Operational Value and Accessibility of Services in SOA-based Intelligence Information Systems

Jugoslav Achkoski[1], Nevena Serafimova[1], Slavko Angelevski[1], Metodija Dojchinovski[1], Dimitar Bogatinov[1]

[1] *Military Academy "General Mihailo Apostolski", Vasko Karangelevski bb, Skopje, Republic of Macedonia*

***Abstract* – The concept of Service-Oriented Architecture (SOA) can be used as a foundation for establishing an integrated Intelligence System, which would be based on services as software components. It offers better coordination among institutions involved in intelligence, thus providing increase of intelligence effectiveness. In this article, the central focus is placed on determining measurement tools that allow evaluation of the service's potential within an Intelligence Information System (IIS).**

The defined metrics' aim is to estimate the accessibility status of services in IIS, thus facilitating the decision-making process prior to initializing a request for intelligence data gathering. Taking into account the individual service characteristics of reliability and cost, we gain additional insight into both momentary and periodic, weighted accessibility status of the system. By employing these estimations we hope to enhance our ability to understand, and consequently control and improve the results produced by our IIS.

***Keywords* – intelligence; decision support; service; accessibility; metric;**

1. Introduction

Senior decision makers expect to have as precise description of the situation in question as possible. The size, the accuracy and the depth of the available information is essential for the decisions to be made and the consecutive activities.

Within the global information environment, challenges for future intelligence operations refer to management of large amount of intelligence data and their presentation in a comprehensible manner. Intelligence cells should process and evaluate reliability and credibility of intelligence information in order to provide a defined picture of the situation at hand. The data picked up by intelligence information collecting sensors (such as HUMINT, IMINT, SIGNT, OSINT etc.) are recorded, filtered, processed and finally, disseminated [1].

Intelligence goals impose adequate processing and evaluation requirements for information that has been collected from different sources, in order to achieve appropriate level of situation awareness. The contexts in which these activities take place include unconventional conflicts such as terrorism, as well as complex non-military information factors by which intelligence is greatly influenced. The sizes of the received data-sets require substantial amount of automated information processing and presentation, since manual processing and evaluation would be very expensive [2], [3].

Intelligence Cycle is created through structured and semantic series of operations. It is a framework where four discrete operations are executed, the end result of which is the intelligence product. These operations follow a sequence of cycling in synchronization with requirements for check-ups and updating, during which they can perform either separately or simultaneously. As such, this process is controlled by the authorities. Following is a description of the Intelligence Cycle as defined in [1], according to NATO Glossary of Terms and Definitions (AAP-6) [4]:

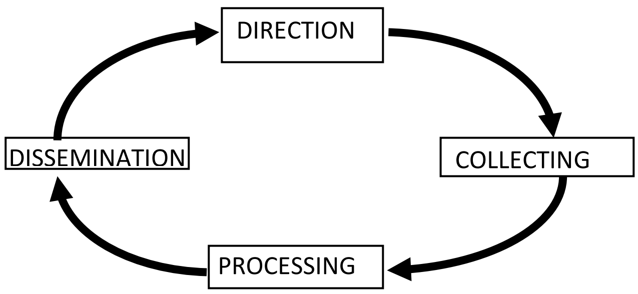

Figure 1. The Intelligence Cycle

Updated information in the Intelligence cells refer mostly to a set of data about the mission and the area of interest. Each piece of information is concerned with a specific situational aspect (for example, a small group of combat vehicles, or explosives theft, or specific training area detection etc.). Authorities require a comprehensive product, where everything has been taken into consideration and important facts fuse into an integrated description [1].

The first, fundamental challenge for automated support of intelligence information fusion refers to their applicability as a combination of data. This can be numerical data, usually in the form of simple tables, or more complex structured data such as relational databases, semi structured messages, totally unstructured texts. As a result, the presentation of data varies from fully numeric and structured, to totally textual and unstructured [2].

The second challenge for automated support of intelligence information fusion refers to the heuristic nature of real human processing in absence of sufficient information. Pieces of information about reality are being compared to current circumstances and related to estimated threats aggregating into an in-depth, more complex situational presentation. Information linkage is directed by the knowledge of structure and behavior of the target groups [2].

