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Supporting Geo-Workflow Management through Object Activity Model

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객체행위모델을 통한 지형정보 프로세스 관리

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ABSTRACT

Management of geo-workflow's changes is one of growing issues and requires more advanced ways and methods to deal with heterogeneous modifications and interactions of process, activity and event over time. A few dominant workflow models have coped with these subjects. There is, however, little consensus for explanation of six dimensions with regard to actor, activity, space, time, reason and effect. This study begins with examining environments of six dimensions and the Hexad model is proposed to elucidate the causes and results of a wide variety of geo-processes and activities. In this paper, we will introduce Hexad Object Activity Model making it possible to interpret manifest motivations, conditions and actions. Full descriptions of six dimensions are often useful for applying to the handling of diverse activities particularly requiring to clarify actor's goal and role at a specific time and space.

KEYWORDS: Geo-Workflow, Activity Diagram, Hexad Object Activity Model

요 약

지형정보 작업관리(워크플로) 연구는 중요한 관심이 되는 분야 중에 하나로 시간변화에 따라 발생하는 사건, 행위 그리고 프로세스들의 상호작용 및 변경 등을 처리할 수 있는 방법 및 모델이 요구된다. 기존의 많은 워크플로 프로세스 모델이 있지만, 육하원칙에 의거하여 행위자의 시간과 공간적 행위 또는 사건을 해석하려는 시도가 많지 않은 듯하다. 이 연구는 6가지의 조건을 조사하고 객체지향적인 헥사드 행위 모델을 제시하여 지형정보 프로세스 및 행위를 분석하고자 하였다. 행위자의 다양한 행위의 원인과 결과를 시공간 개념과 연계하면, 육하원칙의 자세한 분석은 공간의 변화나 공간정보 흐름을 파악하는데 상당한 도움이 된다.

주요어: 지형정보 워크플로, 행위다이어그램, 헥사드 객체행위모델

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INTRODUCTION

Many researches and empirical studies have examined the potential benefits of process and activity models arising from business information system, software engineering, manufacturing and industry, human and social science, and geographic information system, etc. Most of process and activity models have focused on addressing a variety of needs and facilitating communication and management considered to be a part of purposes of workflow management. A workflow process is an abstraction of business process, and it consists of activities(Liu and Pu, 1997) and which correspond to individual process steps, and actors(or agents), which execute these activities. Geo-processes(Alonso and Hagen, 1997) consisting of a collection of tasks or activities might have been divided into several phases and detailed processes in governments and concerned authorities. These diverse processes and activities of geo-information products would often lead to duplicated paths of map databases and their managements. Many national mapping agencies make an effort on reorganizing geo-processes and activities by means of process models or workflow models.

Although governmental or private organizations have used them to support their business processes, business models and workflow model may have some different functions coping with dynamic changes of geo-space that stems from various activities and actions over time. We focus on geo-activity that is considered as a set of subclass of geo-process by introducing salient six dimensions of who(the individual and collective actor) are doing what(activity objective), where(activity place), when(temporal validity of activity), why(activity reasons) and how(the process and effect of putting activity into actions). The principal idea of the mapping of activity model onto object-oriented analysis is the representation of the activity associated with actor, time and space, and all components of the context of six dimensions. Being different from standard workflows, geo-workflows have geo-referenced data at a specific regional location(Weske et al., 1998) and their data are continuously changed through time. Frequently, these data are required to track historical information about the past of spatial changes or previous story about change of each process, activity and event in transactional activities and major planning process, etc. Today's workflow management system might have a little limitation to deal with various ad-hoc changes and structural changes(Van der Aalst, 1999) and their temporal functionality might be rudimentary(Eder and Panagos, 1999) and linear. Meanwhile, change managements of geo-referenced data are mostly time-consuming and difficult to check where and when actors modify or transform geo-process.

Therefore, the Hexad model is semantically designed to keep up with heterogeneous changes of geo-processes and Hexad matrix enables to portray different variants of activity and depict actors behavior through action, time and the history in the context of the Hexad Object Activity Model. The benefits of Hexad model aims to emphasize not only human activities from beginning to ending of geo-workflows with the help of interpretations of concerned analysis, but also feasible application for land transactions and registrations. Particularly, there are also growing concerns for information about mobile actors roles(or agent) and their interactions.

RELATED WORKS

Workflow modeling and business process modeling(WFMC, 1999a) have focused on process improvement and increases of customer services associated with the traditional organizational structure(Bridgeland and Becker 1994) and business processes that might not live up to organizational expectations(Hammer and Champy, 1993). In recent years, more emphasis has been placed on approaches which try to capture working processes in distributed workflow process management(Medina-Mora et al., 1993; Panagos and Eder, 1999) in close connection with business process redesign(BPR). A workflow management system allows the business process to be modeled, executed, monitored, and reported upon later(Eng, 1999).

