Task-role-based workflow authorization model and its implementation in emergency command system of water traffic

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Abstract

Water traffic plays an irreplaceable role in modern traffic as accomplishing heavy transport task in low cost, but the emergency frequency brings serious challenge to ensure safety and rescuing in water. At the same time, the safety supervision departments at all levels lack of modern technical means for prevention and action to emergency, so an emergency command system not only for safety supervision and risk early-warning in normal state, but also for quick response and scientific decision for emergency must be built. In this paper, by the use of the task-role-based workflow authorization model, an emergency command module is realized, which key technology is permission assignment. It accomplishes 7 tasks by 4 roles, besides, by the definition of user, role and task and constrains of relationship among them, and take use of delegation technology and right transmission between roles, emergency command process can executed methodically with high quality and clear target according to emergency plan.

Keywords: water traffic, emergency command, workflow, permission assignment

1 Introduction

Water traffic undertakes heavy transport task, and because of the influence of objective and subjective factors, water emergency occurs frequently, objective factor includes the channel, hydrology, meteorology, aid to navigation, traffic characteristics, hull form, ship(fleet) size, navigation technology; subjective factor includes safety navigation technology, safety management model, quality of employees. Water safety supervision departments at all levels already had related emergency plan and policy, but due to the lack of effective technical support of the emergency command system, some serious problem may often appears in emergency treatment, such as unified scheduling of the manpower and material resources, slow rate of information and data exchange, lack of objective information support for decision-making and commanding, lack of understanding of operators for emergency plan and its operation flow. Therefore, it is urgent to establish a complete set of emergency command system, which not only for safety supervision and risk early-warning in normal state, but also for quick response and scientific decision in emergency.

Emergency command system involves complex business processes, so, workflow technology is introduced and its delegation technology and right transmission between roles is researched, and task-role-based workflow authorization model is constructed for emergency command in this paper according to its actual work logic. The emergency command process is divided into 7 tasks: Record receiving alarm, Department verified, Leader verified, Start order, Disposal action, Final treatment, Task suspension & end, these tasks are dependent and executed in a coordinated manner methodically with high quality and clear target according the emergency plan. This paper is developed from a conference paper of The 5th International Conference on Intelligent Computation Technology and Automation (ICICTA2012), as in [1].

2 Task-role-based workflow authorization model

Workflows typically represent processes involved in manufacturing and office environments, and the definition of the workflows given by WfMC (Workflow Management Coalition) is "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", as in [2, 3].

The task-role-based workflow authorization model associated the role and permission through task, grants different executes right to different users through task state and the roles of users, as in [4]. Besides, a series of constraint mechanism must be used to assign different permission to different users to reduce the mistake and ensure the emergency command execution methodically, as in [5].

1) U (*user*): the set of users, R (*role*): the set of roles, WT (*tasks*): the set of tasks, P (*permission*): the set of permission.

2) $URA \subseteq U \times R$: User Role Assign, represents the many-to-many hibernate from U to R, means the users are fixed to the roles.

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3) $RTA \subseteq R \times WT$: Role Task Assign, represents the many-to-many hibernate from to *WT*, means the roles have right to do the tasks.

4) $RH \subseteq R \times R$: Role Hierarchy, is partial ordering relation on roles set, represented by "$\succ$". There exists $r_1, r_2 \in R$, if $r_1 \succ r_2$, then it means that superior role r_1 has all rights of lower role r_2, and $WT(r_1) = WT(r_1) \cup WT(r_2)$.

5) (u, wt_i, u'): Delegation relationship, represents that user u delegate his task wt_i to u', and u' will take place of u to execute task wt_i.

3 Task-role-based workflow authorization model

3.1 TASKS REPRESENT

In emergency command process, it contains 7 tasks, which includes Record receiving alarm, Department verified, Leader verified, Start order, Disposal action, Final treatment, Task suspension & end, as shows in Table 1.

TABLE 1 The task represent table

NO.	Task Name	Task function brief introduction
wt₁	Record received alarm	Record emergency condition after receive alarm
wt₂	Department verified	Related department verify emergency condition
wt₃	Leader verified	Related leader verify emergency condition
wt₄	Start order	Start emergency disposal
wt₅	Disposal action	Dispose the emergency
wt₆	Final treatment	Related task after emergency disposal
wt₇	Suspension & end order	Suspend or end the emergency action

1) Received alarms record: this task is to save emergency alarm record and report them to management department to ask for verifying after alarm received. To record emergency alarm information rapidly, the quantity of users with permission to execute this task is larger than others.