Within the Network Centric War and the global information environment of asymmetric threats, one of the many challenges lies in data and information management, accompanied by their presentation in a suitable manner. Multinational intelligence cells are facing the risk of information processing overburden, of not being able to respond to the intense income of new information. Hence, they are in constant search for an improved capability for collecting, processing and disseminating of big quantities of data, such as provided by the full spectrum of ELINT, IMINT, HUMINT, MASINT and OSINT [2], and others such as SIGINT, FININT, GEOINT, TECHINT...

This contribution is organized in several parts. Section 2 gives a review of some related previous work. Section 3 describes service's structure of Intelligence Information System (IIS) model based on service oriented architecture (SOA). In section 4, the main results are presented. Of its four parts, the first deals with accessibility to information, in the second the service value metric and its numerical characteristics are defined, the third refers to information accessibility of the system and formulates services' information support index, and in the fourth we outline the allover perspective from the decision-maker standpoint. A round-up and some final remarks are given in the conclusion.

2. Related Work

In [5], resource quality specifies a dimension of software quality assessment in the context of service-oriented architecture. In this light, a resource metrics for distributed systems that supports service-oriented concepts will be given. Similarities and differences of the solutions for service-oriented, component-based and web-based software engineering are analyzed in the context of used and involved resources and their influence on the quality.

In [6], the service-oriented architecture is presented as a contemporary solution for developing enterprise-wide and cross-enterprise distributed application. From the software engineering standpoint, these two types of distributed application appear as a component-based and object-oriented software systems and web applications.

In [18] and [19], there is a comprehensive discussion on SOA common features, measurement metrics, strategy (the hierarchy and the management process), methods and tools of measurement and their relations and application.

3. Services' Structure in IIS

While implementing IIS on a strategic level, we aim toward centralized collection of intelligence data and their publishing in an appropriate manner. On the other hand, the diversity of intelligence departments and agencies can lead to a diversity of information systems' development concepts which usually, are hierarchical and distributed [10].

Service-oriented architecture is viewed rather as an approach in building information systems, than as a finished product that serves a purpose [6]. Application of SOA concepts and technologies induces an urge for building various operation and infrastructure assessment methods [20]. In addition, every business should measure the extent of SOA adaptation with the goals of enterprise [18]. Numerous scientific papers have resulted from these needs, many of them addressing metrics that are used for characteristics' quality evaluation in service-oriented systems (see for example, [15][16][17][21]).

Service-oriented systems consist of a set of providers' points. Each of these points presents service and each service has one or more operations (business functions). In Figure 2 bellow, a business process for collecting intelligence information is presented. The business process is guided by an Intelligence Cycle. Authorities give directions for the collection of data, upon which a "mosaic" of complex information is created.

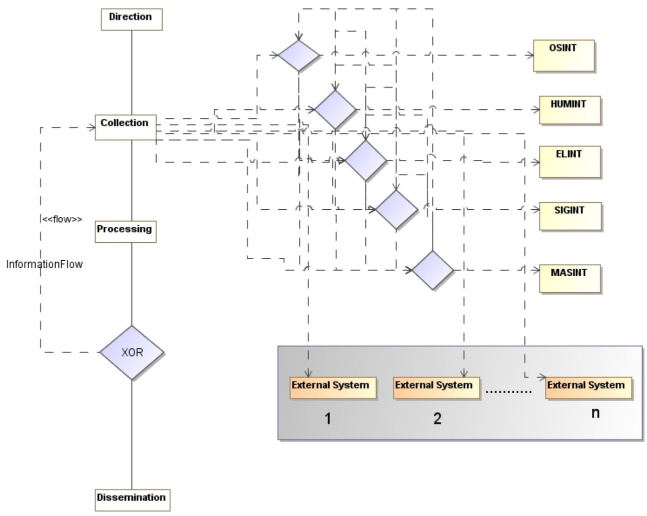

Figure 2. Business process for information gathering

When authorities' directions arrive, the process of gathering information through the Intelligence Cycle is started. This process is based on several subprocesses, with endpoints the intelligence sources of information: Imagery Intelligence (IMINT), Signals Intelligence (SIGINT), Measurement and Signature Intelligence (MASINT), Electronic Intelligence (ELINT), Open-source Intelligence (OSINT), Human Intelligence (HUMINT). These intelligence disciplines are the basis of the contemporary intelligence.