Traditional process modeling approaches coming from Information Control Nets(Ellis and Nutt, 1980), Event-driven Process Chains (Scheer, 1998), and Role Activity Diagrams (Ould, 1995; Kawalek, 1999) would focus on activities. Many enterprises observe that business process approaches utilize process modeling as a way of understanding their own activities or behaviors. On the other hand, object-oriented business process modeling, today, considers a business process as the sum of all those activities(Bauer et al., 1994; Jacobson, 1995) enabling to easily simulate working processes and improve the performance of process redesign.

The variety of object-oriented analysis methodologies available suggests that it is possible to consider any entity, activity and process of businesses as a business object enabling to describe an abstract view of the real world no matter what it looks like. The different object-oriented analysis and design methodologies coming from, OMT(Rumbaugh, 1991), OOSE (Jabcobson et al., 1994), Booch (Booch, 1994) etc use a range of different techniques to document and implement business rules, and there is no yet dominant standard because business concepts could be differently interpreted corresponding to geo-transactional regions, economic organizations, and business items and rules, etc.

In addition, the UML is a collection of specification techniques that are intended for software specification, it might not fully meet the requirements of the geo-sciences because technical software specification may differ from description of multi-dimensional geo-processes and workflows. Thus, it may be hard to circumscribe apparent distinctions of diagram as to which major diagrams can be mapped to the geo-process frameworks. For the purpose of process modeling, activity diagram that is composed of nodes representing activities and edges with control flows(Jager et al., 1999) is used to show what happens in the geo-processes. Activity diagram supports procedural modeling of processes based on the process programming paradigm(Osterweil, 1987). Being different from OMG business objects and event-based model(Cook and Wolf, 1998), geo-process objects often focus on importance of spatial activities that are brought about by direct and indirect actors during a certain period of time. Activity diagrams are based on the event diagrams of Martin and Odell(1994) and are a particular kind of state machines in which the states represent activities and the transitions and completions of an activity(Gehrke et al., 1998).

MODELING OF WORKFLOW ACTIVITY IN GEO-INFORMATION MANAGEMENT

A business object represents a person, concept, process or event in operation, management, planning or accounting of a business or other organization(OMG, 1997). A business object includes attributes, relationship, actions/conditions, events, and interactions that apply to most part of geo-business objects. But a geo-business object is pertinent to information about people, places, and natural things in a spatial way including map production and marketing.

The benefit of process design is to mainly improve several dimensions with regard to products of cycle times, costs, and services and qualities by using a business model that starts to examine current value of their products with questions of why is today, but, is a valuable tool in determining the what should be(Meehan, 1995). Most existing business process modeling methods seek to define 3 or 4 dimensions that begin with analysis of business goals(why), activities and output(what), logical dependencies between activities(when), and role of actors(by whom)(Kueng and Kawalek, 1997). Bridgeland and Becker(1994) discuss four variances(why, what, who and when) of matrix with relevant analysis. Kradolfer and Geppert(1997) argue four requirements(who, when, which and how) of the workflow model. Van der Aalst and Van Hee(1996) examine three variances(what, how and by whom) based on the Petri-nets model. However, it seems that three or four dimensions based on business may not be enough to cope with a variety of process and activity of geo-business that should regularly update change of land records and land uses, and elucidate the causes and effects of dynamic actors behaviors and complicated interactions in geo-processing environments.

With regard to the flows of undertakings in geo-businesses, it might be harder to differentiate exact notions of geo-process, geo-activities and geo-events compared with generic concepts of workflow process and activity. A few models of temporal GIS describe spatial process and its change over time. Here, geo-process is regarded as more comprehensive notion for both spatial and socio-economical characteristics associated with land registration and transfer, and land administration, etc. Thus, geo-process is suitable for interpreting diverse undertakings of geo-businesses.

By introducing temporal validity of each occurrence, it might enable us to identify them. A geo-process consists of collections of activities and events together to describe the life cycle of an object(or entity) associated with unanchored time(Ozsu et al., 1996) like span or period(Snodgrass et al., 1993). A geo-activity describes a duration of action taking place in application domain like a surveying and mapping activity that might have anchored time like interval. It may consist of pairs or many sorts of geo-events. A geo-event is a special kind of object that presents information about transition from one state to another keeping very fixed time point like instant.

