Treadmarks
Shared Memory Computing on Networks of Workstations

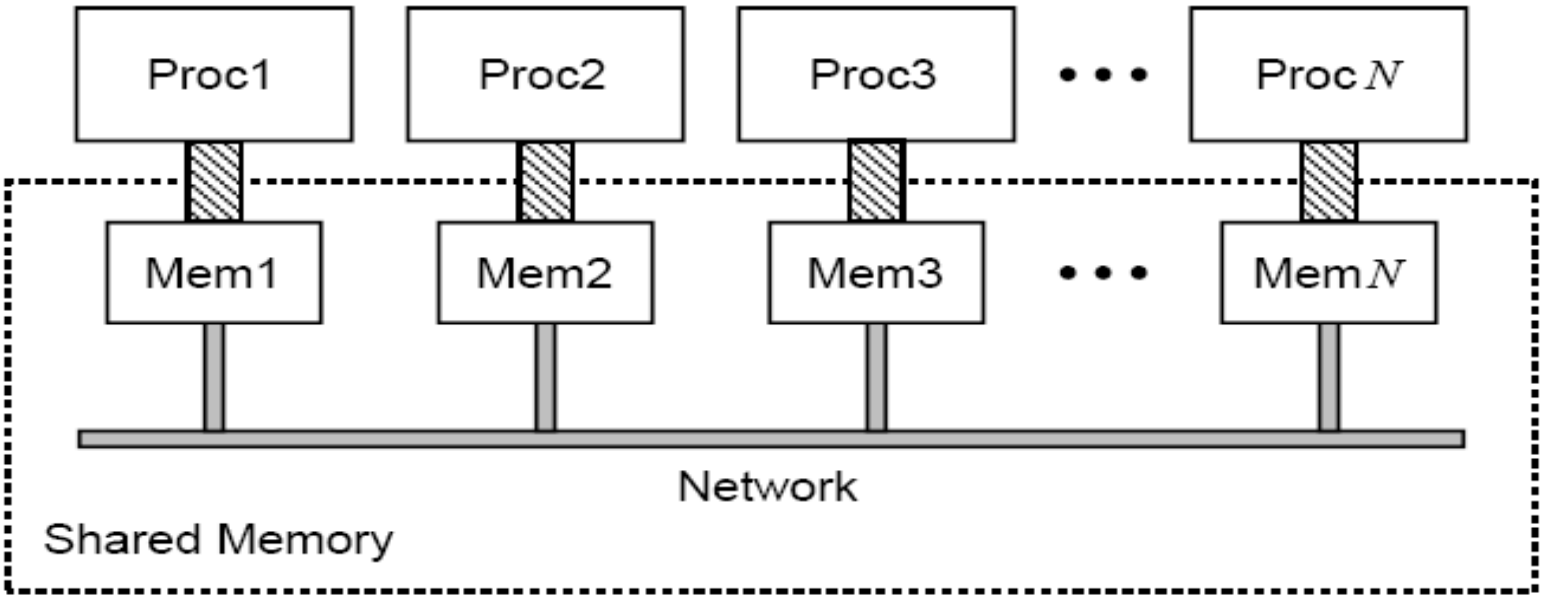
Hongzhou Zhao

2007/3/21

- Distrbuted shared Memory System

- Consist of N networked workstations, each with its own memory, connected by a network

- A global shared virtual memory rather than a collection of distributed address space



