Outline

- *The Case for Non-transparent Replication: Examples from Bayou* Douglas B. Terry, Karin Petersen, Mike J. Spreitzer, and Marvin M. Theimer. IEEE Data Engineering, December 1998

ACID Transaction

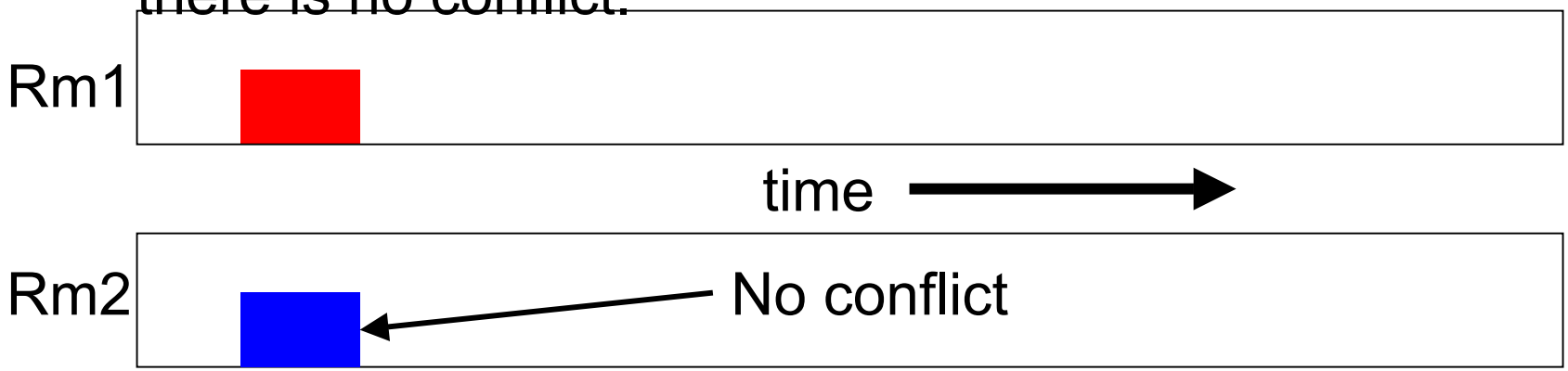
- Transaction has to show up everywhere at the same time or not at all.
  - E.g. when you withdraw cash from your ATM machine, the balance should reflect the actual money left. If it doesn't, then you could go back to a store, use your ATM card and withdraw cash that you do not have
  - E.g. when you make your Airline reservation and the system assigns you a seat, you expect the seat to be available to you (of course, Airlines overbook)
  - E.g. When students register at OASIS, it has to register enough students (upto the class limit)

Replication and Availability

- Replication is a powerful tool that allows us to tradeoff availability for consistency
- Applications need different levels of consistency
- Applications know best on how to deal with inconsistency

Application 1: Meeting room scheduler

- Suppose we have two conference rooms of the same capacity. I want to schedule my meeting in one of the conference rooms. I don't care which exact room it is.
  - If two people reserve the same room at the same time, there is a conflict, but if they reserve the same room at different times or reserve different rooms at the same time, there is no conflict.



