

Recovering from Malicious Tasks in Workflow Systems

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Presentation Organization

- What is a workflow?
- What can a malicious user do?
- How do we repair from malicious attacks?
- What will we do in future?

WHAT IS A WORKFLOW?

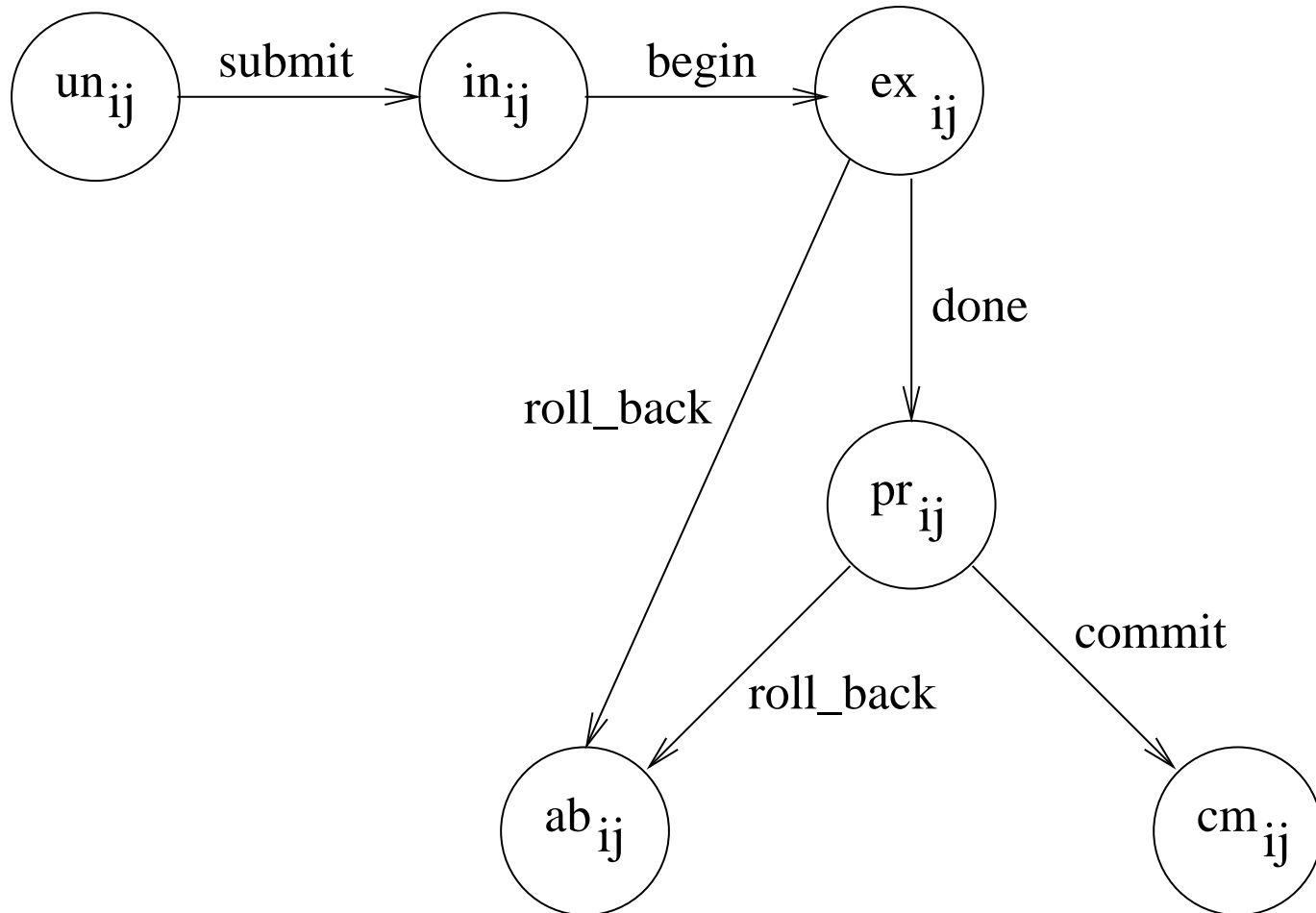
Workflow

- A workflow consists of set of tasks that together achieve some business objective
- Tasks in a workflow must be properly coordinated to ensure correct execution of the workflow
- Such co-ordination is achieved through dependencies
- A workflow is formally denoted as $W_i = \langle T, D, C \rangle$
 - T : set of tasks in the workflow
 - D : set of dependencies in the workflow
 - C : set of completion sets in the workflow