Here, the Hexad model(Figure 1) is proposed to describe processes(or workflows) consisting of activities and events by means of six dimensions that are used to scrutinize the causes and procedures, and results of each planning and workflow that are relevant with an analysis. Each analysis can be interpreted

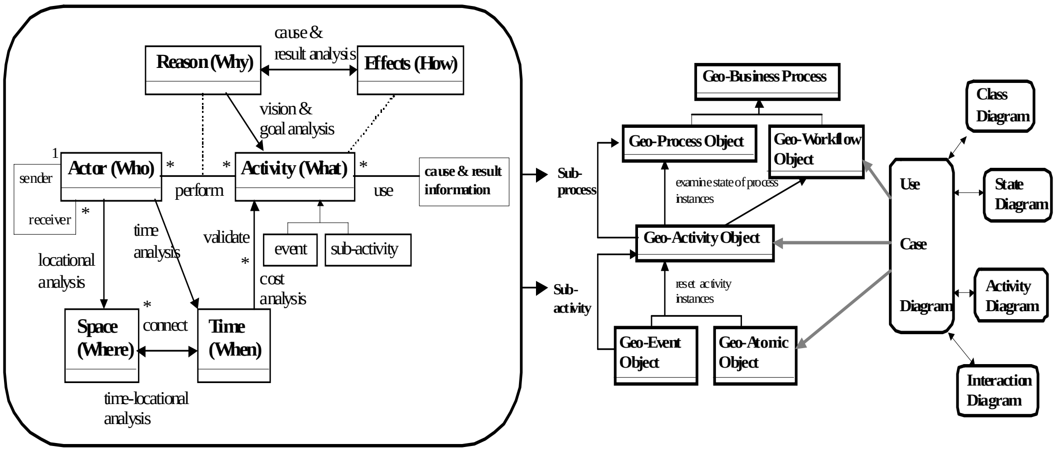


FIGURE 1. Hexad model for geo-process objects

dependently or independently corresponding to the purpose and application of concerned diagrams when special circumstances of geo-process and activity could be expected to lead to different outcomes. Since actor's behaviors and activities are mostly due to specific cases of business, task and undertaking, use case diagram may require and connect with other extra diagrams to expound holistic geo-business processes.

From a strategic perspective, any attempt to rethink a geo-business process always begins with goal of process modeling and dominance of current value and quality as to why current process, activities, and events of human actors (or machines) can not meet customers needs and do not confront with vision and goal of future trends of IT/IS by analyzing mid and long-term strategy or by estimating severe criticisms of their marketing failures. In the target-based point of view, the emphasis is on what process, activity and output should be defined. Through conventional value analysis of customers satisfaction and objectives of each goal, and something to be done by human actors, it enables to take reshape for objectives and practices of goals and evaluate actors behavior and ability. It often requires behavioral analysis of actor that gives birth to workflows (or spatial) changes over time.

From an organizational perspective, the focus is on who carries out this activity. Policy-makers, planners, surveyors and even engineers involve with decisions of process and activities of surveying and mapping. Decision-making is, to a certain extent, considered to be definite events or actions when interactive operations between different groups occur in the course of surveying and mapping.

In the structural perspective, we often consider alteration of a step as a task and an activity in the context of redesigning process. There is always inevitable question how we can reduce redundant spatial and legal data capture and maintenance by unbundling the data from a department application, and improve process cycle time by moving from task orientation to business function orientation(Meehan, 1995). From a behavioral point of view, the emphasis is on when processes and activities are executed. At the same time, it is concerned with measurements of cycle of productive time and computation of delivery of services by analyzing organizational route and procedural path. In terms of location and duration of process, these two dimensions are arising from question about where it takes so long and the backlogs are, land records are old and duplicated etc. Perhaps, it may require time-locational analysis as to where optimal steps and paths are required for obtaining quick conclusion when decision-making process involves with many steps with many different people in several different departments and organizations.

Additionally, there are additional questions about which, whose and whom, etc, but we select representative description and frequent usage of natural phenomenon to explain the real world. Interpretation of six dimensions is also investigated at the domains of information enterprise architecture(Sowa and Zachman, 1992) focusing on two-dimensional matrix of representations(scope, business model, etc.) and aspects of six variances(what, how, etc) (Beznosov, 2000) for workflow. This dimensions is also spotlighted by spatio-temporal research focusing on change over time(Liou, 1999). The Hexad model is designed to not only support for a specific analysis at the domain of geo-businesses, but also connect a particular diagram when needing to specify more details of geo-workflows with the help of use-case diagram, state diagram and activity diagram. Furthermore, it enables to explicate actors rule (or agent) determining a majority of geo-spatial changes and interacting with other agents who often give rise to subsequential operations and actions of changes.