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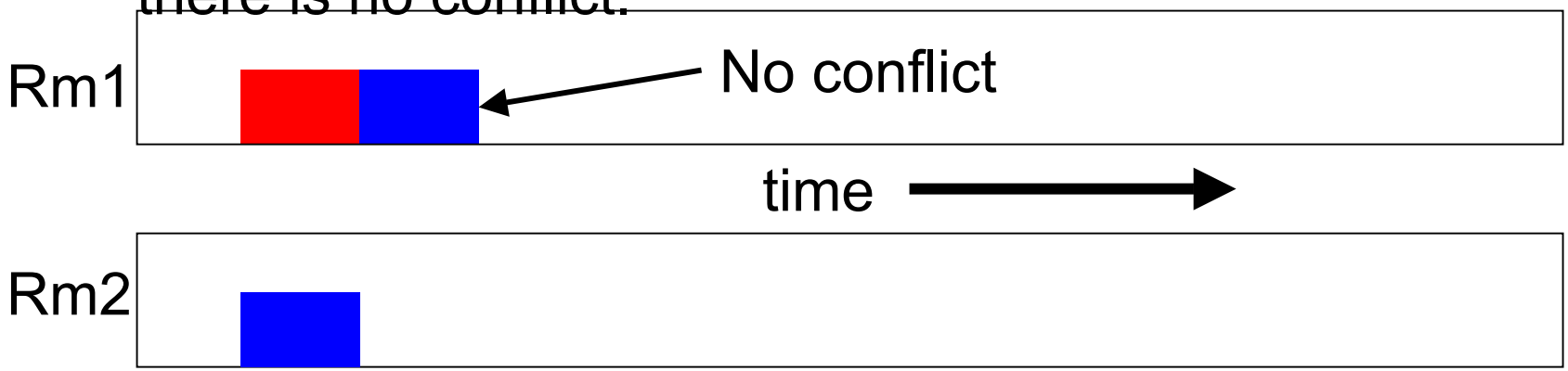

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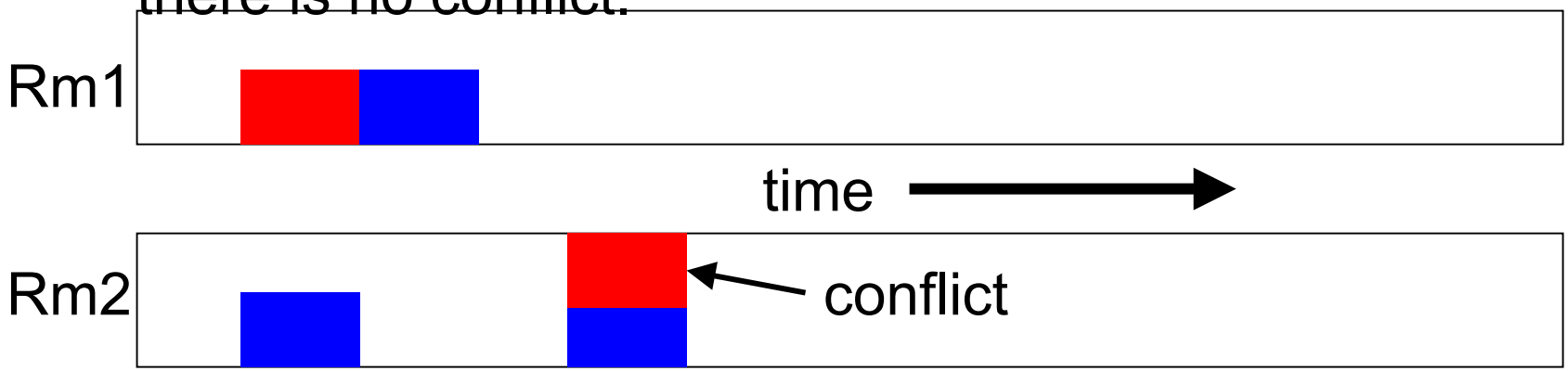
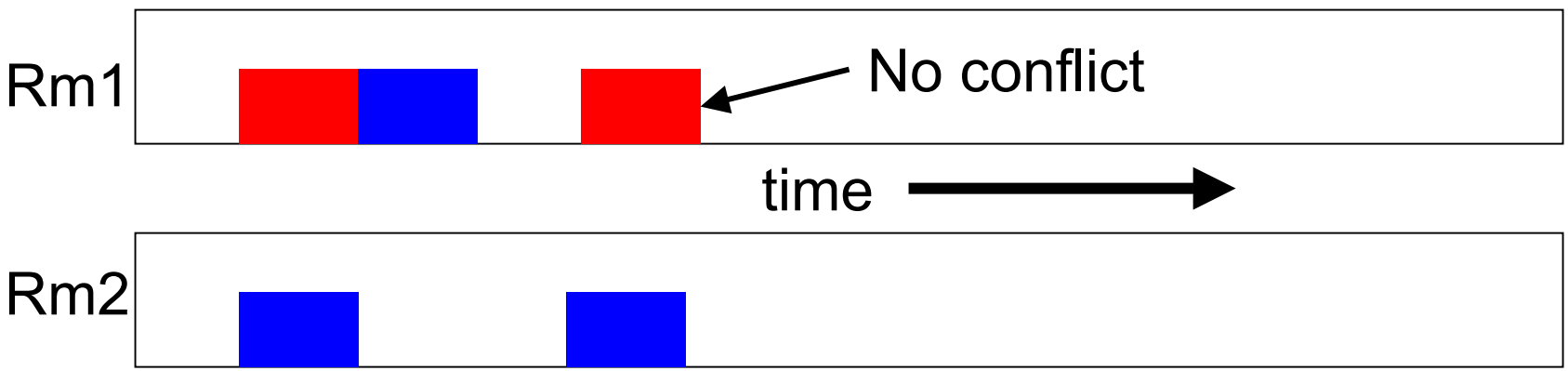