Workflow Tasks

- Workflow W_i consists of tasks $\{T_{i1}, T_{i2}, \dots, T_{in}\}$
- Each task T_{ij} performs a logical unit of work
 - It is executed atomically
 - Consists of data operations
 - read operations ($r_{ij}[x]$)
 - write operations ($w_{ij}[y]$)
 - Associated with primitives
 - Begin (b_{ij})
 - Abort (a_{ij})
 - Commit (c_{ij})

States of Task T_{ij}



Control Flow Dependencies

- A control flow dependency $T_{ki} \rightarrow T_{kj}$ specifies how the execution of primitives of task T_{ki} causes the execution of primitives of task T_{kj}
- Types of control flow dependencies
 - commit dependency, abort dependency, begin dependency,
 - begin-on-commit dependency, begin-on-abort dependency,
 - force-begin-on-begin dependency, force-begin-on-commit dependency,
 - force-begin-on-abort dependency, exclusion dependency

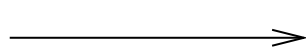
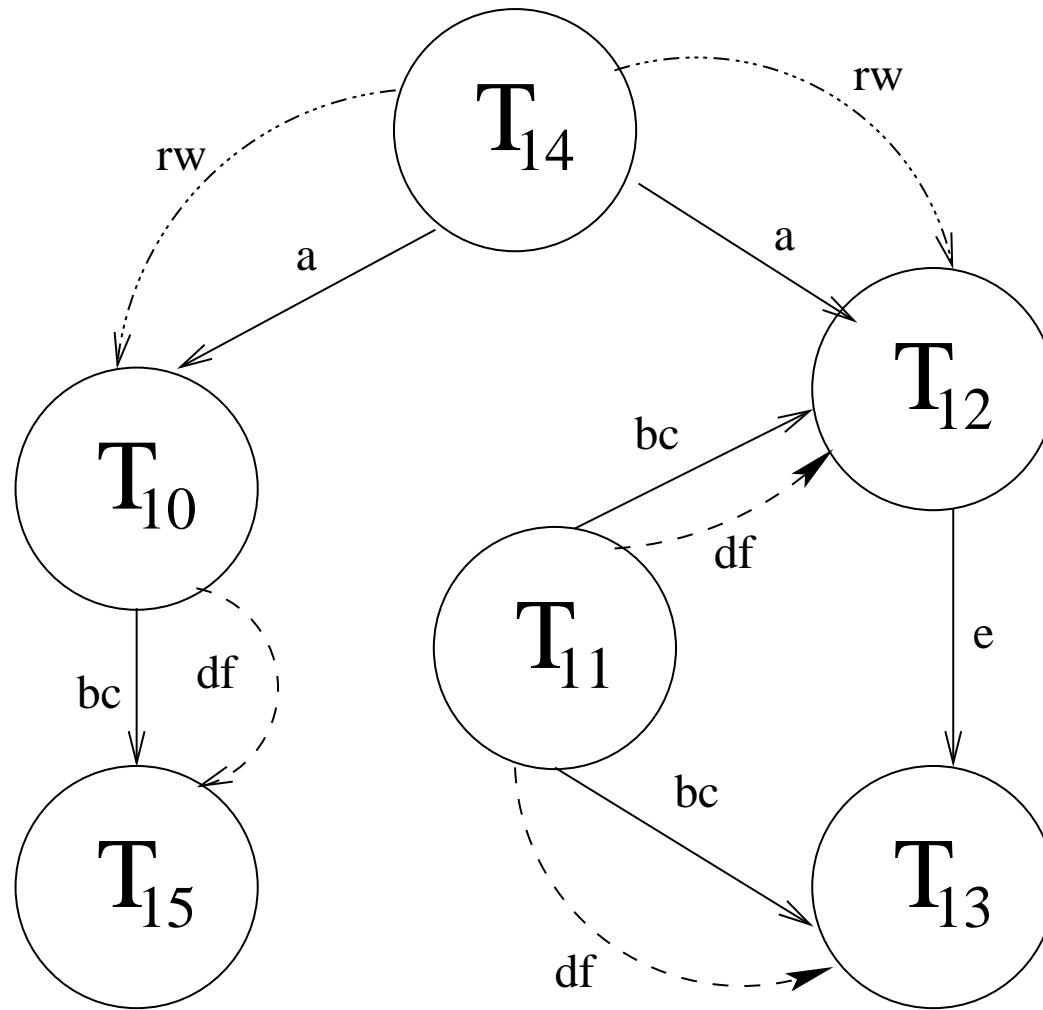
Data-Flow and Read-Write Dependencies

