Advanced Transaction Processing

In this chapter, we go beyond the basic transaction processing schemes discussed previously, and cover more advanced transaction-processing concepts, including transaction-processing monitors, workflow systems, main-memory databases, real-time transaction systems, and handling of long-duration transactions by means of nested transactions, multi-level transactions and weak degrees of consistency. We end the chapter by covering weak degrees of consistency used to handle multidatabase systems.

This chapter is suited to an advanced course. The sections on TP monitors and workflows may also be covered in an introductory course as independent-study material.

Coverage of remote backup systems has been moved from this chapter to the chapter on recovery, while coverage of transaction processing in multidatabases has been moved into this chapter from its earlier position in the distributed database chapter.

Exercises

26.7 Explain how a TP monitor manages memory and processor resources more effectively than a typical operating system.

 Answer: In a typical OS, each client is represented by a process, which occupies a lot of memory. Also process multi-tasking over-head is high.

A TP monitor is more of a service provider, rather than an environment for executing client processes. The client processes run at their own sites, and they send requests to the TP monitor whenever they wish to avail of some service. The message is routed to the right server by the TP monitor, and the results of the service are sent back to the client.

The advantage of this scheme is that the same server process can be serving several clients simultaneously, by using multithreading. This saves memory space, and reduces CPU overheads on preserving ACID prop-

erties and on scheduling entire processes. Even without multi-threading, the TP monitor can dynamically change the number of servers running, depending on whatever factors affect good performance. All this is not possible with a typical OS setup.

26.8 Compare TP-monitor features with those provided by Web servers supporting servlets (such servers have been nicknamed *TP-lite*).

  Answer: Web application servers supporting servlets (as also Web application servers providing similar functionality through other language APIs) have many features of TP monitors. For example, they allow a single process, or a few processes, to serve a large number of requests by exploiting multi-threading. Systems built to handle large numbers of requests usually have routers that divide up incoming traffic between a large number of Web application servers. Web application servers typically lack a few features such as support for transaction coordination (using two-phase commit), which TP-monitors support, i although some application servers do have addon features that support transaction coordination.

26.9 Consider the process of admitting new students at your university (or new employees at your organization).

   a.   Give a high-level picture of the workflow starting from the student application procedure.

   b.   Indicate acceptable termination states and which steps involve human intervention.

   c.   Indicate possible errors (including deadline expiry) and how they are dealt with.

   d.   Study how much of the workflow has been automated at your university.

Answer:

   a.   Students typically apply online to the university. Once they have filled in all details of their form, they submit it, and pay application fees. The fee payment is itself a sub-workflow, involving an external party such as a credit card company or bank, and possibly a third-party payment gateway as an intermediary to the credit card company or bank.

      At this point the university has to process the form. The first step of processing by the university is to check that the applications are complete; if anything is incomplete, the student has to be informed and given a chance to correct the form. Typically there is date for starting the decision process; all forms received up to that date are taken together, and after filtering on some criteria, and inputs from various people involved in the admission process, an admission decision is made. Subsequently forms may be placed in accepted, rejected, or wait-listed state.

This decision is conveyed back to students. The notification is done by email and SMS, and the deliver of email/SMS can itself be considered as an automated workflow since it involves external services, with persistent message delivery queues.

b. Acceptable termination states include: student admitted and student rejected; intermediate states may include student wait-listed, which will eventually end up in either admitted or reject state. The eventual decision on admission or rejection (or temporary wait-listing) will require human decisions. Applications may be rejected early if some requirements are not met, such as application fees not paid, without human intervention.

c. At IIT Bombay, as in most institutions today, applications, including fee payment are online and automated. Humans are involved in the decision making process, but there is a fair degree of bulk processing, for example cutoff marks are specified for standardized exams, and all students below the cutoff are automatically rejected. Once the decision is made, the notification by email/SMS is itself a workflow, which is automated.