AN EXTENSION OF HEXAD MODEL TO HETEROGENEOUS GEO-INFORMATION PROCESSES

Since there are diverse domains, processes, and activities in geo-business objects, it may be hard to describe overall attributes of objects. Consistent with the above the Hexad model structure, a generic multi-dimensional object-oriented model is used to explain the framework of geo-information process. In any GIS/LIS agency or engineering enterprise, it has been classified into four and five objects such as process, activity, event, actor and their history.

Although the WFMC(1999b) defines the characteristics of workflow process definition, workflow process, activity and event, there might be other requirements for the relationships between process and activity concerning basic principle of the cause and effect, actor, space and time. Additionally engineering and database applications might have led to dynamic interpretations of processes and activities. Many researchers and scientists have long articulated process and activity model, however, it might be still hard to classify and aggregate various types of activity.

Particularly, multi-dimensional aspects of geo-activity objects are too immense to define activity instances when connecting with process and event instances. Here, we focus on further activity model enabling to illustrate the relationships between process and activity state, and actor manipulation. The holistic approach is used to portray a framework of geo-process (Figure 2) that intends to deal with activity object as a core of workflows leading to the history at a specific application. It shows hierarchical or procedural flows of surveying

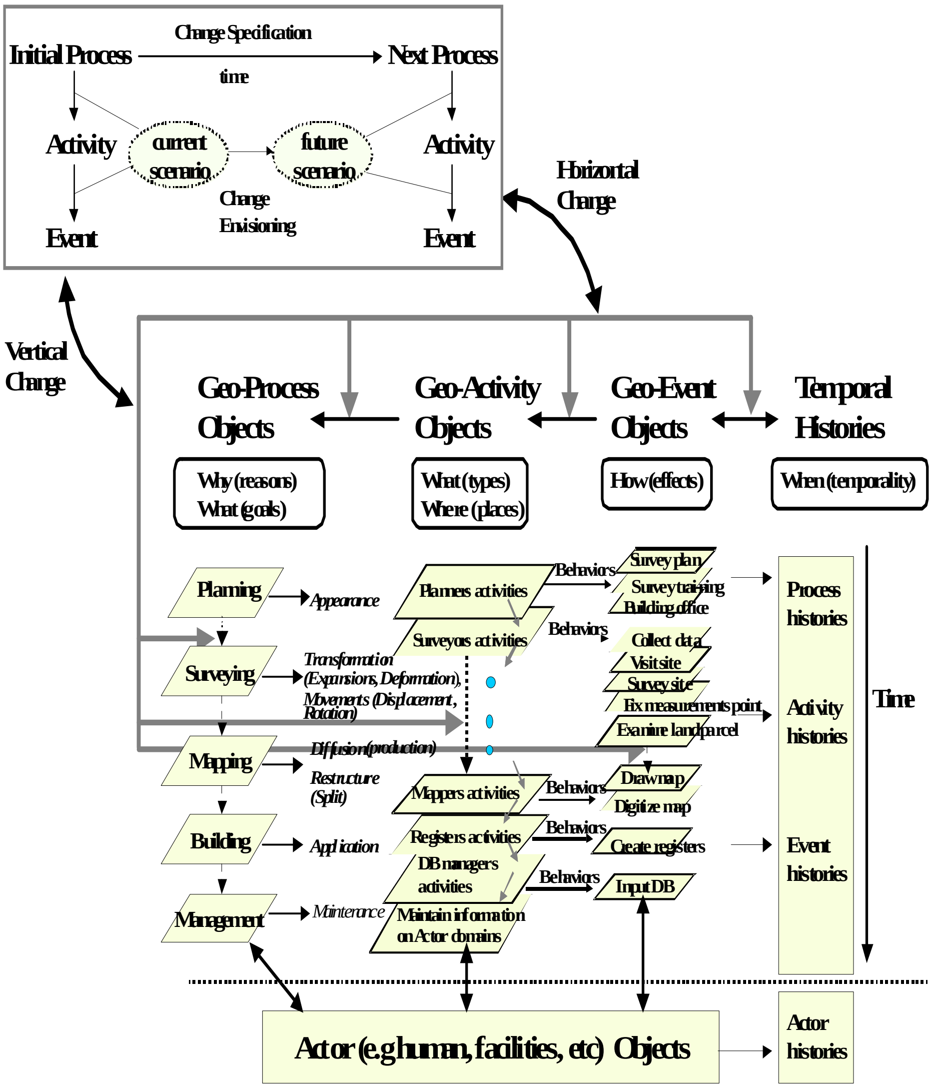


FIGURE 2. Generic framework of geo-information processes

and mapping consisting of geo-process, activity, event, and temporal history that are also composed of their sub objects. The Hexad model provides a basic principle for description of spatial changes from initial process to next process at the horizontal and vertical level. The relationship between current and future scenario of geo-process provides a principal concept for the framework of spatial connection or transition over time. Temporal histories are interpreted as discrete or continuous stories of connections and interactions between actor's objects or spatial objects.