In terms of its organization and contents, the Intelligence Cycle demonstrates various complexities which, as a principle, should not influence the quality of the final intelligence product. To this we should add another significant role played by the external information systems, through the process of collection and dissemination of information. These systems can also be used as an external node that sends requirements for intelligence information.

When data arrive, they are stored in the IIS upon which are subjected to an intensive analysis, in order to create a structured intelligence product. If the collected information is insufficient for creating an intelligence product and additional information is needed, the process for data gathering starts all over.

Dissemination is the final step in the business process of the Intelligence Cycle. According to previously established security procedures and policies, information is being disseminated in an appropriate way.

The model of SOA-based IIS presented in Figure 3, is built to completely fulfill the intelligence role and assignments, as well as compatibility requirements for connection to information systems of similar institutions [13], [14].

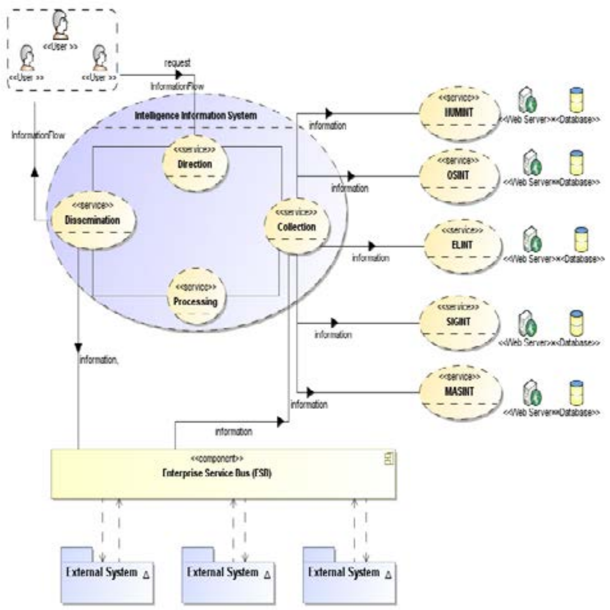

Figure 3. Schematic presentation of the SOA-based IIS

This IIS model shows three types of users: service providers, service consumers and intelligence. Service consumers are institutions (such as Crisis Management Center, MOI, Intelligence Agency or others) that require information from IIS or provide information as a notification.

All services are feeding data from appropriate service providers, information systems of government institutions or agencies included in Intelligence Cycle, or other information systems that are service providers for inter-institutional governance. Service providers of systems that support the workflow processes, define web services which are exploited by the users according to appropriate security levels of the service registers.

Experiences from recent researches dealing with SOA-related issues show that agencies, departments, institutions and other stakeholders can push and pull data on a standardized and flexible manner through communication interfaces using XML schema and web services.

4. Service value metric and system accessibility

A comprehensive intelligence query will tackle many and diverse information aspects. With this in mind, we should be aware that the quality of information has far too many attributes for all of them to be confidently considered within a single model. Moreover, some of them (such as for example, relevance or coherence) may not be needed or even applicable during the process of planning and will become important only in the stage of data analysis. Having in mind the nature of the intelligence product and in order to facilitate the decision process, we create service value metrics that highlight the following information characteristics: *accessibility*, *reliability* and *cost*.

These combined elements of the value metrics of a service, considered as a part of a larger IIS, are aimed towards describing the service's potential for efficient and cost-effective execution of a given data collecting task. We treat each of these characteristics as distinctive metric features and assume no inherent dependencies between any two of them. Furthermore, while we obviously treat accessibility and reliability as enhancing the service value, the calculated cost for data gathering will clearly act as its reductor.

During the decision-making process, these metrics are coupled with a value indicating the expected number of services with positive accessibility status. We obtain this value as a result of a Markov model for the accessibility states of the information system, characterized by the number of services with accessibility and appropriate transitional parameters.

1.1. Measuring the Accessibility of a Service

By information accessibility of a service we will assume *availability*, *obtainability* or *retrievability* of information for that service, during the period of need. The comprising services of a given intelligence system are not always in a position to have access to the subject of interest. They cannot be expected to possess or promptly collect the necessary data at arbitrary moment, neither is the needed information always available. The circumstances that influence the information accessibility status of a service (such as its geospatial position, activity status, environmental issues, etc.) can be numerous and variable. Therefore, we will use the benefits of applying simplified assumptions that will allow implementation of a transitional model of accessibility, in which time-framed estimation of transitional parameters is used.

