduje zväčšenie vzduchovej medzery, čo má za následok zhoršenie účinnosti, ako aj samotných parametrov motora.

Únik kvapaliny, ako aj problémy s účinnosťou indukčného motora mali za následok hľadanie inej koncepcie pohonného motora púmp. Takouto sa javí koncepcia, v ktorej je rotor motora súčasťou pumpy a je ponorený v pumpovanej kvapaline. Pri tomto riešení je rotor často ponorený do chemicky agresívneho prostredia. Klietkový rotor asynchrónneho motora v takomto prípade neprichádza do úvahy. Na takéto aplikácie sa veľmi dobre hodia rotory s feritovými permanentnými magnetmi. Stroncium-feritové permanentné magnety sú chemicky inertné a tým použiteľné v aplikáciách s agresívnym prostredím.



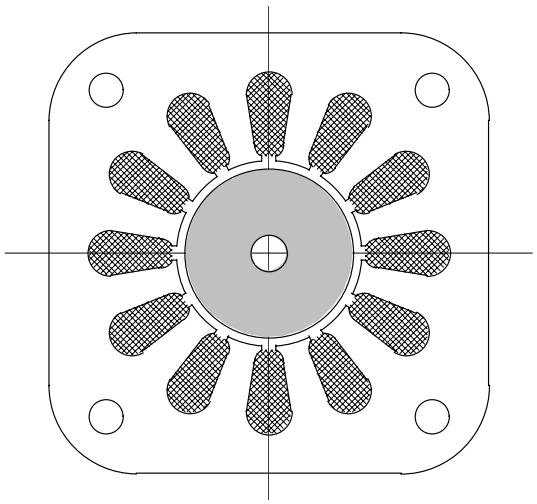
Obr. 1 Motor s vodnou pumpou
Fig. 1 Motor with water pump

Z elektrického hľadiska majú stroncum-feritové magnety veľký špecifický odpor, čo má za následok minimálne straty vírivými prúdmi. Umožňujú konštrukcie strojov s veľkou vzduchovou medzerou, čo je pri konštrukciách s „mokrým rotorom“

žiadúce. Na obrázku 1 je znázornená spojenie motora a vodnej pumpy.

2. KONCEPCIA MOTORA

Na obrázku 2 je uvedené konštrukčné usporiadanie dvojfázového synchrónneho motora s permanentným magnetom na rotore. Stator je tvorený magnetickým obvodom zloženým z magnetických plechov. Po vnútornom obvode je v drážkach uložené koncentrické dvojfázové vinutie. Rotor je tvorený permanentným magnetom, ktorý je magnetovaný tak, že po jeho obvode sú vytvorené dva magnetické póly. Predpokladáme, že vinutia sú identické. Elektromagnetický moment je vytváraný vzájomnou interakciou medzi statorovým prúdom a rotorovým magnetickým poľom. Elektromagnetický moment je určený časovým priebehom statorového prúdu a elektromotorickým napätím indukovaným od premenlivého magnetického toku rotora.

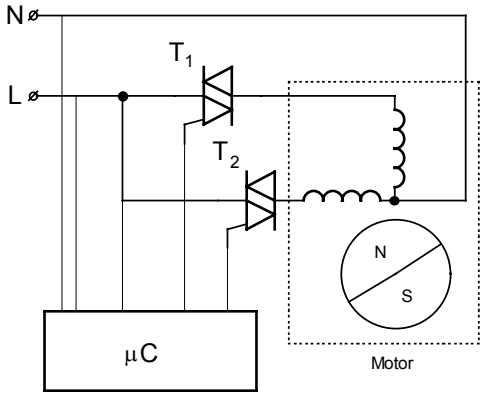


Obr. 2 Rez motorom
Fig. 2 Cross-sectional wiew

Priebeh statorového indukovaného napätia jednotlivých fáz má harmonický priebeh. Matematicky je možná jeho náhrada sinusovou, resp. kosinusovou funkciou.

3. TRIAKOVÝ MENIČ

Pre vytvorenie dvojfázového napájacieho systému napätí je pre jednoduchosť a veľmi nízke zaobstarávacie náklady použitý najjednoduchší triakový menič. Tento pozostáva v z dvoch triakov, po jednom v každej fáze, tak, ako je to uvedené na obrázku 3. Triaky sú riadené z mikropočítačového čípu, ktorý je synchronizovaný na vstupné napájacie napätie. Triak zabezpečí frekvenčný rozbeh tak, že zo sinusovsky vstupného napájacieho napätia sú vyberané polvlny napätia, aby sa vytvorilo frekvenčne premenlivé po frekvenčných skokoch sa meniace napätie.



