Decision Support for Selecting Workflow Software Products+

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요 약 최근 많은 기업들이 비즈니스 프로세스 자동화를 위한 새로운 정보기술로 워크플로우를 도입하고 있다. 워크플로우 소프트웨어는 여러 벤더 제품과 고려해야할 선정기준이 많다는 점 때문에 도입 기업은 복잡한 의사결정 문제에 직면하게 된다. 벤더들로부터 제공되는 제품은 서로 다른 특징들을 가지고 있어 충분한 경험과 전문지식이 없는 경우어려움을 겪기 마련이다. 본 연구에서는 워크플로우 소프트웨어 제품 평가와 선정을 위한 의사결정 방법으로 계층적분석과정(Analytic Hierarchy Process: AHP)을 제시한다. 우리는 AHP 구현도구인 Expert Choice를 사용하여 워크플로우 유형 및 상업용 제품의 중요도를 도출한 다.

Abstract There are currently several workflow software products on the market, and they vary in their capabilities and features. Since there is no single workflow product that dominates others in all aspects, it is difficult to evaluate their superiority. Few methods are available about their selection. This paper suggests a decision support method for selecting the most appropriate workflow software products using the Analytic Hierarchy Process method. We prioritize the importance of four classes of workflow applications as well as 13 commercial products.

1. Introduction

Recently, many companies have adopted information technologies for management innovation. Here we pay attention to workflow since, in the mid-1990s, technology newly emerged as a tool for business reengineering. There is tremendous growth in the workflow market around the world. The Workflow Management Coalition (WfMC) is a well-known initiative to develop standards for the adoption and development of workflow. It describes workflow as: The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules, and a workflow

management system(WFMS) as: A generic software tool, which allows for the definition, execution, registration, and control of workflows[25]. The WFMS means a software system used to make workflow-enabled business applications[8].

Workflow-based applications have made a contribution to the world of business and have been applied in all conceivable industries. It can increase the operational efficiency of process occurring in a business, and results in cost saving and improved quality of customer service[4]. Some roles performed by staff can be replaced by the workflow system and work can be performed faster.

Workflow software is a package delivered by workflow vendors and WFMS becomes a key component of workflow software. Because workflow software has many features and product types, what managers truly need is decision support that will help them make an intelligent choice among the several existing workflow

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software. Making the right choice of software can have a profound impact on the success of business applications. A wrong selection would certainly have a lasting adverse impact on the business performance. Once a software system is implemented, going back is extremely difficult; it is too expensive to undo the changes the package brings into a company.

Selection of the right software package to meet end-user information requirements is critical to the success of management information systems[23]. A key obstacle in the acquisition of a package is uncertainty about package modification time and cost, vendor viability, and the ability of the package to meet user needs[9].

The characteristics of workflow software are similar to business processing reengineering(BPR) tools, as well as enterprise resource planning(ERP) products, because they are both enterprise widely applicable software packages and major focus is to support business processes. A close relationship between the use of BPR tools and BPR success was expected[12]. The selection of the most appropriate ERP products is a semi-structured decision-making problem without agreed-on formal procedures[11, 14].

Workflow software selection is a complex decision-making problem. The complexity stems from a multitude of tangible and intangible factors affecting software choices, as well as the intrinsic difficulty of making numerous trade-offs among those factors. There are likely to be discrepancies between the needs of the organization and the features of the package. The software selection problem is made difficult by the multiplicity of competing products and the lack of expertise and experience of users in the methods of software evaluation[2]. Although the selection process for workflow is similar to that proposed for the acquisition of any software packages, differences arise in their evaluation criteria and choice methods.

In this paper, we suggest the Analytic Hierarchy Process(AHP) method[21, 22] for selecting workflow software. The AHP is an intuitively easy method for formulating and analyzing decisions. It was developed to solve a specific class of problems that involves prioritization of potential alternate solutions. This is achieved by evaluation of a set of criteria elements and sub-criteria

elements through a series of pairwise comparisons. We describe possible evaluation criteria that are made up of AHP hierarchies and show how the AHP method is implemented to the prioritization of commercial workflow software.