In this light, we create a Markov model for the purpose of assessment of the accessibility of certain information to a service, in which we assume two possible states for a service: accessible (marked as 1) and inaccessible (marked as 0). Furthermore, the interchange between the two states is expressed by parameters indicating the intensity of transition, with parameter η being the intensity of transition from 1 to 0, and α the transition intensity from 0 to 1.

Let $P_1(t)$ and $P_0(t)$ be the probabilities that the service is in a position of accessibility and respectively, inaccessibility of needed information. Then its transitions between the states 0 and 1 during a time interval Δt are governed by the following equations:

$$\begin{aligned} P_0(t+\Delta t) &= P_0(t)\cdot(1-\alpha\cdot\Delta t)+P_1(t)\cdot\eta\cdot\Delta t \\ P_1(t+\Delta t) &= P_0(t)\cdot\alpha\cdot\Delta t+P_1(t)\cdot(1-\eta\cdot\Delta t) \end{aligned} \quad (1)$$

By transforming the system in the form

$$\begin{aligned} \frac{P_0(t+\Delta t)-P_0(t)}{\Delta t} &= -\alpha\cdot P_0(t)+\eta\cdot P_1(t) \\ \frac{P_1(t+\Delta t)-P_1(t)}{\Delta t} &= \alpha\cdot P_0(t)\cdot-\eta\cdot P_1(t) \end{aligned} \quad (2)$$

and letting $\Delta t \to 0$, we obtain a system of LDEs:

$$\begin{aligned} P_0'(t) &= -\alpha\cdot P_0(t)+\eta\cdot P_1(t) \\ P_1'(t) &= \alpha\cdot P_0(t)-\eta\cdot P_1(t) \end{aligned} \quad (3)$$

Its closed-form solution gives the time-dependent probabilities $P_1(t)$ and $P_0(t)$ for our service to be in position of 1 (accessibility) or 0 (inaccessibility) in respect to the needed data, at a moment *t* of the observing period. Hence, we have:

$$\begin{aligned} P_0(t) &= -\frac{\alpha}{\eta+\alpha}\cdot e^{-(\eta+\alpha)t}+\frac{\alpha}{\eta+\alpha}, \text{ and} \\ P_1(t) &= \frac{\alpha}{\eta+\alpha}\cdot e^{-(\eta+\alpha)t}+\frac{\eta}{\eta+\alpha}. \end{aligned} \quad (4)$$

We will define the time-dependent *function of accessibility* for a given service, with

$$A(t;\alpha,\eta)\equiv P_1(t)=\frac{\eta}{\eta+\alpha}+\frac{\alpha}{\eta+\alpha}\cdot e^{-(\eta+\alpha)t} \quad (5)$$

where α and η are the parameters of transition defined as above, with a given initial state of accessibility assumption, A(0)=1.

For the *estimated accessibility* of a service in the time period $[\tau,T]$ we have:

$$A_{\tau,T}=\frac{\int_\tau^T\left(\frac{\eta}{\eta+\alpha}+\frac{\alpha}{\eta+\alpha}\cdot e^{-(\eta+\alpha)t}\right)dt}{T-\tau} \quad \text{i.e.,}$$

$$A_{\tau,T}=\frac{\eta}{\eta+\alpha}+\frac{\alpha}{(\eta+\alpha)^2(T-\tau)}\cdot\left(e^{-(\eta+\alpha)\tau}-e^{-(\eta+\alpha)T}\right) \quad (6)$$

If we let $\tau = 0$, the estimated *initial period accessibility* for the time frame $[\tau,T]$ will be

$$A_T=\frac{\eta}{\eta+\alpha}+\frac{\alpha}{(\eta+\alpha)^2\cdot T}\cdot\left(1-e^{-(\eta+\alpha)T}\right) \quad (7)$$

while the *general accessibility* for infinite time horizon $[0,\infty)$ is given by the value

$$A_G=\frac{\eta}{\eta+\alpha} \quad (8)$$

1.2. The Service Value Metric

Now we turn to the other two elements of our metric: reliability and cost of information. The reliability *r* of information collected by a certain service can be perceived as the probability of accuracy for that particular information. Its value can be determined empirically from previous history of a given information service, according to:

$$r=\frac{k}{n} \quad (9)$$

where 'n' presents the total amount of information collected by the service during some past period of time (consisting of one or more intelligence cycles) and 'k' is the amount of accurate (or proven) information among them. It is clear that the possible values of r lie in the interval [0,1].