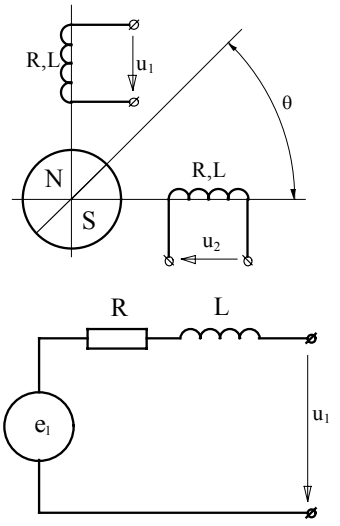
Obr. 3 Triakový menič
Fig. 3 Triacs converter

Pretože záťažový moment pumpy v oblasti malých rýchlostí je minimálny, pre rozbeh nie je potrebný veľký dynamický moment.

4. MATEMATICKÝ MODEL MOTORA

Matematický popis dvojfázového synchrónneho motora je oveľa jednoduchší, ako trojfázového s ohľadom na fakt, že vinutia sú ortogonálne, a tým magneticky od seba nezávislé. Matematicky popis sa zúži na jednofázovú verziu.

Na obrázku 4 je uvedená jednofázová náhradná schéma motora takéhoto motora.



Obr. 4 Jednofázová náhradná schéma
Fig. 4 Per-phase equivalent circuit

Predpokladáme, že vinutia sú identické a magneticky symetrické. Okamžitá hodnota príkonu je vyjadrená vzťahom:

$$p = u_1 i_1 + u_2 i_2 \tag{1}$$

Tento pozostáva z troch častí:

$$p = p_j + p_m + p_e \tag{2}$$

Kde:

$p_j = R\left(i_1^2 + i_2^2\right)$ - predstavuje straty v statorovom vinutí;

$p_m = L\left(i_1 \frac{\mathrm{d}i_1}{\mathrm{d}t} + i_2 \frac{\mathrm{d}i_2}{\mathrm{d}t}\right)$ - predstavuje jalový výkon;

$p_e = e_1 i_1 + e_2 i_2$ - prestavuje elektrický výkon stroja;

Konštanty R, L sú odpor statorového vinutia, resp. synchrónna indukčnosť.

Elektromagnetický moment stroja je možné určiť z elektrického výkonu a rýchlosti motora podľa vzťahu:

$$m = \frac{p_e}{\omega} = \frac{e_1 i_1 + e_2 i_2}{\omega} \tag{3}$$

Pre výpočet okamžitej hodnoty momentu stroja je potrebné vypočítať priebehy okamžitých hodnôt fázových prúdov. Tieto je možné určiť z napäťových rovníc stroja:

$$\begin{aligned} u_1 &= Ri_1 + L\frac{\mathrm{d}i_1}{\mathrm{d}t} + e_1 \\ u_2 &= Ri_2 + L\frac{\mathrm{d}i_2}{\mathrm{d}t} + e_2 \end{aligned} \tag{4}$$

V ustálenom stave je možné pokladať rýchlosť motora za konštantu. Riešenie rovníc sa zjednoduší, ak nahradíme čas napäťových rovniciach (4) polohou rotora. Napäťové rovnice v tomto prípade nadobudnú tvar:

$$\begin{aligned} u_1 &= Ri_1 + L\omega\frac{\mathrm{d}i_1}{\mathrm{d}\theta} + e_1 \\ u_2 &= Ri_2 + L\omega\frac{\mathrm{d}i_2}{\mathrm{d}\theta} + e_2 \end{aligned} \tag{5}$$

Kde: θ je uhol polohy rotora.

Vnútorné indukované napätia jednotlivých fáz sú harmonické funkcie a matematicky je ich možné vyjadriť:

$$\begin{aligned} e_1 &= E.\sin\left(\theta - \gamma\right) \\ e_2 &= -E.\cos\left(\theta - \gamma\right) \end{aligned} \tag{6}$$

Kde: E je maximálna hodnota indukovaného napätia.

5. PRIEBEHY VÝSTUPNÝCH NAPÄTÍ Z MENIČA

Predpokladáme, že triaky sú ideálne spínače. V ustálenom stave je triak $T1$ plne otvorený. Na fázu 1 je pripojené plné sieťové napätie. Triak T1 plní funkciu meniča len počas rozbehu. Predpokladáme, že napájacie napätie je harmonické, takže môže byť vyjadrené vzťahom:

$$u_1 = U_m.\sin\theta \tag{7}$$

Kde: $\theta = \omega t$ je uhol vyjadrujúci polohy rotora motora. U_m je maximálna hodnota napätia siete.