Meanwhile, there are many activity-oriented approaches from IDEF0(Huo, 1993), workflow activity model(Eder and Liebhart, 1994), etc and role-oriented models(Warboys, 1998). Some approaches may fail to represent the true complexity of work(Kueng and Kawalek, 1996) and may not be suitable for describing transactional complexity of temporal logics among various activities. Since maintenance for consistent and effective collections and updates of geo-spatial data and business information over time requires enormous efforts and expenses, an appropriate method for change envisioning should be considered. In other words, a major issue of geo-processes and activities is that actors are often the originators of horizontal and vertical changes and final collectors of distributive informations about their artifacts.

Procedural alteration or vertical changes might be considerably examined by setting predefined rule and scenarios. But, horizontal changes range from a workplace to other workplace occurring at different space and time. It might be more burdensome to detect spatial changes. When considering continuous geo-activities of land splits and merges, and spatial changes over time, we should constantly maintain validity of cadastral maps information about what and where and when spatial features are changed and how their versions can be managed from the beginning of surveying to the last goal of geo-workflow management. It must be major issues and problems in some countries.

HEXAD OBJECT ACTIVITY MODEL

Now, our conceptual idea of Hexad Object Activity Model(HOAM) is proposed to depict various properties of activity for explanation of process and event as well as their history by using state transition diagram and the Hexad matrix. In our model, an activity may consist of many atomic activities as objects that are similar to small unit of events or transactions. But, there is a subtle difference between an atomic activity and a transaction(Chiang, 1997). The HOAM is based on object-oriented concept that supports role, association, persistency of object, and history of an object, etc. This model is designed to provide the dynamic behavior of objects associated with events, messages and methods within the state transition diagram of the activity that supports an activity or event-based design of objects. It associates each activity(or object) with a finite set of states(Breu and Grosu, 1998) and enables to model state changes by incoming activity. Particularly, the cooperation of actor who participates in a common task requires the coordination of the task-related geo-activities as well as the coordination of the resources used during the execution of geo-process. In this case, it should determine the exact sequence of the activity to be performed in accordance with anticipated change specification and may choose the collaboration mode for concurrent execution of actors actions(Rusinkiewicz et al., 1995).

With regard to time, although the temporal aspects add another dimension to the scheduling of activity and workflow model, geo-business process and workflow typically try to reduce turnaround times and improve process execution duration for sub-processes and activities and absolute deadline of products(Eder and Panagos, 1999). Two perspectives of temporal requirements in process modeling are associated with duration of a task and occurrence of a task at a specific time. At certain points in activity model, it often focuses on the event time and transaction time based on temporal object model(Ozsu et al., 1996) providing geo-time management. We do not look into the issues of temporal object model, but our HOAM can have interface with temporal object model consisting of time instant, time interval and time span.

Figure 3 shows the primitive set of states between two activities. As an idle state, an initiation means an inactive event that is not executed. A ready state corresponds to conditions of activity or results in disable status linking with stop, and an active state has been activated or suspended. Finally, the state commits and aborts. This diagram consists of 3 steps(e.g. waiting, activating and ending) (Joeris and Herzog, 1998) of transition/operation which can be invoked over time. Each transition interacts with time. In case of geo-transaction for land registration management, a typical transaction executes a sequence of event and then requests a commit or abort through the online and the Internet.

To model a real life of activity, a class diagram should define all attributes, methods, and rules that are common to all instances of all activities postulating an Activity Class(or Type) that connects with the use case activity diagram. However, this approach is dependent on the geo-event and geo-activity characteristics stemming from combination of six dimensions within the framework of collaborative geo-activities. This state transition diagram of object activity can be extended to or related with human activity level in order to explicate transaction model of land banking and geo-processing applications. The HOAM also provides dynamic features for actions principle