2. Previous Works Related to Software Selection

Traditionally, many researchers have suggested guidelines and methodologies for selecting packaged software in organizations. This is regarded as a multi-criteria decision-making problem[2, 3]. Expertise of the decision-makers who participate in the selection procedure is an important factor and the decision-making procedure should be supported from software vendors[15]. Generally, the decision-making procedure follows six steps, such as identify function, weight function, develop criteria, assign value, rate technique, and calculate score[18]. In the selection of evaluation criteria, its useful to regard critical success factors[16]. Major criteria include vendor support, cost, hardware and operating system factors and the scoring method[20]. It is important to identify user requirements such as technical and functional requirements, and documentation and training and vendor information[3]. In the decision-making procedure, end users should be involved[17]. Software selection is the same problem as selecting vendors[10] and the organizational culture should match the culture of vendors[1]. Chaffey[4] described alternatives for procurement of software as: cost, quality, delivery time, and business needs.

3. AHP Model

The AHP is popular among multiple criteria decision-making(MCDM) methods. The benefits of the AHP are its capability to accommodate subjective and inconsistency in human judgments, as well as its simplicity in converting a normative procedure to a decision support system through the PC-based Expert Choice program [5, 7]. The AHP is based on three principles: decomposition, comparative judgments, and synthesis of priorities. It suggests that a 1 to 9 scale be used to quantify

the decision-makers strength of feeling between any two alternatives with respect to a given attribute.

In this paper, the evaluation criteria that make up the AHP model were derived from prior research. The Workflow and Groupware Strategy(W&GS)[24] has issued a report that compares workflow products. The report was cited as an excellent outcome in the workflow handbook recently issued by WfMC[6]. The report covers the definition of 12 workflow comparison criteria, together with their justification and their breakdown into weighted features. For each criterion, the results of the 13 products compared were described. However, the report does not provide an evaluation model, as well as overall priorities of workflow products. Because this is only a text-based report, it is difficult to apply these evaluation data into a real problem.

Similarly, Kim and Moon[13], and Perez and Rojas[19] have suggested evaluation criteria for selecting WFMS. We first select commonly discussed criteria and add two important criteria from the W&GS report to build the AHP model. We summarize the definition of main criteria and their sub-criteria that are described by the W&GS report, shown in Tables 1 and Table 2, respectively.

4. Commercial Products

The W&GS recommended 13 workflow products to be considered as possible options, denoted by W1, W2, ·, W13. COSA Workflow from COSA Solutions(W1) joins a powerful organization model featuring multiple group hierarchies to a Petri net formalism to describe the procedure. COSA offers an HTML worklist handler and Lotus Notes integration. Panagon Visual Workflo(W2) is an object-oriented evolution of the first workflow product ever developed from FileNet. It provides class hierarchies with inheritance, facilitating the definition of process variations with simple diagrams. W3(W3) from W4 provides an excellent level of functionalities with production workflow throughput. HTML forms are automatically generated and can be redrawn graphically using an HTML editor. Enterprise Workflow(W4) from Eastman Software is a highly scalable workflow solution for imaging. It offers a form-based development environment. Dolphin(W5) from Fujitsu is an ad-hoc engine proposing directly to end-users to instant define and run workflow applications. Bizflow from Handysoft(W6) is a flexible workflow engine that provides well-designed graphical definition tools. It has a Web-based interface, as well as a client/server interface based on ActiveX objects. TeamWARE(W7) from Fujitsu offers outstanding dynamic capabilities.

<Table 1> Definition of main criteria

Criteria	Definition
Throughput rates(THPT)	The efficiency of the engine, and its capacity to run on top of a distributed cluster of servers
Process power(PROP)	The capacity of the procedure development environment to express the real complexity of procedures
Dispatching and organization representation(DOAR)	The capacity to dispatch each individual activity to the participant
Enterprise application integration(ENAI)	For lager deployment of workflow applications across the enterprise, the use of advanced application integration technologies
Distribution(DIST)	The ability to allow several workflow systems, which in turn are distributed, to inter-operate across the network
Internet support(INTS)	The ability to access workflow application from a simple Web browser
Dynamic changes(DYNC)	The ability to change procedures dynamically in unforeseen situations
Procedure definition(PROD)	The ability to minimize the time required to define a process
Activity definition(ACTD)	The ability to avoid programming of activities and replace them with descriptions or simple scripts

The procedure definition can be completed and modified while the process is in progress. MQ/Series Workflow(W8) from IBM with a true object-oriented design offers a high level of re-usability. It concentrates on procedure management and powerful organization modeling.