While we assess the cost for obtaining certain information from a given service, we are urged to include not only the operational resource requirements for that service, but also the risks that can emerge during the process. The cost value can be nominally expressed by a positive number **U.** Having obtained information costs for all other services of the IIS, each of the U-values can be normalized to **u**, thus having its value within [0,1].

With the assessed values of **r** and **u**, we create the time-dependent *service value metric* for a service in an intelligence information system, as

$$SV(t) = \frac{r}{u} \cdot A(t) \quad (10)$$

where A(t) is as in (5). Using **r** and **u** to define *effectiveness parameter* **ε** = r/u of a service having values in [0,∞), we will obtain our *service value metric* in the form of

$$SV(t; \alpha, \eta, \varepsilon) = \frac{\eta\varepsilon}{\eta+\alpha} + \frac{\alpha\varepsilon}{\eta+\alpha} \cdot e^{-(\eta+\alpha)t} . \quad (11)$$

That this function is well defined follows directly from the definition of A(t) as a solution to the Markov model (1). Here we should stress the need that the values of **r** and **u** and thereby, the value of **ε** as given, are subjected to periodical reconsiderations. The estimated *initial service value* for period [0,T] is

$$SV_T = \frac{\eta\varepsilon}{\eta+\alpha} + \frac{\alpha\varepsilon}{(\eta+\alpha)^2 \cdot T} \cdot \left(1 - e^{-(\eta+\alpha)T}\right) \quad (12)$$

and for the infinite horizon period [0,∞), we have general *service value* estimation

$$SV_G = \frac{\eta \cdot r}{(\eta+\alpha) \cdot u} \quad (13)$$

where all values on the right side are as previously described.

1.3. Measuring System Accessibility

In an IIS, setting of a minimal number of services that should have access to information of interest is related to the general accuracy and completeness of received data, i.e. the degree of precision, correctness and detail to which they represent the real states of the world. Therefore we ask, how many of the services from our system have information accessibility at a given moment?

We could of course, use the previously defined accessibility probabilities from (5), (6) and (7) and define the probability distribution on the number of services with access. However, this will not be very practical, especially if we have a large service's set at hand. Once again, the answer to this question will be pursuited through the Markov model approach to information accessibility, this time for a service information system.

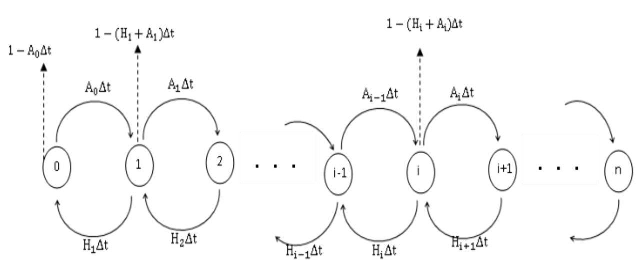

Figure 4. Diagram of the IIS's status, showing the number of services with information accessibility.

If the IIS is comprised of n services, than its accessibility status has (n+1) possible states, each of which can be described by an element of the set $\{0,1,\ldots,n\}$. Specifically, *i* indicates a state in which exactly i services have information access. As depicted by the diagram in Figure 5, the system passes form a state *i* to one of its neighboring states having exactly one more or one less services with asserted accessibility. The transitional parameter A_i represents the intensity of transition from i to (i+1), while H_i measures the intensity of transition from i to (i-1). If $P_i(t)$ is the probability that the service information system is in state *i* at a moment t, then the movement of the system through the states can be described by the following Markov model:

$$\begin{aligned} P_0(t+\Delta t) &= (1 - A_0 \cdot \Delta t) \cdot P_0(t) + H_1 \cdot \Delta t \cdot P_1(t) \\ P_i(t+\Delta t) &= A_{i-1} \cdot \Delta t \cdot P_{i-1}(t) + (1 - (A_i + H_i)\Delta t) P_i(t) + \\ &\quad + H_{i+1} \cdot \Delta t \cdot P_{i+1}(t) \quad (i = \overline{1, n-1}) \\ P_n(t+\Delta t) &= A_{n-1} \cdot \Delta t \cdot P_{n-1}(t) + (1 - H_n \cdot \Delta t) \cdot P_n(t) \end{aligned} \quad (14)$$