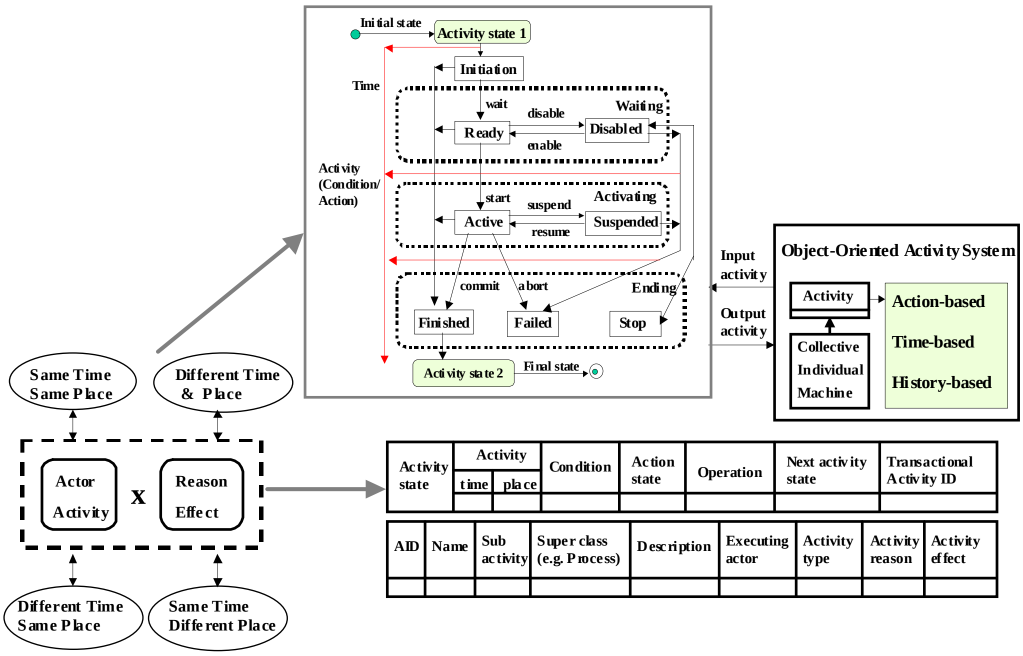


FIGURE 3. Hexad Object Activity Model

helping the user to expound versatile their activities because someone needs six dimensions and others only require three or four dimensions.

The numerous combinations of Hexad matrix are more pliable to illustrating the origin and heart of geo-activities since spatial changes and workflow changes are occurred at the same place and time or different place and time connecting with other 4 parameters. Obviously, it requires dynamic temporal models and their functions to track historical information on human activity or previous story about each process, activity and event of land transactional activities and major planning process. The HOAM also includes three features of dynamic properties of activity based on action, time and the history. In terms of the history, it is time-ordered sequences of all previous states of the activity. The history plays a major role in representing the foregoing footprints of geo-process as it shows the evolution of the process over time. With respect to geo-activity history, we refer to the histories of user activities or objects. By inspecting the activity history, particularly the change of current state activity's over time, dynamic monitorings of geo-activity and event are possible, but requires more accurate temporal logic system. In conjunction with temporal object model, the HOAM is capable of comparing previous and current state of activity and denoting attributes of each activity.

GEO-ACTIVITY DESIGN APPROACH

Geo-process models and workflow systems define, execute, and monitor the flow of work within mapping organizations by using a computerized representation of work procedures and activities. There are unforeseen activities and events arising from dominant human actors. There are also other technical staffs who support decision-makers, have extra roles in causing unforeseen activities and events. Much intensions and attractions pay attentions to the ways and questions on how to handle unforeseen situations and how to design for unanticipated, but very decisive activity. Although geo-activity design describes solutions for a set of common way of configurations, there is a lack of a systematic way to integrate different activity designs. With the benefit of extension of state transition diagram and activity diagram, it may be able to generalize activity design that applies to various types of geo-activities ranging from land surveying and to land management and administration.

Activity design begins with the recognition of existing environments in terms of surveying plan, law, regulations, etc that define and identify geo-activities(Figure 4), and then continuously generates activity instances (Teege, 1996) and transform theirs attributes and methods. By interacting with actors, it brings about determinant results of geo-information products or feedbacks of activity. However, there are always technical problems in detecting what activities are happened and changed, and where they are. To respond these questions, a set of collaborative work for geo-workflow management that is appropriate to the web-based system can be considered. Generally, it would be impossible for actors to know about other geo-activities and specific state of other actors such as their roles, whether they are active in the system.