- A data-flow dependency $T_{ik} \rightarrow_{df} T_{ij}$ signifies that there is an output produced by task T_{ik} which is an input to task T_{ij}
- A read-write dependency $T_{kl} \rightarrow_{rw} T_{ij}$ signifies that there exists some data item x such that
 - T_{ij} reads x after T_{kl} has updated it
 - if any T_{pq} updates x after T_{kl} has updated x but before T_{ij} reads it, then T_{pq} is aborted

Example Workflow

- Tasks in the workflow
 - T_{10} : Reserve a car from Company B
 - T_{11} : Reserve a ticket on Airlines A
 - T_{12} : Purchase the Airlines A ticket
 - T_{13} : Cancel the airlines reservation
 - T_{14} : Reserve a room in Resort C
 - T_{15} : Cancel the car reservation
- Example completion sets
 - $\{T_{14}, T_{10}\}, \{T_{14}, T_{11}, T_{12}\},$
 - $\{T_{11}, T_{13}\}, \{T_{10}, T_{15}\}$

Example Workflow (2)



control flow dependency

WHAT IS THE PROBLEM?

Security of a Workflow

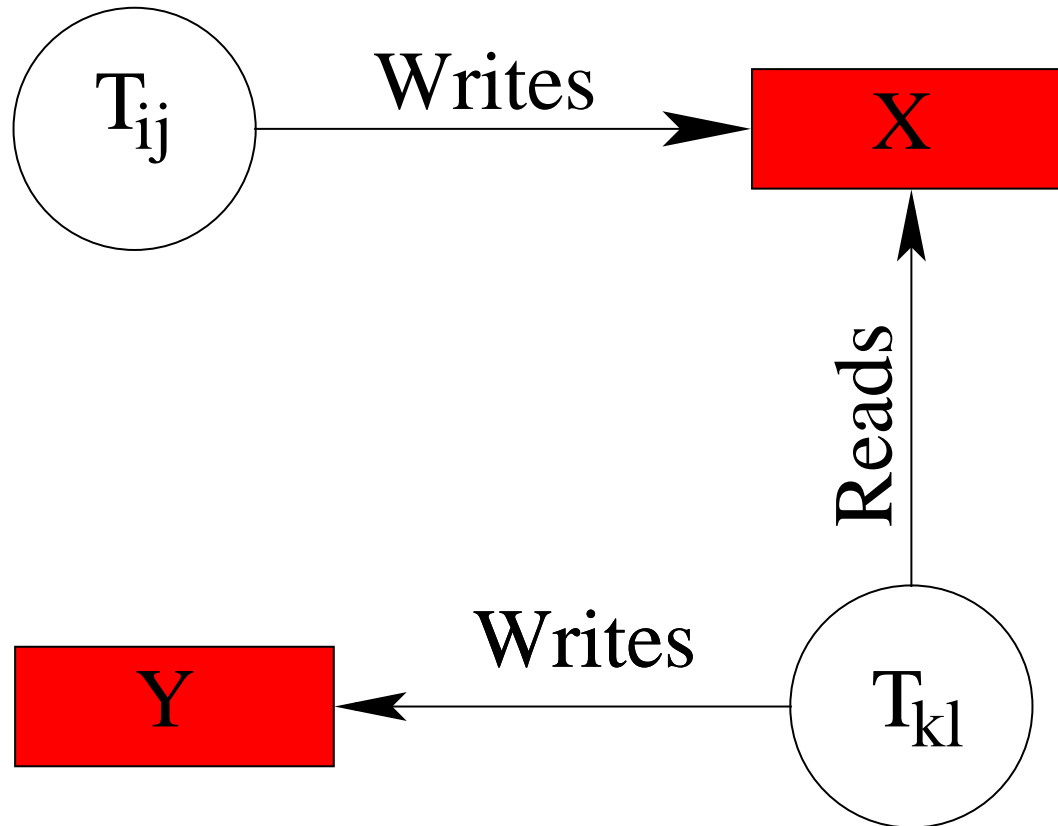
- Vulnerabilities cannot be completely eliminated from a system
- Preventive measures for protecting the system are not enough
- Workflow may be subjected to attacks
- Malicious user can create illegal tasks or execute corrupt tasks in a workflow
- *Malicious tasks* are the committed tasks submitted by attacker
- *Malicious workflow* contains at least one malicious task