2) Department verified: this task is to verify the newest reported emergency information in alarms record list, it can judge if the emergency is false alarm or not, and ascertain the dangerous situation is excluded or not.

3) Leader verified: this task is to treat verified and reported emergency from department.

4) Start order: this task is to start emergency plan and inquire about the state of the started emergency.

5) Disposal action: this task is to inquire the handling emergency, it only can inquire the emergency in disposal state of "started" in one month in default.

6) Final treatment: this task is to complete final treatment to started or ended emergency.

7) Task suspension & end order: this task is to suspend or end any reported or verified emergency.

3.2 ROLE REPRESENT

In this system, there are 4 roles: Leader, Expert, Commander and Executor as shows in Table 2.

TABLE 2 The role represent table

NO.	Role name	Role function brief introduction
r₁	Leader	The person in over-all command
r₂	Expert	Provide decision opinion and take participate in making disposal scheme and action
r₃	Commander	Organize emergency disposal action
r₄	Executor	Carry out emergency disposal action and provide related information to leaders

4 Workflow Model for Emergency Command

4.1 MODEL FOR EMERGENCY COMMAND WORKFLOW

Refer to the symbol expression in references [6-8] about workflow, in this paper, workflow model for emergency command is represented.

Given: $WT = \{wt_1, wt_2, wt_3, wt_4, wt_5, wt_6, wt_7\}$, they are expressions for all of the tasks of Record received alarm, Department verified, Leader verified, Start order, Disposal action, Final treatment, Task suspension & end order; $U = \{u_1, u_2, u_3, u_4, u_5, u_6, u_7\}$, they are expressions for all of the users of *A, B, C, D E, F, G*; $R = \{r_1, r_2, r_3, r_4\}$, they are expressions for all of the roles of Leader, Expert, Commander, Executor, *A* is Leader, *B* is Expert, *C* and *D* is Commander, *E, F, G* is Executor. So, the User Role Assign is: $URA = \{(u_1, r_1), (u_2, r_2), (u_3, r_3), (u_4, r_3), (u_5, r_4), (u_6, r_4), (u_7, r_4)\}$, and the Role Task Assign is: $RTA =$ $\{(r_1, wt_3), (r_2, wt_5), (r_3, wt_2), (r_3, wt_4), (r_4, wt_1), (r_4, wt_6), (r_4, wt_7)\}$.

There also have 3 constraints:

1) The user for task of Start order must be same as the one for Department verified, listed as $C_1 : must\_do(u, wt_4) \leftarrow (u, wt_2) \in C_{wt_4}$, C_{wt_i} is the set of constraints related to wt_i.

2) The user for task of Task suspension & end order must be same as the one for Final treatment, listed as: $C_2 : must\_do(u, wt_7) \leftarrow (u, wt_6) \in C_{wt_7}$.

The user for task of Final treatment can't be same as the one for Record received alarms, listed as: $C_3 : cannot\_do(u, wt_6) \leftarrow (u, wt_1) \in C_{wt_6}$.

4.2 AN EXAMPLE FOR EMERGENCY COMMAND WORKFLOW

The flow graph for emergency command is shown in Figure 1, there are 4 user-sets in 4 roles from left to right, and the emergency command is executed according to the arrow direction. At first, Record received alarm is executed by u_5 with r_4, this is step 1, then it will be executed according to the arrow direction. The users have fingers in emergency command is $u_5 \to u_3 \to u_1 \to u_3 \to u_2 \to u_6 \to u_6$, they finished 7 tasks methodically. Following is the detail calculative process:

1) Received alarms record: $EU\left(wt_1^1\right) = user\left(role\left(J_{WT}\left(wt_1^1\right)\right)\right) = user\left(role\left(wt_1\right)\right) = user\left(r_4\right) = \{u_5, u_6, u_7\}$,

where wt_1 is the task of Record received alarm. wt_1^1 is a task instance of wt_1, EU is users set which can executed wt_1^1. J_{WT} is a task mapping from one task instance to related task, which make each wt_i^k have the equal of $J_{WT}(wt_i^k) = wt_i$, $role\left(wt_i\right) = \left\{r \in R \middle| \left(r, wt_i\right) \in RTA\right\}$ is a role mapping function, it maps each wt_i to r_i; $user\left(r_i\right) = \left\{u \in U \middle| \left(u, r_i\right) \in URA\right\}$ is a user mapping function, it maps each r_i to u_i.