To illustrate the concept of actor behaviors detection, consider the above example user and

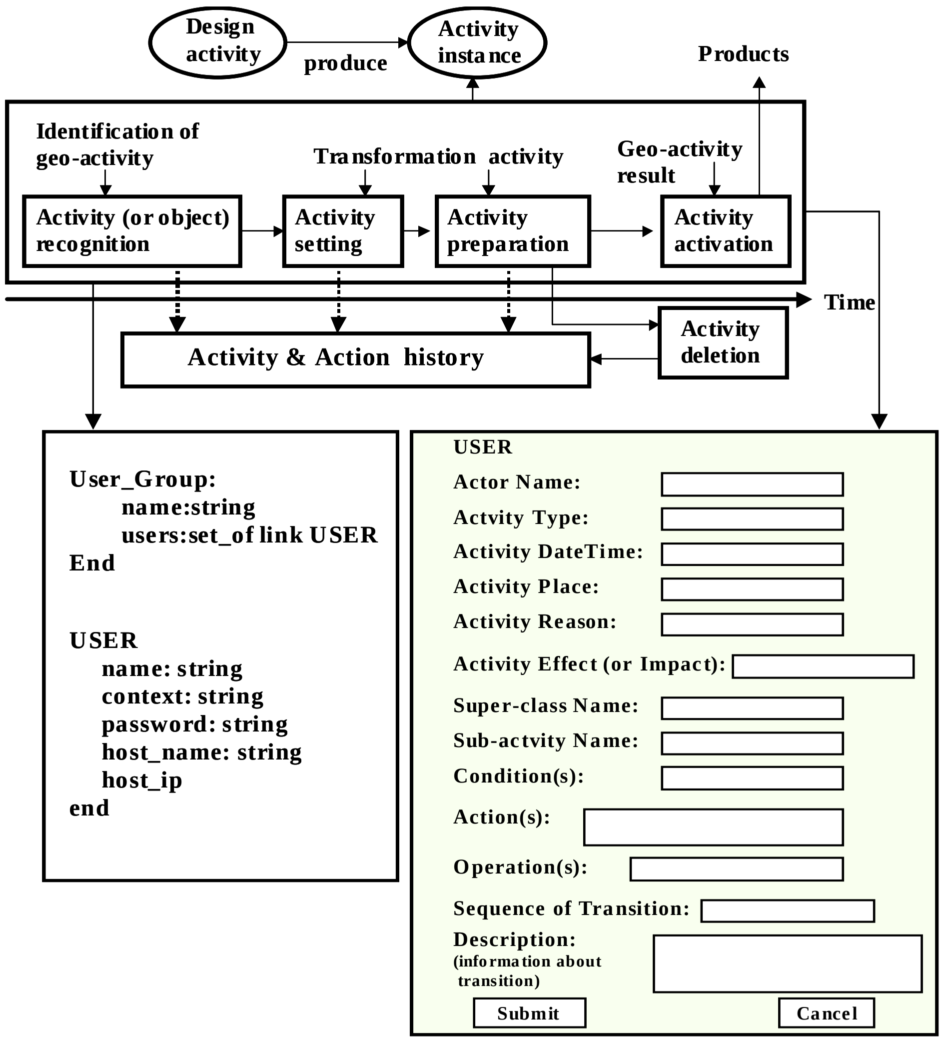


FIGURE 4. Transition of activity design

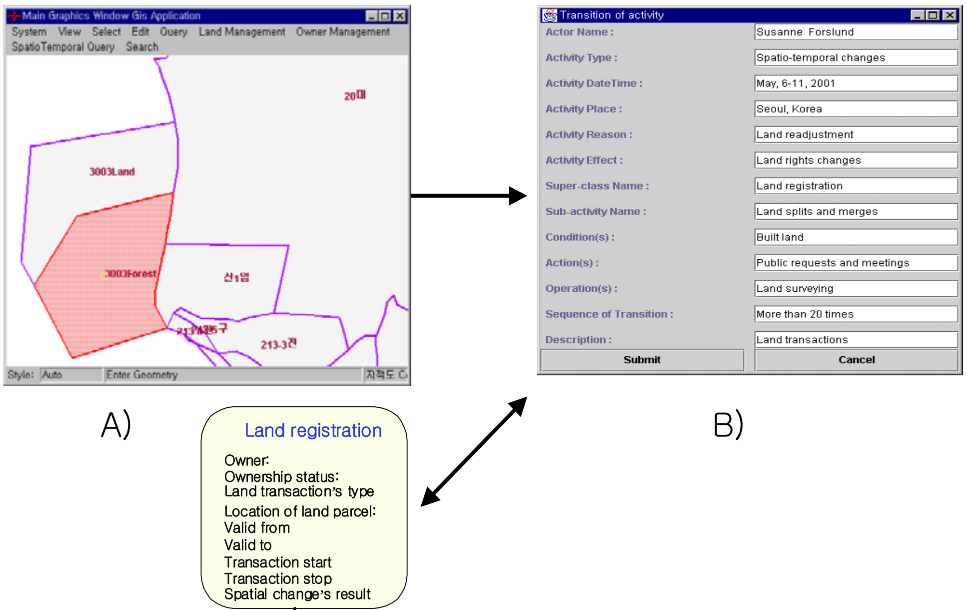
group class in state transition diagram(Figure 3). Each geo-activity is represented as an object in which the operating manager(or user) stores pertinent information and can be aggregated in a user-group or large group of geo-activity databases. The main constraint with this approach is that it might be hard to bind information of geo-activitys changes from different departments and other concerned authorities. Particularly, when the same contents of actor activities arise from different users, a dynamic way of temporal logic properties must be considered. Since existing geo-workflow models might have limitations to support dynamic changes of geo-activities with temporal object, it might be hard to illustrate how our conceptual model of HOAM could be involved with generic workflow model. Here, we do not delve into more detail of transactional workflow activities that are regarded as major issues of databases.