\<Table 2\> Definition of sub-criteria

Main criteria	Sub-criteria	Definition
THPT	Single system throughput(SS)	The single processor throughput and the capacity of the server implementation
	Distributed implementation(DI)	The capacity of the implementation to run on a distributed cluster of servers
	Client implementation(CI)	The clients ability to react to users with high throughput work constraint
PROP	Network structure(NS)	A set of basic network construction blocks that can be combined to represent the most complex processes
	Variables definition(VD)	Multiple values for one variable, variable type definition mechanism, and indexing on process instance variables
	Exception processing(EP)	Time processing features and wait for event features
	Complexity management(CM)	Multiple processes and version control
	Process verification(PV)	A set of features to verify the correct definition of a process, thus avoiding the discovery of errors
DOAR	Dispatching rules(DR)	For each activity, a method to select a participant according to rules
	Organizational mode (OM)	A description of the organization in an abstract way
	Administration and privacy(AP)	Administration of the organizational model and additional authorization systems
	Substitution rule(SU)	The capability of appointing a substitute for a participant of he/she is not available
	Import from directories(ID)	The feature of avoiding the lengthy creation of users lists in the organizational model
DIST	Import and export(IE)	Import and export facilities with built-in filtering mechanisms
	Automatic cooperation mechanism(AM)	When two engines co operate across a network, the facility to enable co-operation
DYNC	Change network definition(CN)	The capability to dynamically change the network description for a specific process insta
	Change variable definition(CV)	The ability to add or delete variables dynamically
	Late sub-network definition(LS)	The ability to define in the main process activities that will be implemented later by the definition of sub networks
	Change activity implementation(CA)	Change of the activity implementation without stopping system
	Change dispatching rule (CD)	Government of the assignment of activities to participants
PROD	Graphical definition(GD)	The ability to define the network of the process definition graphically
	Embedded features(EF)	Features at the engine level to define process by providing a way of proposing users actions
	Assisted definition of rules/conditions(AD)	A syntax directed editor, mixed with list-based selection of atoms depending on their position
	BPR and simulation(BS)	Import/export to BPR/simulation tool and discrete simulation capabilities
ACTD	Forms generation tools (FG)	Tools to define what a participant has to provide as part of an activity
	Action library and scripting(AS)	The ability to define the execution part of the activity by combining a library of actions, either by a visual tool or by a scripting language
	Activity library(AL)	A set of components, from which a complete process can be rapidly built without the need to define or script activities
	Ready-to-use integration tool(RI)	Integration tools that facilitate automation of activities by integrating office systems, information systems, and imaging and document management
	Multi-lingual support(ML)	Support of different language views to participants

Staffware(W9) from Staffware Co. offers a good balance between production and administrative workflow requirements.

Activity implementation uses form definition and a scripting language that can be deployed on Windows and Java clients. SERprocess(W10) from SER offers production workflow class features with a good organization model. It features advanced development environments including Java-compliant interfaces. InTempo(W11) from JetForm is based on Mail/Web-based activity delivery with no client/server permanent relationship resulting in easy enterprise-wide deployment. It offers flexible dispatching rules and calendar based time computation. WFX(W12) from Eastman Software is a work management solution with extensive programmability features and full document management integration. It proposes intuitive work management definition and operation, dynamic change capabilities. TIB/InConcert(W13) from TIBCO integrates object-oriented technology, document management and a process model. It offers easy definition of procedures that can be deployed through client/server, Java and HTML-based clients.

5. Evaluation

The weight of main criteria is computed by pairwise comparisons from a decision-maker. The weight of sub-criteria uses the evaluation data suggested by W&GS. After computing the weight
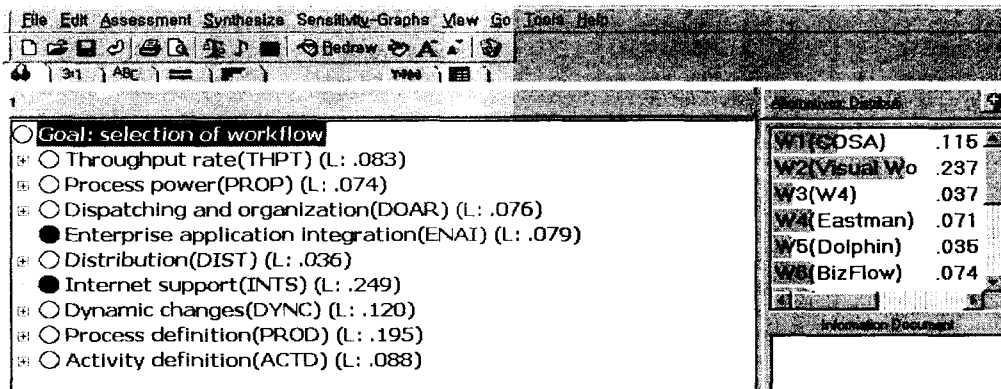
<Table 3> Product scores with respect to criteria