- Key design features

- Memory consistency model

Relaxed consistency model: lazy release consistency

- Virtual Memory Page Protection

Virtual memory hardware to detect access, use multiple writer protocol

- Application Programming Interface

Synchronization, critical sections

Use of barrier, lock

- Treadmark C interface

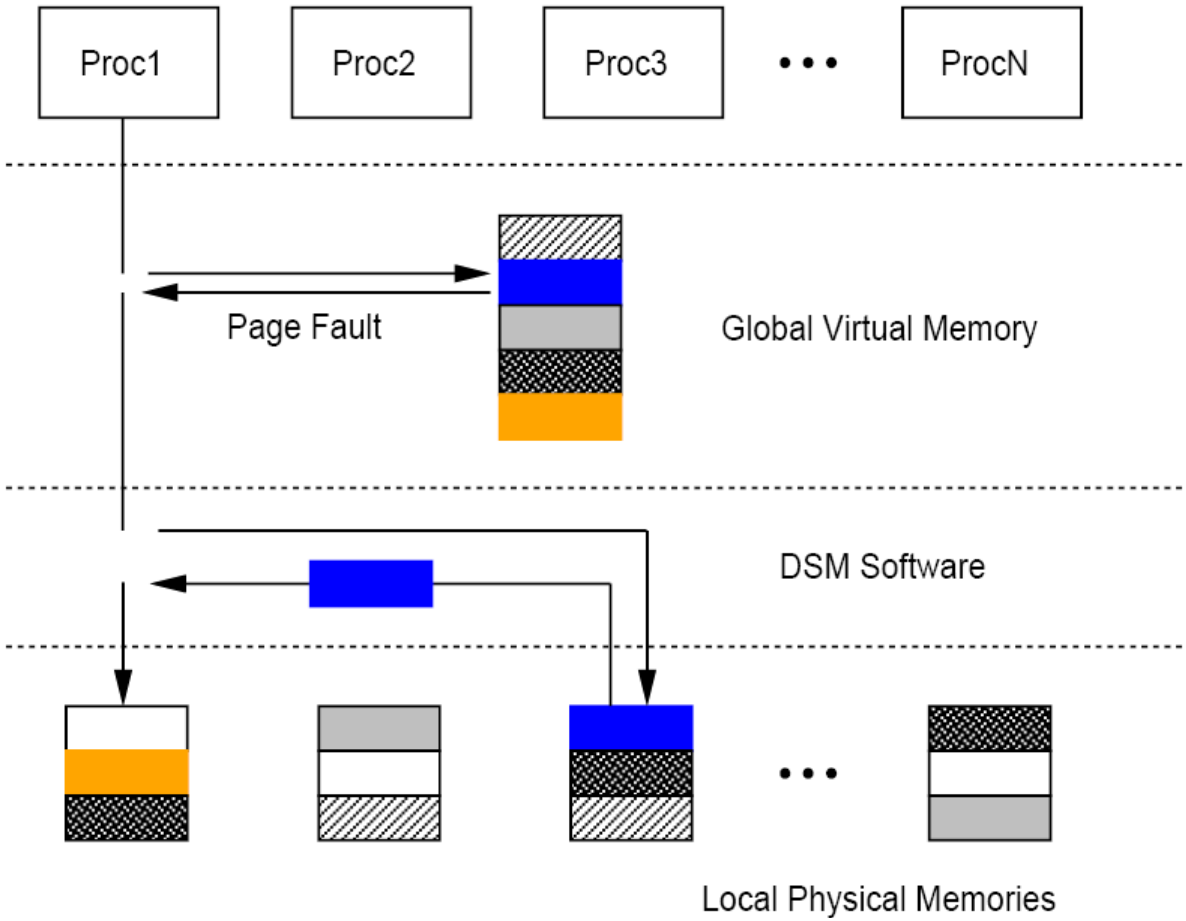
```
#define TMK_NPROCS
extern unsigned Tmk_nprocs;
extern unsigned Tmk_procid;
#define TMK_NLOCKS
#define TMK_NBARRIERS
void Tmk_startupint ( int argc char **argv);
void Tmk_exit( int status);
void Tmk_barrier(unsigned id);
void Tmk_lock_acquire(unsigned id);
void Tmk_lock_release(unsigned id);
char *Tmk_malloc(unsigned size);
void Tmk_free(char *ptr);
```