26.10 Answer the following questions regarding electronic payment systems:

a. Explain why electronic transactions carried out using credit-card numbers may be insecure.

b. An alternative is to have an electronic payment gateway maintained by the credit-card company, and the site receiving payment redirects customers to the gateway site to make the payment.

   i. Explain what benefits such a system offers if the gateway does not authenticate the user.

   ii. Explain what further benefits are offered if the gateway has a mechanism to authenticate the user.

c. Some credit-card companies offer a one-time-use credit-card number as a more secure method of electronic payment. Customers connect to the credit-card company's Web site to get the one-time-use number. Explain what benefit such a system offers, as compared to using regular credit-card numbers. Also explain its benefits and drawbacks as compared to electronic payment gateways with authentication.

d. Does either of the above systems guarantee the same privacy that is available when payments are made in cash? Explain your answer.

Answer:

a. Credit card numbers can be easily stolen by someone who handles the card (for offline transactions) or may be stolen in bulk from computers where they are stored in (online) shops where a purchase was made. Some who has got the number (including verification

numbers such as the widely used CVV number) can make purchases online using these numbers.

b. i.   Even if the gateway does not authorize the user, as long as the user can check the authenticity of the gateway (using HTTPS protocol certificates), the user knows that the credit card numbers are only handled by a trusted party; the site receiving the payment never gets to even see the card number.

ii. If the gateway further authenticates the user, using additional passwords (usually this is done by further redirecting the user to the bank which issued the credit card, so the user need not trust the gateway with passwords), even someone who has access to the credit card number cannot make online purchases using the credit card. Such authentication is mandatory for online payments in some countries.

c. One-time-use credit card numbers cannot be used again, so even if it is stored at the site receiving the payment, and subsequently compromised, it cannot be used to make any further purchases online. Thus, it has similar benefits to a system using authentication. However, its drawback is that the user has to perform extra actions to get a one-time-use number.

d. With cash, it is quite possible to make completely anonymous purchases, with complete privacy. None of the above systems guarantees the same privacy as cash. First, the credit card company knows who you bought things from, so there is not question of a fully anonymous purchase. Second, even though your identity can be concealed from the site where you make a purchase, law enforcement officials can get information from both the site and the credit card company, compromising your privacy completely.

26.11   If the entire database fits in main memory, do we still need a database system to manage the data? Explain your answer.
    Answer: Even if the entire database fits in main memory, a DBMS is needed to perform tasks like concurrency control, recovery, logging etc, in order to preserve ACID properties of transactions.

26.12   In the group-commit technique, how many transactions should be part of a group? Explain your answer.
    Answer: As log-records are written to stable storage in multiples of a block, we should group transaction commits in such a way that the last block containing log-records for the current group is almost full.

26.13   In a database system using write-ahead logging, what is the worst-case number of disk accesses required to read a data item from a specified disk page. Explain why this presents a problem to designers of real-time database systems. Hint: consider the case when the disk buffer is full.

Answer: In the worst case, a read can cause a buffer page to be written to disk (preceded by the corresponding log records), followed by the reading from disk of the page containing the data to be accessed. This takes two or more disk accesses, and the time taken is several orders of magnitude more than the main-memory reference required in the best case. Hence transaction execution-time variance is very high and can be estimated only poorly. It is therefore difficult to plan schedules which need to finish within a deadline.

26.14 What is the purpose of compensating transactions? Present two examples of their use.

Answer: A compensating transaction is used to perform a semantic undo of changes made previously by committed transactions. For example, a person might deposit a check in their savings account. Then the database would be updated to reflect the new balance. Since it takes a few days for the check to clear, it might be discovered later that the check bounced, in which case a compensating transaction would be run to subtract the amount of the bounced check from the depositor's account. Another example of when a compensating transaction would be used is in a grading program. If a student's grade on an assignment is to be changed after it is recorded, a compensating program (usually an option of the grading program itself) is run to change the grade and redo averages, etc.

26.15 Explain the connections between a workflow and a long-duration transaction.

Answer: A long-duration transaction is still expected to finish within the time of a user interaction, whereas a workflow may last for a very long time. Long duration transactions can be aborted at any point, whereas a workflow cannot simply be rolled back, instead it has to be moved to an acceptable termination state.