To partly explain a conceptual model of HOAM for geo-workflows, a simplified land registrations dialog box and a case of attribute table are illustrated and then all requirements are input into the transaction of activity. The transaction time will be recorded in master file when actors notify their activity's attributes based on our conceptual model of HOAM (Figure 5).

Figure 5A shows an example of land split concerned with changes of ownerships(owner management) and the history of land use (land management), and feasible query for spatial changes enabling to examine historical reasons and impacts of actors activities. Figure 5B and 5C illustrates a simple user interface to be connected with 5A how geo-workflow processes and activities are occurred and modified over time.

During individual work periods, it is conceptually designed to share transaction data that there exists a common workspace(Figure 5B) to guarantee a private access and use when searching for historical activity.

However, it is a snapshot of land split or



ID	Owner	Activity reason	Activity type	Activity location	Activity DateTime	Activity impacts	Geo feature
1	Kim	Cultivation	Land use change	Seoul	May 6, 2000	Spatial changes	
2	Susanne	Land transfers	Cadastral split	Seoul	Dec 12 2000	Ownership changes	

C)

FIGURE 5. An example of transaction of activity in land registration

land merge describing origins, transitions and ending of spatial alterations. To consistently and effectively examine various changes at far distant areas, the handling of geo-referenced data may require collaborative works. This is one of serious research issues when multi-actors(or agents) interact with each other, and then give birth to unpredictable activities and events in unknown place and time. Therefore, many workflow models and business process models that consist of dynamic modelers enabling to support non-specific application in geo-business process could harmonize with our ideas of HOAM supported by 3D modeling.

To be able to prove possible feasibility of Hexad model in socio-economical areas, we assume actors(who) role determining a majority of reasons and results of spatial charges of land use, particularly associated with economic inequality of access to lands, houses and public infrastructure. Actors who are risk in environmental degradation are a high mobile and migrate to look for amenable land and houses over time. The timelines of individual shifts are very unpredictable as to when they move in and how they move out. The time use survey based on geo-workflow might be useful to track footprints of human vestiges and natural changes of landscape as well as efficiency of logical networks. Probably, new concept of geo-workflow model including a concept of Hexad model helps us to consider more valuable activity model in geo-sciences.

CONCLUSIONS

Most approaches to business or workflow modeling have a large variation in their conceptual constructs and their ability of comprehensible understandings of various processes and activities. There might be, however, few efforts on redefining the context of six dimensions even in prevailing areas of process modelings. Slight disparity between generic workflow and geo-workflow might not be problematic concerns, but should be manifest because many different aspects of legal, economical and cultural geo-process exist and are required to be integrated into one mechanism.

In this study, we propose the model of the Hexad and HOAM. The model provides a general framework for the design of geo-activity through a few diagrams. A principal idea of the model is associated with the concept of activity by interpreting six dimensions and their combination. The activity model expounds generic characteristics of their types and attributes enabling to interpret multiple types of activity.

The most significant contribution is the fact that a conceptual model of the Hexad and HOAM may have dynamic potentials and feasibilities to expound a real life of geo-activities and events. Particularly, activity diagram is used to assist our conceptual HOAM in connection with state transition diagram and use case diagram. The model is designed to illustrate geo-events execution at the object level and portray actors activity at the geo-spatial level by expounding action, time and the history.

To detect unforeseen geo-activity and event, geo-activity design semantics are suggested with the transition of activity to describe activity's methods and attributes connecting with six dimensions no matter where actors are. But, it is likely that the HOAM should be extended to action-based system at the human level when complicated land banking systems are required. By illustrating an example of land registration, an integrated geo-workflow model might be required for a variety of users requirements with regard to the history management, time and cost analysis of geo-information products, and the footprint of actors effects and impacts on their important decision-makings. KAGIS

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