By transforming this system in the form:

$$\begin{aligned} \frac{P_0(t+\Delta t) - P_0(t)}{\Delta t} &= A_0 \cdot P_0(t) + H_1 \cdot P_1(t) \\ \frac{P_i(t+\Delta t) - P_i(t)}{\Delta t} &= A_{i-1} \cdot P_{i-1}(t) + (A_i + H_i) \cdot P_i(t) + \\ &\quad + H_{i+1} \cdot P_{i+1}(t), \qquad (i = \overline{1, n-1}) \\ \frac{P_n(t+\Delta t)}{\Delta t} &= A_{n-1} \cdot P_{n-1}(t) + H_n \cdot P_n(t) \end{aligned} \quad (15)$$

and letting Δt→0, we get

$$\begin{aligned} P_0{}'(t) &= A_0 \cdot P_0(t) + H_1 \cdot P_1(t) \\ P_i{}'(t) &= A_{i-1} \cdot P_{i-1}(t) + (A_i + H_i) \cdot P_i(t) + H_{i+1} \cdot P_{i+1}(t) \\ &\quad (i = \overline{1, n-1}) \\ P_n{}'(t) &= A_{n-1} \cdot P_{n-1}(t) + H_n \cdot P_n(t) \end{aligned} \quad (16)$$

This system of LDEs has (n+1) unknown functions, and solving it analytically can be a tedious task. Therefore, we assume final (stationary) values for the probabilities of *i* at Δt→∞, and label them with p_i for i=0,…,n, respectfully. The resulting non-differential $(n+1)^{th}$ order system of linear equations,

$$\begin{aligned} 0 &= A_0 \cdot p_0 + H_1 \cdot p_1 \\ 0 &= A_{i-1} \cdot p_{i-1} + (A_i + H_i) \cdot p_i + H_{i+1} \cdot p_{i+1} \\ &\quad \text{for } i = 1, \ldots, n-1 \\ 0 &= A_{n-1} \cdot p_{n-1} + H_n \cdot p_n \end{aligned} \quad (17)$$

is handled easily by recursion, resulting in the following probability values:

$$p_i = \frac{A_0 \cdot \ldots \cdot A_{i-1}}{H_1 \cdot \ldots \cdot H_i} \cdot p_0 , \quad \text{for all } i = 1, \ldots, n \quad (18)$$

We should notice here that the system (17) is linearly dependent and has one superfluous equation. Thus we can confidently go along with the form (18) which indicates that the probabilities of all of the states from 1 to n depend on the probability p_0 of the state 0, where all services are deprived of information accessibility.

Let now x_o be the minimum number of services that should go in line with particular information, creating thus required level of supportiveness or otherwise, information acceptability. According to (18), a number of

$$E_S = \sum_{0}^{n} i \cdot p_i = p_0 \cdot \sum_{1}^{n} \frac{A_0 \cdot \ldots \cdot A_{i-1}}{H_1 \cdot \ldots \cdot H_i} \cdot i \qquad \textbf{(19)}$$

services are expected to have information access. We will refer to the value of E_s as the *information support index* for the given service information system. If $E_s < x_0$ and particularly, if this difference is significant, we have a signal to opt for activation of a considerably higher number of services than the needed x_o thus rising the probability of receiving satisfactory feedback, or even postpone activities in the given circumstances and/or consider functional improvements. If on the other hand $E_s > x_0$, staying rather closer to x_o or, in a case of significant difference, choosing more freely among the services would be advisable.

1.4. The Model of Decision Process

While preparing for an intelligence operation through IIS, there are several questions that have to be asked. Does a particular service have access to the information we need? How many of the services do have access in a given time period? How reliable are these services? How much will it cost for the information to be provided? These are some of the main questions that will influence the planning process. The above constructed measurement tools help the analyst in providing the required answers.