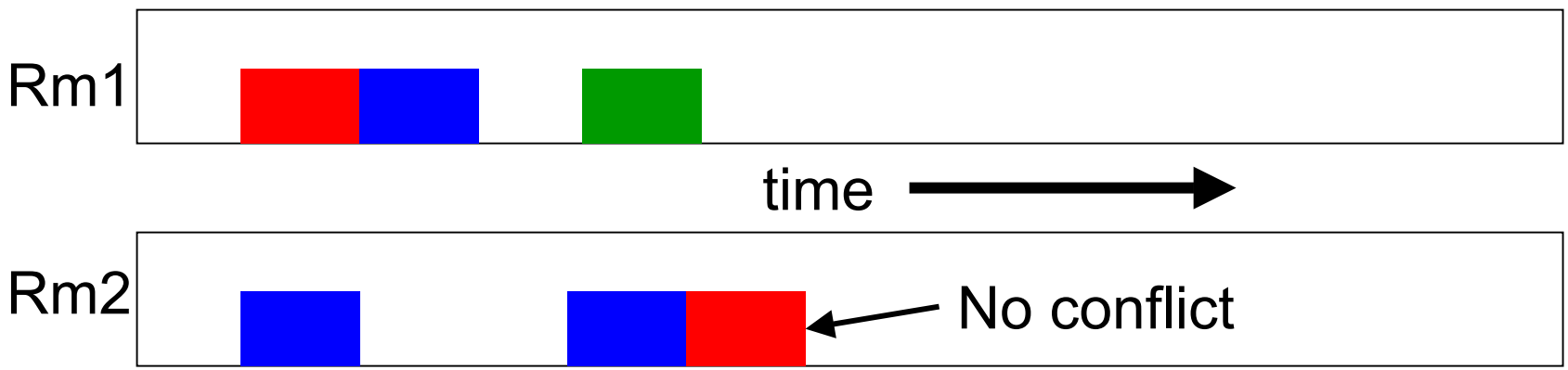
Application 1: Meeting room scheduler

- We can lock the entire database
  - Not needed when there is no conflict
  - In the case of conflicts, there is an application specific way to deal with the conflict – we move one reservation to the other room.