A	B	C	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
	SS	1-6		3							6				
THPT	DI	1-10				10	1								
	CI	-													
	NS	0-22					15		20			20		15	
	VD	0-18		16	16				6					16	
PROP	EP	0-15	13							5,6					
	CM	0-16		16	16							16		7	
	PV	0-15	15									5			
	DR	1-20	20		20									7	
	OM	0-14	13			5	5								
DOAR	AP	0-17						16							11
	SU	0-5	5	0											0
	ID	0-3		1			3		3	1		3	3	3	3
ENAI		0-30		5					5					5	14
DIST	IE	0-10	9	6	9						9		9		
	AM	0-10								10				3	
INST		0-28		26										15	
	CN	0-5	0			0		5	5	0	0		0		5
	CV	0-5				0		5	5	0	0	0	0		5
DYNC	LS	0-5				0	0	5	5				0	0	
	CA	0-5							5	1	1		1		
	CD	0-5	2	2	2	2	2	5	5	2	2	2	2	2	5
	GD	0-15	14	14				14		14				9	
PROD	EF	0-20	17							5					
	AD	0-5		5	5	5	5	5				0			
	BS	0-25	25		0	0							0	0	
	FG	0-19	3											19	
	AS	0-20			7	18									
ACTD	AL	0-16	13	13		13	6								
	RI	0-20			9	20	9					20			
	ML	1-5		0	5	0			0	0		0	0	0	5

of criteria and the synthesized priorities of each product, we perform a sensitivity analysis. Generally, a chief information officer, or members in the task force team, decides the importance of the main criteria. However, because our focus is on illustration of the AHP concept for decision support, the evaluation data are acquired from an expert who has expertise related to a workflow systems.
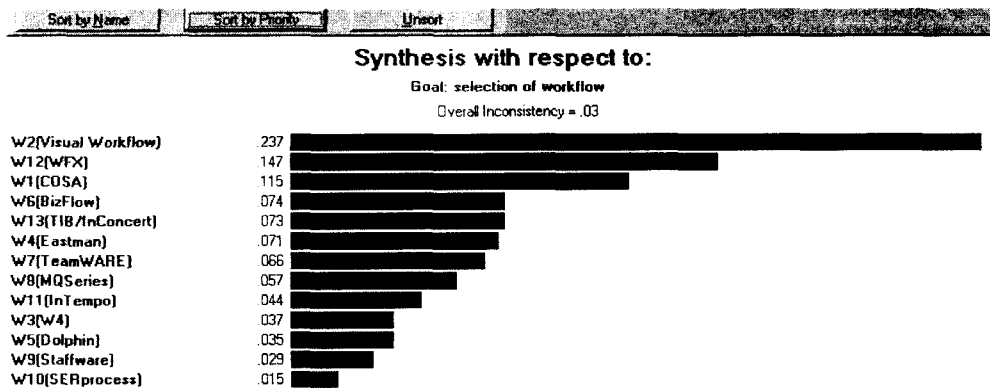
We used the Expert Choice program as a tool for implementing the AHP model. The decision-maker was provided with a measure of the inconsistency of the given pairwise comparisons. The consistency ratio(C.R.) provides a measure of the probability that a purely random manner was used in the pairwise comparison matrix. A value of the C.R. under 0.1 is typically acceptable[22]. With respect to the main criteria,

we repeated the pairwise comparisons until the C.R. was less than 0.1 and we got the value 0.03. In order to evaluate alternatives or workflow products, we did not apply pairwise comparisons but used the data grid method provided by the Expert Choice program. Like spreadsheet models, this method has been used to reduce the number of pairwise comparisons in the many alternatives.