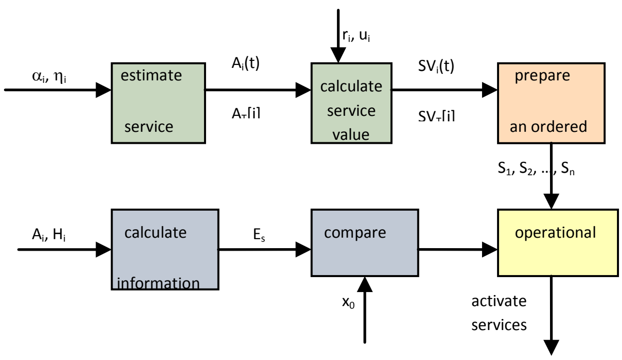

Figure 5**.** Functional presentation of an example decision process, related to service value estimations

The diagram shown on Figure 5 gives an example of a process organization during the activity planning stage, when decision has to be reached on how many and which of the services are to be activated for the purpose of data collecting. Two parallel computations take place, one for the *services values* and the other for the *information support index*. Using the time-framed service values, a descending list of services is prepared. In addition, by comparing the system's information support index E_s with the information support threshold x_0, the number of services that will be activated is determined. The final decision is made by selecting from the top of the services' list. The parameters α_i, η_i, A_i, H_i, r_i and u_i are intrinsic characterizations of the service **i** and are determined from empirical evidence. As such, they should be subjected to updating after one or few intelligence cycles.

5. Conclusion

A good model of an Intelligence Information System contributes to Homeland Security and Civil Military Emerging Risks assessment. It provides information in an appropriate way by implementing pushing and pulling mechanisms into information systems, selection of data and creation of information from raw data that are further used in creating intelligence products and dissemination reports for the authorities. The implementation of service-oriented architecture in IIS increases the intelligence efficiency, whereas the established developmental methodology and models are the basis for building of an efficient information system.

In this contribution we are focused on some information specific metrics that are used for assessing of the operational value of services prior to their engagement, based on their performances, functionality and costs. The main purpose of defining *service value* is promotion of the planning process, in order to enable our system to perform more efficiently and deliver better results. As defined, these metrics quantify some aspects of the IIS structure and operation. The combination of the service value quantification and the estimated service accessibility within a given period of time can be used as a valuable decision tool that will enhance the information gathering process.

An advantage of the suggested metrics is their adaptability, i.e. they can be applied on all services and service compositions that are part of a service-oriented architecture. Still, an important issue that is implied by its application is the need of good models for estimation of the parameters that make its constituting parts. This remains a subject for some future research efforts.

In this article, we consider independent services: there is no operational or information exchanging link between them. By weakening this assumption, further results in relation to the presented issues can be considered.

References

[1]. Joachim Biermann: *A Knowledge-Based Approach to Information Fusion for the Support of Military Intelligence, Military Data and Information Fusion*, RTO meeting proceedings MP-IST-040, Prague, Czech Republic,(20 to 22 October 2003)

[2]. Joachim Biermann; Louis de Chantal; Reinert Korsnes; Jean Rohmer; Cagatay Uendeger. *From Unstructured to Structured Information in Military Intelligence: Some Steps to Improve Information Fusion*. SCI Panel Symposium, London, United Kingdom (2004)

[3]. Cellary, W., and S. Strykowski, *E-Government Based on Cloud Computing and Service-Oriented Architecture*, The 3rd International Conference on Theory and Practice of Electronic Governance ICEGOV 2009, Bogota (Colombia), November 10-13, 2009, ACM Press, ISBN 978-1-605558-663-2, pp. 5-10 (2009)

[4]. NATO Standardization Agency (NSA), AAP-6(2002) *NATO Glossary of Terms and Definitions*, http://www.nato.int/docu/stanag/aap006/aap6.htm

[5]. Rud, D.; Schmietendorf, A.; Dumke, R.: *Resource metrics for service-oriented infrastructures*. In Proceedings of the Workshop on Software Engineering Methods for Service Oriented Architecture 2007" (SEMSOA 2007), Hannover, Germany pp. 90-98, May 10-11(2007)

[6]. Rud, D.; Schmietendorf, A.; Dumke, R.: *Product metrics for service-oriented infrastructures*. In Proceedings "16th International Workshop on Software Measurement/DASMA Metrik Kongress 2006" (IWSM/MetriKon 2006), Potsdam, Germany, pp. 161-174, November 2-3,(2006)

[7]. Kunz, M.; Schmietendorf, A.; Dumke, R.; Wille, C.: *Towards a Service-Oriented Measurement Infrastructure*, Proceedings of the 3rd Software Measurement European Forum (SMEF), Rome, Italy, pp. 197-207, May 10-12 (2006)

[8]. Gebhart, M., & Abeck, S.. *Metrics for Evaluating Service Designs based on SoaML*, International Journal on Advances in Software, 4(1&2), 61-75 (2011a). http://iariajournals.org/software/

[9]. OMG, *Service oriented architecture modeling language (SoaML) – specification for the uml profile and metamodel for services (UPMS)*, Version 1.0 Beta 1, (2009).