Malicious Tasks

- Malicious tasks may corrupt database items
- Malicious tasks may trigger some other tasks
- Presence of dependencies help spread damage

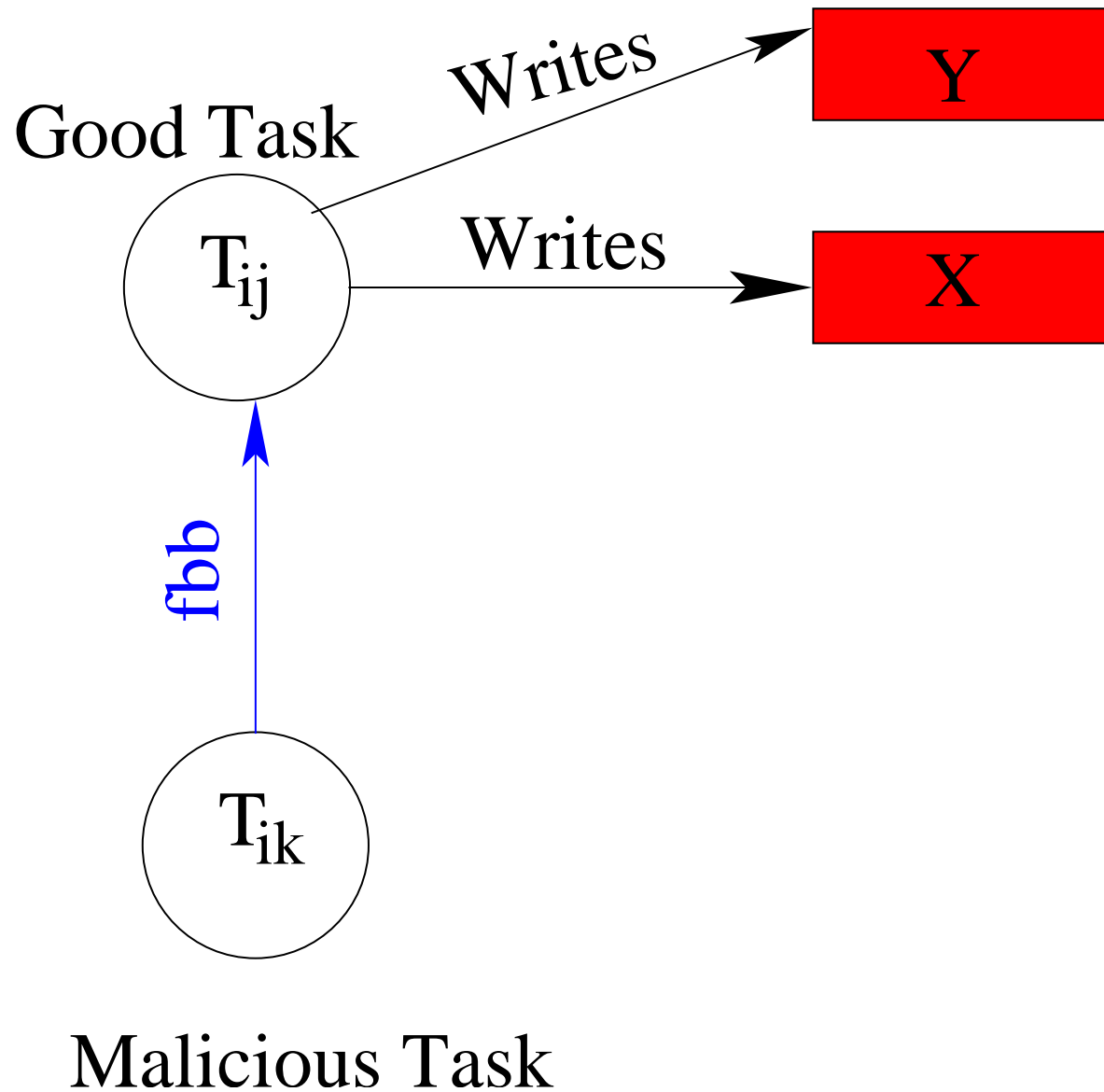
Corrupting Data Items

Malicious Task



Good Task

Dependencies Spreading Damage



HOW DO WE REPAIR FROM SUCH AN ATTACK?

Information needed for Repair

- Recovery algorithm needs to know
 - the actions that need to be performed during recovery
 - stored in the corresponding workflow schema
 - state of the workflow after some malicious attacks
 - stored in workflow log records
- All such information is stored in stable storage

Workflow Schema

- Workflow schema defines the type of a workflow
- Workflow is an instance of some workflow schema
- Workflow schema is specified by
 - types of inputs needed by workflow instances
 - types of outputs generated by workflow instances
 - specification of the types of tasks
 - dependencies between different types of tasks
 - set of completion sets for this type of workflow

Workflow Log Records

The following log records get written in stable storage

- Execution of begin primitive of workflow W_i :
 $\langle START\ W_i,\ WS_i \rangle$
- Execution of complete primitive of workflow W_i :
 $\langle COMPLETE\ W_i \rangle$