The product evaluation data provided by W&GS is shown in Table 3(main criteria denoted by "A" ; sub-criteria denoted by "B" ; score range denoted by "C"). We rated each score on a Likert five-point scale(very high, high, normal, low, and very low) and assigned their value from 0 to 1 in increments of 0.2. Originally, the W&GS report only applied a two-point scale such as high and low. In Figure 1, the criterion "Internet support" gained the highest priorities, and

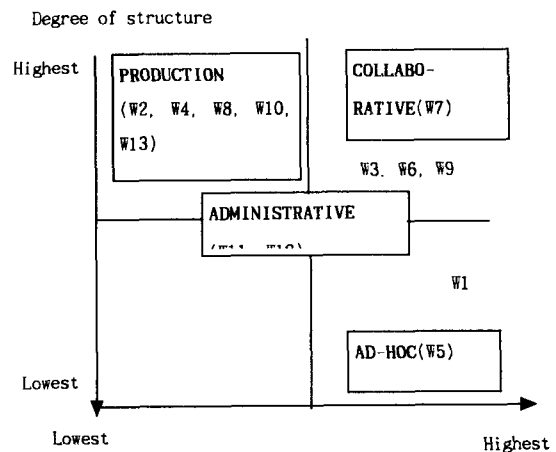<Figure 1> Priorities of main criterion method provided by the Expert Choice

<Figure 2> Synthesized priorities of workflow software products

activity definition was the second highest in the main criteria. Figure 2 displays the synthesized priorities of 13 workflow software products with respect to the goal. Visual workflow(W2) gained the highest priorities and rank in the workflow products. In the prioritization of sub-criteria, the criterion "graphical definition" gained the highest priority in the sub-criteria.

6. Prioritization of Workflow Application Classes

Workflow applications generally fall into four different classes: production, administrative, collaborative, and ad-hoc. Production workflow is an intensive application with dedicated agents working full time on repetitive operations. This corresponds to very formal procedures with few variations, for example, insurance underwriting, legal case management, and home loans. Administrative workflow corresponds to well-defined procedures related to day-to-day operations such as purchase order processing, expense claims, and personnel management procedures. Collaborative workflow involves less rigid procedures where the essential feature is providing a structure for cooperation between participants. Ad-hoc workflow relates to applications where the procedure is simple and not defined in advance and is specific to each case instance.

Figure 3 displays the classification of 13 workflow products by four workflow applications. Generally, the workflow applications are classified according to the degree of structure and the degree of collaboration. The synthesized priorities of workflow application classes are as follows: administrative(0.301), collaborative(0.262), production(0.241), and ad-hoc(0.196). The administrative workflow gained the highest priorities in the workflow applications.

Degree of structure

<Figure 3> Classes of workflow applications vs. workflow products

7. Sensitivity Analysis

A sensitivity analysis is used to verify the robustness of the decision to changes in the input variables. In the AHP model, by increasing or decreasing the importance of the criteria, it depicts how well each alternative performs on each main criterion. It should be noted that if a criterion is not sensitive, it would be better to eliminate it from the AHP model. Through a performance analysis graph in the workflow products, when comparing the initial ranks of the alternatives(i.e., W2 is the first and W12 is the second), we can accept W2 is the highest in the alternatives because W2 did not change its rank according to the change of criteria weights. Therefore, we could conclude W2 has really the highest priorities in the workflow products. Similarly, when we increased the weight of the criterion, the rank of workflow classes did not change according to the change of the weight of the main criteria. We could accept that all the criteria should be included in the AHP model.

8. Conclusion

In this paper, we proposed the AHP model for evaluating workflow software products. The work to define evaluation criteria is mostly important in the constitution of the AHP model. The results reported in this paper offer several contributions to both the firms, which intend to build a workflow system, and the vendors who produce workflow software products. In many decision-support problems, domain experts, or a person who currently needs to get a solution, have decided these decision criteria and their importance because this is time-consuming for gaining relevant judgments. As with our approach, it is recommended to utilize the evaluation data for criteria ready suggested by specialist groups. Although the criteria and their evaluation scores regarding workflow products are suggested, it is not easy to apply them to a real case and get solutions without a model.

Our methodology will be helpful to those who are going to adopt a best workflow product in their organizations. Their decision depends on subjective judgment of the decision-maker because many commercial workflow products have different capabilities. We can easily select the best workflow product by deciding the relative importance of the main criteria in the AHP model.

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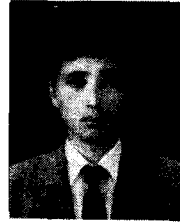
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주요 관심분야
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