Naproti tomu triak T2 je v ustálenom režime napol otvorený. T2 pracuje s uhlom fázového riadenia $\alpha \approx 90^\circ$. Pripojené napätie nadobúda hodnoty:

$$u_2 = \begin{cases} 0 & pre \quad \beta - \pi \le \theta \le \alpha \\ u & pre \quad \alpha \ge \theta \ge \beta \end{cases} \tag{8}$$

Kde: β je uhol vypnutia triaku.

Tvar napätia u_2 môžeme matematicky vyjadriť pomocou Fourierovho rozvoja v tvare:

$$u_2 = U_m \left\{ \begin{aligned} &a_1 \cos\theta + b_1 \sin\theta + \\ &\sum_{k=2}^{\infty}\left[a_k \cos\left(k\theta\right) + b_k \sin\left(k\theta\right)\right] \end{aligned} \right\} \tag{9}$$

Kde koeficienty Fourierovho radu je možné vypočítať:

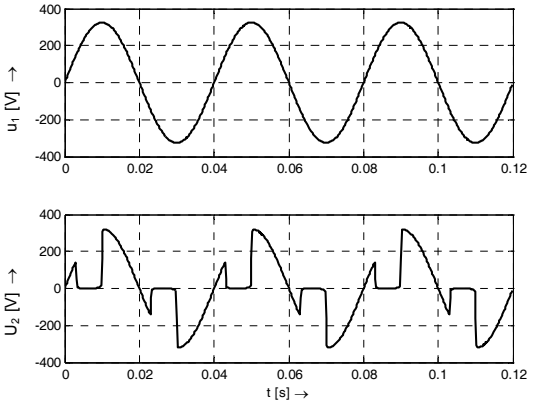
$$a_1 = \frac{1}{\pi}\left(\sin^2\beta - \sin^2\alpha\right)$$

$$b_1 = \frac{1}{\pi}\left(\beta - \alpha - \sin\beta\cos\beta + \sin\alpha\cos\alpha\right)$$

$$a_k = \frac{1+\left(-1\right)^{k+1}}{2\pi}\left\{ \begin{aligned} &\frac{1}{1-k}\left[\cos\left(1-k\right)\alpha - \cos\left(1-k\right)\beta\right] + \\ &\frac{1}{1+k}\left[\cos\left(1+k\right)\alpha - \cos\left(1+k\right)\beta\right] \end{aligned} \right\}$$

$$b_k = \frac{1+\left(-1\right)^{k+1}}{2\pi}\left\{ \begin{aligned} &\frac{1}{1-k}\left[\sin\left(1-k\right)\beta - \sin\left(1-k\right)\alpha\right] - \\ &\frac{1}{1+k}\left[\sin\left(1+k\right)\beta - \sin\left(1+k\right)\alpha\right] \end{aligned} \right\}$$

Na obrázku 5 sú znázornené priebehy napájacích napätí jednotlivých fáz. Priebehy sú vypočítané pomocou uvedených analytických formúl.



Obr. 5 Priebehy fázových napätí
Fig. 5 Phase voltage waveform

6. VÝPOČET PRÚDOV A MOMENTOV

Priebehy veličín motora boli vypočítané na základe nameraných veličín dvojfázového synchrónneho motora výkonu $P = 80W$, napájaného z jednofázovej elektrickej siete $U = 230V / 50Hz$.

Pri výpočtoch boli použité nasledovné parametre:

$E = 160V \; pri \; 3000ot/\min, L = 0,46H, R = 80\Omega$

Vlastnosti prvej fázy

Prvá fáza je napájaná plným napätím. Pre elektrický obvod fázy platí napäťová rovnica:

$$u_1 = R.i_1 + \omega L \frac{\mathrm{d}i_1}{\mathrm{d}\theta} + e_1 \tag{10}$$

Analytickým riešením diferenciálnej rovnice dostávame výraz pre fázový prúd:

$$i_1 = \frac{U - E.\cos\gamma}{R^2 + L^2\omega^2}\left(R\sin\theta - L\omega\cos\theta\right) + \frac{E.\sin\gamma}{R^2 + L^2\omega^2}\left(R\cos\theta + L\omega\sin\theta\right) + C.e^{-\frac{R}{\omega L}\theta} \tag{11}$$