- Execution of begin primitive of task T_{ij} : $\langle START\ T_{ij} \rangle$
- Execution of abort primitive of task T_{ij} : $\langle ABORT\ T_{ij} \rangle$
- Execution of commit primitive of task T_{ij} : $\langle COMMIT\ T_{ij} \rangle$
- Execution of write operation $w_{ij}[X]$: $\langle T_{ij}, X, v, w \rangle$

Recovery Algorithm Overview

- Recovery algorithm proceeds in four phases
 - Phase 1: Undo malicious workflows
 - Phase 2: Find all affected tasks
 - Add good tasks that read corrupted data items to the list of affected tasks
 - Add tasks that are control-flow dependent on the affected tasks and which must be aborted to the affected list
 - Phase 3: Undo all the affected tasks
 - Phase 4: Resubmit the incomplete workflow to the scheduler

WHAT WILL WE DO IN FUTURE?

Conclusion and Future Work

● Contributions

- Malicious tasks in a workflow can cause damage
- Dependencies in a workflow help spread the damage
- Our algorithm
 - finds affected tasks to assess the damage
 - repairs the damage by undoing malicious and affected tasks
 - maintains dependencies during the recovery process

● Future Work

- Formalize the notion of correct execution and correct repair of a workflow
- Investigate how to recover from malicious transactions in other advanced transaction processing models