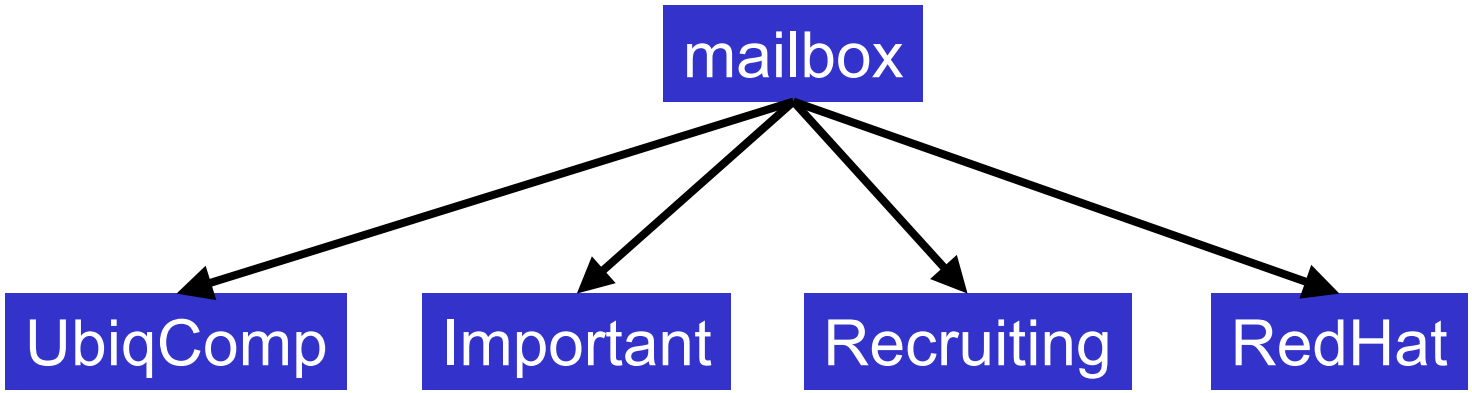


Application 1: Meeting room scheduler

- We can lock the entire database
  - Not needed when there is no conflict
  - In the case of conflicts, there is an application specific way to deal with the conflict – we move on reservation to the other room
  - If the other room is reserved, we ask the user, they can easily move the reservation to another acceptable time



Application 2: Shared mailbox



- Shared mailbox folders- shared between, me, my TA, my secretary
- We all replicate the mailbox.
  - OP1: I see a mail from the class, respond to it and delete it
  - OP2: The TA sees the same mail and files it in UbiqComp
  - OP3: I see a mail from my wife and file it in important

Application 2: Shared mailbox

- All of us operate on the same mailbox
- You can lock the entire mailbox before we operate
  - Can't work when disconnected
  - Clearly not necessary for operation OP1 or OP2 and OP3
  - For operation OP1 and OP2, it is no clear who should win, should the mail be deleted or should it be filed in UbiqComp?

Two approaches to building replicated services

- Transparent replication system:
  - Allow systems that were developed assuming a central file system or database to run unchanged on top of a strongly-consistent replicated storage system (e.g. Harp)

- Non-transparent replication system:
  - Relaxed consistency model – access-update-anywhere
  - Applications involved in conflict detection and resolution. Hence applications need to be modified (e.g. Bayou, Coda file system etc)

Hypothesis

- Applications know best on how to resolve conflicts
- Challenge is providing the right interface to support cooperation between applications and their data managers
  - Programmers do not want to deal with propagating updates, ensuring eventual consistency
    - Anyone who has synchronized the project files in school, work, and home can feel the pain..
  - Programmers want to set replication schedules and control how conflicts or detected and resolved
    - Record level conflict detection rather than file level

Bayou

- Update-anywhere replication model:
  - Bayou manages databases that can be fully replicated at any number of sites
  - Applications can read and write to any single replica of the database (lazy group update)
  - Once a replica accepts a write operation, this write is performed locally and propagated to all other replicas via pair-wise reconciliation protocol