[10]. Divac D., Milivojević N., Grujović N., Milivojević V., Borota J.: *Service-Oriented Architecture of Modern Hydroinformation System*, In Proceedings of the 1st International Conference on Information Society Technology (ICIST 2011), Kopaonik, Serbia, March 6 - 9, (2011)

[11]. Sanjeev Kumar, Vijay Dakshinamoorthy, M.S. Krishnan, *Impact of SOA Use on Performance Outcomes of Information Sharing in Supply Chain*, In proceedings of Conference on Information Systems and Technology (CIST 2007), Seattle, WA, USA, (2007)

[12]. Constantin Marian. *Services Used to Integrate Banking Front Office Applications*, Open Source Science Journal Vol. 2, No. 3,. pp. 15-23 (2010)

[13]. Jugoslav Ackoski, Vladimir Trajkovik and Danco Davcev, *Service-Oriented Architecture Concept for Intelligence Information System Development*, The Third International Conferences on Advanced Service Computing SERVICE COMPUTATION 2011 (IARIA), Rome, Italy, (201)

[14]. Brehm, N., & Marx Gómez, J.: *Web Service-based specification and implementation of functional components in Federated ERP-Systems*, 10th International Conference on Business Information Systems, Poznan, Poland, (2007)

[15]. B. Elvesæter, A.-J. Berre, A. Sadovykh, Specifying *Services using the Service oriented architecture Modeling Language (SoaML): A baseline for Specification of Cloud-based Services*, the 1st International Conference on Cloud Computing and Service Science (CLOSER 2011), 7-9 May 2011. http://closer.scitevents.org/

[16]. Gebhart, M., Baumgartner, M., Oehlert, S., Blersch, M., & Abeck, S. (2010). *Evaluation of Service Designs based on SoaML*, In J. Hall, H. Kaindl, L. Lavazza, G. Buchgeher, & O. Takaki (Eds.), Proceedings of the Fifth International Conference on Software Engineering Advances (ICSEA) (pp. 7-13). doi: 10.1109/ICSEA.2010.8 (2010)

[17]. Maynard, M, Dimitoglou, G., *A Service Oriented Architecture Complexity Metric, Based on Statistical Hypothesis Testing*, Intl. Conference on Software Engineering Research and Practice, Vol. I, pp. 214-221. (2008)

[18]. Marzieh Asgarnezhad, Ramin Nasiri, Abdollah Shahidi, *A Systematic Method for Performance Analysis of SOA Applications*, International Journal of Computational and Mathematical Sciences, Vol. 38, pp. 76-82 (2010)

[19]. Paul Brebner, Liam O'Brien, Jon Gray. *Performance Modelling for Service Oriented Architectures*. 30th International Conference on Software Engineering. ICSE 2008. May 10-18, Leipzig, Germany, (2008)

[20]. Wenguang, Wang, Weiping Wang, Yifan Zhu and Qun Li. *Service-Oriented Simulation Framework: An Overview and Unifying Methodology*. International Journal of SIMULATION: Transactions of the Society for Modeling and Simulation International. first published on December 21, 2010. DOI: 10.1177/0037549710391838 (2010), http://sim.sagepub.com/content/early/2010/12/18/0037549710391838.abstract

[21]. Achkoski, J. Trajkovik, V. *Usage of Service-Oriented Architecture for Developing Prototype of Intelligence Information System*, TEM JOURNAL - Technology, Education, Management, Informatics 11/2012; Volume 1 / Number 4(2217-8333):234

Corresponding author: *Jugoslav Achkoski*
Institution: *Military Academy, Skopje, Republic of Macedonia*
E-mail: *jugoslav. achkoski@ugd.edu.mk*