The task of Record received alarm can be executed by u_5, u_6 or u_7, in this example, it is executed by u_5;

2) Department verified: $EU\left(wt_2^1\right) = \{u_3, u_4\}$, in this example, it is executed by u_3;

3) Leader verified: $EU\left(wt_3^1\right) = \{u_1\}$, there is only one leader in this example, so it must be executed by u_1;

4) Start order: due to the constraint C_1, $EU\left(wt_4^1\right) = U\left(u, wt_2^1\right) = \{u_3\}$, so, in this example, it must be executed by u_3, U is the user who have executed wt_2^1;

5) Disposal action: $EU\left(wt_5^1\right) = \{u_2\}$, there is only one expert in this example, so it must be executed by u_2;

6) Final treatment: $C_3 : cannot\_do\left(u, wt_6\right) \leftarrow \left(u, wt_1\right) \in C_{wt_6}$, this constraint means the user who has done wt_1 is forbidden to executed wt_6, so on the basis of this constraint: $EU\left(wt_6^1\right) = user\left(role\left(J_{WT}\left(wt_1^1\right)\right)\right) - U\left(u, wt_1^1\right) = \{u_5, u_6, u_7\} - \{u_5\} = \{u_6, u_7\}$, in this example, it must be executed by u_6 or u_7, here let u_6 execute it;

7) Task suspension & end order: as C_2, $EU\left(wt_7^1\right) = U\left(u, wt_6^1\right) = \{u_6\}$, in this example, it must be executed by u_6.

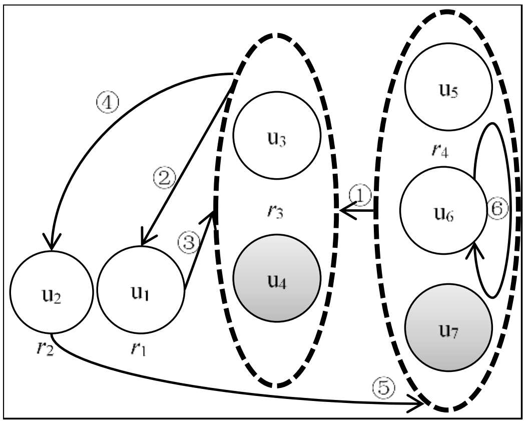

FIGURE 1 The flow graph for emergency command

4.3 DELEGATION IN EMERGENCY COMMAND WORK FLOW

In the above model, any actual task wt_i^k must be accomplished by one certain user u_j with correspond right. But when u_j is out or the tasks are too many for him to accomplish rapidly, wt_i^k will become the bottleneck of the whole wt^k, and because emergency flow is schedule dependent, the whole wt^k cannot be executed due to wt_i^k blocking, which will decrease the emergency command efficiency and acts inimical to safety of lives and property in water traffic. So, the delegation technology must be used in emergency command workflow model.

Theoretically, the delegation is not a model, it is just a very normal problem that needs to be resolved in actual application. If one task wt_i is assigned to user u, but he is too busy to accomplish, by the use of delegation technology, he can delegate wt_i to user u' to ensure the whole workflow can be done rapidly.

Delegation $\left(u, wt_i, u'\right)$ cannot be done successfully unless it can meet the following conditions, as in [9-12]:

1) The agent is not principal own: $u' \neq u$;

2) wt_i has not been delegated yet: $\left(u, wt_i, u'\right) \neq \varnothing$;

The agent and principal must all have operation right to wt_i: $role(wt_i) \in role(u)$ and $role(wt_i) \in role(u')$.