Bayou Write

3-tuple: <update><dependency check><mergeproc>

For example,

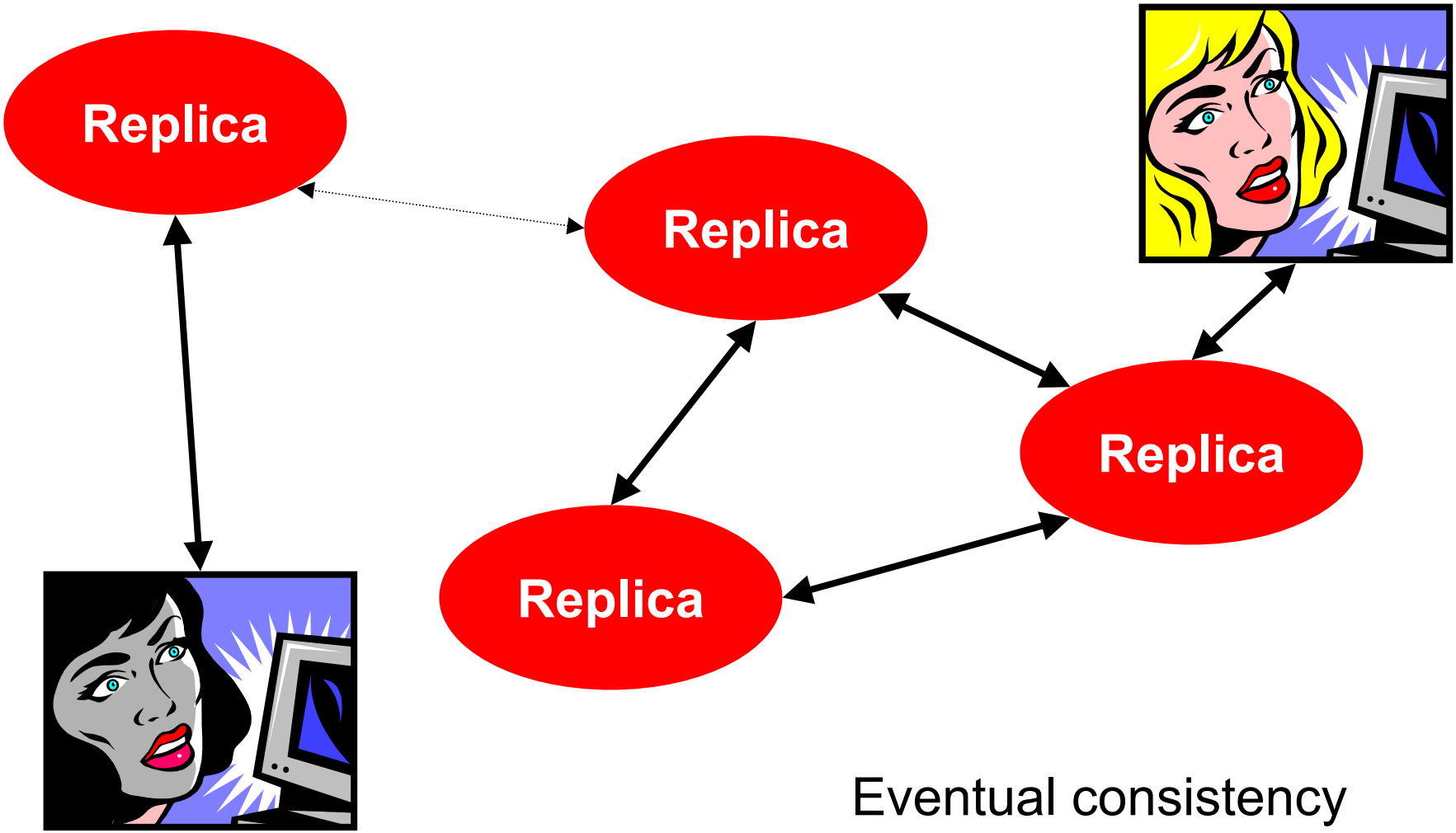
Update: <insert, Boyd527, 2/17/2002, 11:15am, 50min, “Ubiquitous Computing”>

Dependency check: <Is there an entry in Boyd527 database on 2/17/2002 at 11:15am for 50 min? expected answer is empty>

Mergeproc: <Try 2/17/2002 at 12:15pm for 50min; if successful write that tuple>

- sometimes users like conflicts

Pair-wire reconciliation



Eventual consistency

Global commit order assigned by Primary server

Replica management

- New replicas are cloned from existing replicas
- Information about new replicas propagate with normal writes (“creation write”)
- Information about retired replicas also propagate with normal writes (“retirement write”)
- Replicas are created by users or sys. Admins.
- Replication schedule is controlled by users
- Sometimes users want to choose specific replicas
- Tentative and committed data
  - Applications can choose to read tentative or committed data

Technology impact

- TrueSync - end-to-end synchronization software and infrastructure solutions for the wireless Internet
  - http://www.starfish.com/

- SyncML - SyncML is the common language for synchronizing all devices and applications over any network.
  - Ericsson, IBM, Lotus, Motorola, Nokia, Palm Inc., Psion, Starfish Software etc. (614 companies)
  - http://www.syncml.org/

Discussion