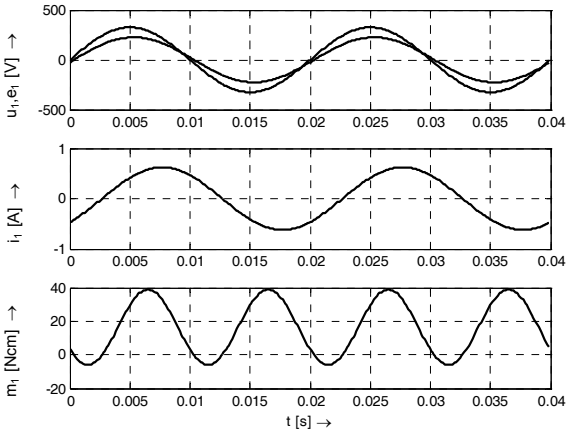
V ustálenom režime je integračná konštanta:

$C.e^{-\frac{R}{\omega L}\theta} = 0$.

Okamžitá hodnota momentu prvej fázy sa vypočíta na základe priebehu prúdu a indukovaného napätia podľa vzťahu:

$$m_1 = \frac{e_1\, i_1}{\omega} \tag{12}$$

Na obrázku 6 sú uvedené priebehy okamžitých hodnôt veličín prvej fázy.



Obr. 6 Vypočítané hodnoty prvej fázy
Fig. 6 Calculated quantities of the first phase

Vlastnosti druhej fázy

Triak druhej fázy pracuje s uhlom fázového riadenia $\alpha \approx 90^\circ$. Uhol vypnutia triaku závisí od momentu, keď fázový prúd poklesne na nulu. Indukované napätie fázy a napájacie napätie sú v elektrickom obvode len počas vedenia triaka, to je v intervale vedenia $\langle \alpha, \beta \rangle$. Priebeh indukovaného napätia počas intervalu $\langle \alpha, \beta \rangle$ je možné taktiež vyjadriť Fourierovým rozvojom v tvare:

$$e_2 = -E\left\{ a_{1i}\cos\theta + b_{1i}\sin\theta + \sum_{k=2}^{\infty}\left[a_{ki}\cos(k\theta) + b_{ki}\sin(k\theta)\right]\right\} \tag{13}$$

Kde koeficienty rozvoja sú dané výrazmi:

$$a_{1i} = \frac{1}{2\pi}\left[\sin(2\beta-\gamma) - \sin(2\alpha-\gamma) + 2(\beta-\alpha)\cos\gamma\right]$$

$$b_{1i} = \frac{1}{2\pi}\left[\cos(2\alpha-\gamma) - \cos(2\beta-\gamma) + 2(\beta-\alpha)\sin\gamma\right]$$

$$a_{ki} = \frac{1+(-1)^{k+1}}{2\pi}\left\{\begin{array}{l}\frac{1}{1+k}\left[\begin{array}{l}\sin\left((1+k)\beta-\gamma\right)-\\ \sin\left((1+k)\alpha-\gamma\right)\end{array}\right]+\\ \frac{1}{1-k}\left[\begin{array}{l}\sin\left((1-k)\beta-\gamma\right)-\\ \sin\left((1-k)\alpha-\gamma\right)\end{array}\right]\end{array}\right\}$$

$$b_{ki} = \frac{1+(-1)^{k+1}}{2\pi}\left\{\begin{array}{l}\frac{1}{1+k}\left[\begin{array}{l}\cos\left((1+k)\alpha-\gamma\right)-\\ \cos\left((1+k)\beta-\gamma\right)\end{array}\right]+\\ \frac{1}{1-k}\left[\begin{array}{l}\cos\left((1-k)\beta-\gamma\right)-\\ \cos\left((1-k)\alpha-\gamma\right)\end{array}\right]\end{array}\right\}$$

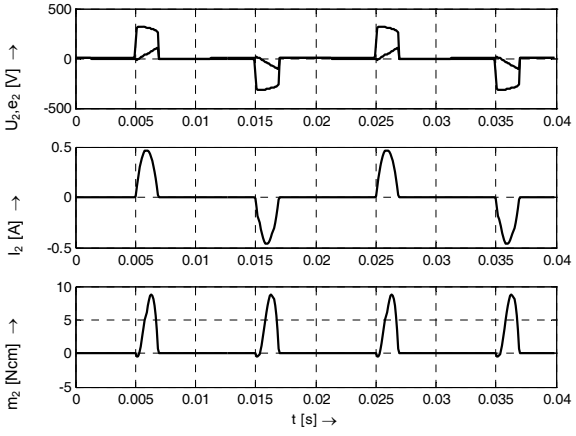
Pre elektrický obvod druhej fázy platí napäťová diferenciálna rovnica:

$$u_2 = R.i_2 + \omega L \frac{\mathrm{d}i_2}{\mathrm{d}\theta} + e_2 \tag{14}$$

Jej analytickým riešením dostávame výraz pre fázový prúd:

$$i_2 = \frac{\omega L}{(\omega L)^2 + R^2}\left[\begin{array}{l}\left(a_1U_m + a_{1i}E\right)\left(\frac{R}{\omega L}\cos\theta + \sin\theta\right)+\\ \left(b_1U_m + b_{1i}E\right)\left(\frac{R}{\omega L}\sin\theta - \cos\theta\right)\end{array}\right] + \sum_{k=2}^{\infty}\frac{\omega L}{(k\omega L)^2 + R^2}\left[\begin{array}{l}\left(a_kU_m + a_{ki}E\right)\\ \left(\frac{R}{\omega L}\cos k\theta + k.\sin k\theta\right)+\\ \left(b_kU_m + b_{ki}E\right)\\ \left(\frac{R}{\omega L}\sin k\theta - k.\cos k\theta\right)\end{array}\right] + C.e^{-\frac{R}{\omega L}\theta} \tag{15}$$

V ustálenom stave je integračná konštanta $C.e^{-\frac{R}{\omega L}\theta} = 0$.



Obr. 7 Vypočítané hodnoty druhej fázy
Fig. 7 Calculated quantities of the second phase

Okamžitá hodnota momentu druhej fázy je daná výrazom:

$$m_2 = \frac{e_2 i_2}{\omega} \tag{15}$$

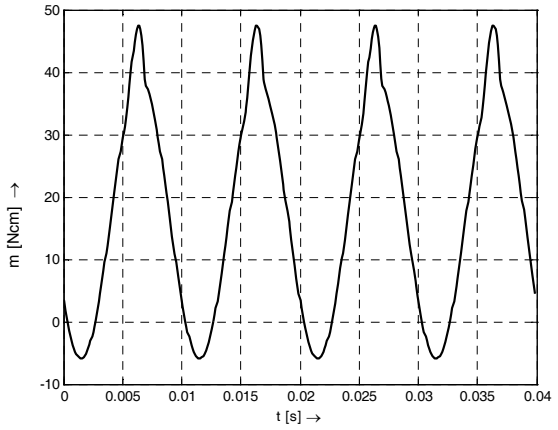
Na obrázku 7 sú uvedené priebehy okamžitých hodnôt veličín druhej fázy.

Uhol vypnutia triaka β musí byť vypočítaný z rovnice (15) numericky dosadením $i_2 = 0$.

7. VÝPOČET CELKOVÉHO MOMENTU MOTORA

Celkový elektromagnetický moment motora je daný algebraickým súčtom momentov jednotlivých fáz:

$$m = m_1 + m_2 \tag{16}$$



Obr. 8 Priebeh celkového momentu motora
Fig. 8 Total torque waveform of the motor

Z priebehu uvedenom na obrázku 8 je zjavné, že priebeh elektromagnetického momentu je veľmi zvlnený. Druhá fáza prispieva k celkovému momentu stroja len veľmi málo. Prúd druhej fázy je silno vytláčaný rotorovým indukovaným napätím do oblasti prerušovaných prúdov. Uhol vedenia triaku je menší ako $\pi/2$.

8. ZÁVER

V predkladanom príspevku je uvedená metodika výpočtu priebehov prúdov a momentov dvojfázového synchrónneho motora s permanentným magnetom na rotore. Analytický výpočet priebehov veličín stroja dáva možnosť predvídať správanie sa motora ustálenom stave. Je možné predpokladať, že pri uvedenom zvlnení elektromagnetického momentu sa motor bude prejavovať zvýšeným hlukom.

Z vypočítaných priebehov jednoznačne vyplýva, že momentový príspevok druhej fázy k celkovému momentu je zanedbateľný. Určitým riešením sa zdá byť nesymetria jednotlivých fáz, to znamená vinutia s rôznym počtom závitov, prípadne iný uhol otvorenia triakov. Všetky iné riešenia vedú ku komplikovanejším napájacím zdrojom, čo sa jednoznačne odrazí na cene celkového zariadenia.

POĎAKOVANIE

Autori vyjadrujú vďačnosť Grantovej agentúre Slovenskej republiku s ktorej finančným príspevkom predkladaná práca vznikla. Problematika bola riešená v rámci výskumnej úlohy VEGA 1/2178/05.

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BIOGRAPHY

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7. Following the Summary will be a single 10 points blank line.

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