4.4 DELEGATION IN EMERGENCY COMMAND WORK FLOW

The workflow bottleneck is solved only to a certain extent through delegation technology, but because of some matters, the user u neither accomplish wt_i rapidly, nor delegate it to others (called No Answer), which will cause wt_i at a standstill, and it is very harmful to emergency command, and this can be solved by right transmission between users with different roles. According to Role Hierarchy relationship ($r_1 \succ r_2 \succ r_3 \succ r_4$), the system can automatically send wt_i ($role(wt_i) = r_j$) to $u'' \in user(r_{j-1})$ with higher level role, as in [13, 14]. The No Answer time *t* is fixed by the system administrator according to need of the actual condition.

As a general rule, there are enough users with r_4 that busy or "No Answer" condition may not come forth; and every emergency must be start the disposal order by leader with r_1, so at least one user with r_1 must be stand by to ensure emergency workflow be accomplished well.

Right transmission mainly be used between r_2 and r_3, when wt_2^k should be executed by one user with r_3, but it is not executed in *t*, the system will send it to one user with r_2, it will be executed by user with r_2, or when it is not executed in *t* either, wt_2^k will be executed by user with r_1 to ensure the emergency command be executed rapidly.

For the emergency command workflow in this special condition, the constraints of C_1, C_2 and C_3 can be not followed strictly, because in this condition, all the tasks that users with $r_{i+1} (0 < i < 2)$ should execute are done by user with r_i or even higher level role, which is very useful to ensure the emergency command be executed rapidly.

5 Task-role-based workflow authorization model

To achieve work process management, this system used the method of permission control and process state control to achieve distributed management for each node emergency command. Each module of the system used permission control, the user is unable to operate the module without related distributed permissions, and if the user has got related operation permission, the business trend is specified according to current "disposal status" flag of emergency. And different users with certain operation rights can get different emergency lists, as shown in Table 3.

1) Record received alarm: to record the emergency more rapidly, because there are many users with right to execute this task, all disposal status in one month is inquired without limited in default in this sub-module, at the same time, the received alarm record is saved and reported to management departments to ask for verifying.

TABLE 3 Emergency disposal status table

NO.	Sub-module	Disposal status should be inquired
1	Record received alarm	All status is inquired with no limited
2	Department verified	1.Reported 2.False alarm 3.Excluded
3	Leader verified	1.Reported
4	Start order	1.Reported 2.Started
5	Disposal action	1.Started
6	Final treatment	1.Started 2.Ended
7	Suspension & end order	1.Started 2.Reported 3.Suspended 4.Ended

2) Department verified: this sub-module is used for verifying the newest reported emergency information. In default, the records with status of "Reported", "False alarm" and "Excluded" in one month are inquired, while with others are not. After the alarm is verified by the management department, it can be judged whether the emergency is false alarm or not, and ascertain the dangerous situation is excluded or not.

3) Leader verified: this sub-module is used to inquire and treat verified and reported emergency from department. In default, the records with status of "Reported" in one month are only inquired, to make the leader to treat alarm and give order rapidly.

4) Start order: this sub-module is used to start emergency plan rapidly, and inquire the handling status of the started emergency. In default, the records with status of "Reported" and "Started" in one month are inquired, while other status is not.

5) Disposal action: this sub-module is used to inquire the solving emergency. In default, the records with the status of "Started" in one month are inquired, while with others are not.

6) Final treatment: in this sub-module, the records with status of "Started" and "Ended" in one month are inquired, while with other status is not. Only the emergency with above two mentioned status are final treated in this sub-module.

7) Suspension & end order: in this sub-module, the records with status of "Reported", "Started", "Suspended" and "Ended" in one month are inquired, while with other status are not. Any emergency action can be suspended or ended in this sub-module.

This paper used workflow technology to achieve emergency command subsystem of Three Gorges Reservoir tributaries water transport emergency command system, system interface is shown in Figure 2, in which the alarm record list can be seen, this list contain all records in one month without limited.

FIGURE 2 Emergency command subsystem

6 Conclusion

In this paper, according to the need of emergency command system for water traffic, a task-role-based emergency command workflow model is constructed by the use of workflow technology. Delegation technology and right transmission between roles is researched for properly application in this model, it can ensure smooth completion of emergency command process, improve the efficiency of emergency command, and have important significance in improving water emergency rapid command capability.

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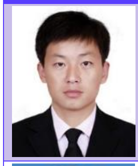

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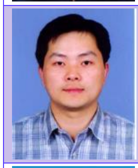

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