Assignment 1

- Due: January 12, 1999. Please put your e-mail address and daytime phone number on your solution set.
- In order of decreasing preference, please email your solution to nspring@cs.washington.edu and philbe@microsoft.com, bring it to class on a floppy disk, or bring hard copy. See Course Information handout for policy on late assignments.
- Read Chapter 1 of the textbook.

Problem 1

Perfect is a highly reliable storage device with built-in battery backup. It supports two operations:

- PerfectRead(StorageAddr, MemoryAddr) – read the contents of storage location StorageAddr in Perfect into main memory location MemoryAddr
- PerfectWrite(StorageAddr, MemoryAddr) – copy the content of main memory location MemoryAddr into storage location StorageAddr in Perfect

Each operation either succeeds in its entirety and returns SUCCESS or has no effect and returns FAIL.

VerySimple is a database system that uses the Perfect device. VerySimple executes operations one at a time (so no synchronization of parallel threads is needed). It offers the following operations:

- Start(t) - Start a new transaction and return a transaction identifier $t > 0$, which is different from the transaction identifier of any other active transaction. (A transaction is *active* if it has been created by a Start operation and has not yet executed a Commit or Abort operation.)
- Commit(t) - commit transaction t
- Abort(t) - abort transaction t
- Read(StorageAddr, MemoryAddr, t) – read the contents of storage location StorageAddr into main memory location MemoryAddr on behalf of transaction t.
- Write(StorageAddr, MemoryAddr, t) – copy the content of main memory location MemoryAddr into storage location StorageAddr of XYZ on behalf of transaction t.

Some properties of Perfect and VerySimple:

a. A VerySimple transaction is an ordinary application program whose first operation is Start, whose last operation is Commit or Abort, and which has some Read and Write operations sprinkled throughout the program.
b. An application program can only use VerySimple operations to access the content of Perfect. VerySimple uses 2N+1 storage locations in Perfect for its own purposes. These storage locations are not accessible via Read and Write operations. One of the 2N+1 storage locations contains the Active Transaction ID. The other 2N locations store backup values of (up to) N updated storage locations. For each updated storage location, the address and old value are stored as a pair <BackupAddr, BackupValue>, occupying two locations.
c. A transaction may update no more than N storage locations.
d. If VerySimple gets an operation request when the storage device is inaccessible, it returns an error.
e. If VerySimple crashes when an operation is running, the caller will time out waiting for a response and should assume the operation had no effect.
f. After VerySimple is launched, it invokes its Recover operation before executing any user operations.
g. VerySimple is a server program that is shared by all client applications. There is only one copy of VerySimple operating for a given Perfect device.
h. An operating system failure never affects the content of Perfect.
i. A power failure never affects the content of Perfect.

The implementation of VerySimple's operations are as follows:

Read(StorageAddr, MemoryAddr, t):

i. If (the Active Transaction ID $\neq$ t) then { when Active Transaction ID = 0, set it to t }
   (I.e., If Active Transaction ID $\neq$ t, block the caller until it can be set to t.)
ii. Perform the Read operation

Write(StorageAddr, MemoryAddr, t):
i. If (the Active Transaction ID ≠ t) then { when Active Transaction ID = 0, set it to t }
ii. If t has already updated N storage locations, then return with an error.
iii. Add <StorageAddr, Content(StorageAddr)> to the backup area
iv. Copy the content of main memory location MemoryAddr into storage location StorageAddr

Commit(t):
i. If Active Transaction ID ≠ t, then return with an error.
ii. Clear the backup area
iii. Set the Active Transaction ID in Perfect to zero.

Abort(t):
i. For each pair <A, B> in the backup area, copy B into storage location A.
ii. Clear the backup area
iii. Set the Active Transaction ID in Perfect to zero.

Recover
i. If the Active Transaction ID > 0, then call Abort(Active Transaction ID).
ii. Set Active Transaction ID in Perfect to zero.

Questions:
A. For each of the ACID properties, either explain why VerySimple transactions satisfy the property or show a counterexample where it does not satisfy the property.
B. Redo your answer to (1) assuming that step (i) of Read is deleted.
C. What goes wrong if property (g) is dropped? Does VerySimple now violate an ACID property?
D. If property (h) is dropped, then step (i) of Read and Write must execute within a critical section, to ensure two transaction don't become active at the same time. What else goes wrong if property (h) is dropped?
E. Why is step (i) of Commit needed? (Hint: consider a failure of VerySimple.)

Problem 2

In this problem, we will explore the different styles of system that may be relevant to applications associated with an airline reservation system. It is well known that the reservation application itself requires TP functionality, since reservation requests must be ACID transactions, the system must be highly reliable and available, etc. But what about the following related applications?

a) Plan and produce a flight schedule (i.e., routes, departure times) for next year, to maximize revenue subject to the available equipment, airport space, airplane maintenance capacity, and crew availability.
b) Process a customer's request for mileage credit in the airline's mileage award program. (I.e., a customer forgot to give his or her mileage program ID number to the agent when taking the flight, and therefore submits a copy of the ticket and boarding pass afterwards to get mileage award credit.)
c) Get today's flight arrival and departure times in a given city, taking into account the latest information about weather or equipment delays, early arrivals, etc.
d) Update the reservation system's database with a given large set of pricing changes. (Across all airlines, there are millions of pricing changes per week.)
e) Submit a complaint at the airline's web site.
f) Show the current airplane location, outdoor temperature, altitude, flight time so far, and estimated time of arrival on a display on an airplane.

For each application, is a TP system the best style of system to implement it?

- If so, explain why
- If not, then explain why not, and suggest one or more other types of system would be more appropriate and why.