- Example – Jacobi

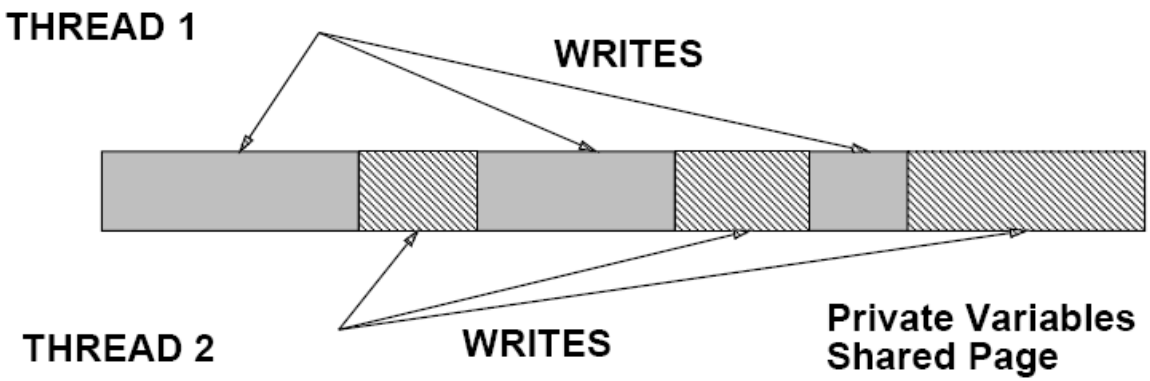
```
length = M / Tmk_nprocs;
begin = length * Tmk_proc_id;
end = length * (Tmk_proc_id+1);

for( number of iterations ) {

    for( i=begin; i<end; i++ )
        for( j=0; j<N; j++ )
            scratch[i][j] = (grid[i-1][j]+grid[i+1][j]+
                             grid[i][j-1]grid[i][j+1])/4;

    Tmk_barrier(1);

    for( i=begin; i<end; i++ )
        for( j=0; j<N; j++ )
            grid[i][j] = scratch[i][j];

    Tmk_barrier(2);

}
```

- Problems with sequential consistency model

First DSM system, IVY



- simplicity and intuitive
- unnecessary communication cost
  - send a message involves trap into OS kernel
  - only the processor acquire the lock need to be invalid
- false sharing
  - unrelated data loacated in the same page
  - due to page size, a serious problem
  - ping-pong effect

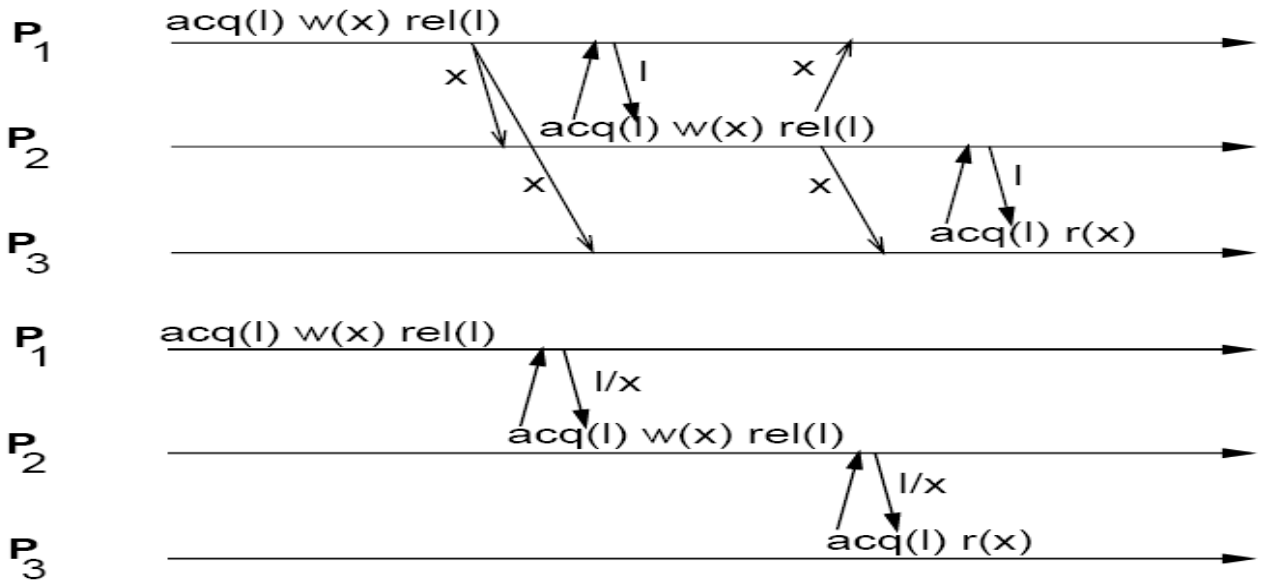


- Release Consistency

memory update by p become visible to q only when a subsequent release by p become visible to q

- Lazy Release Consistency

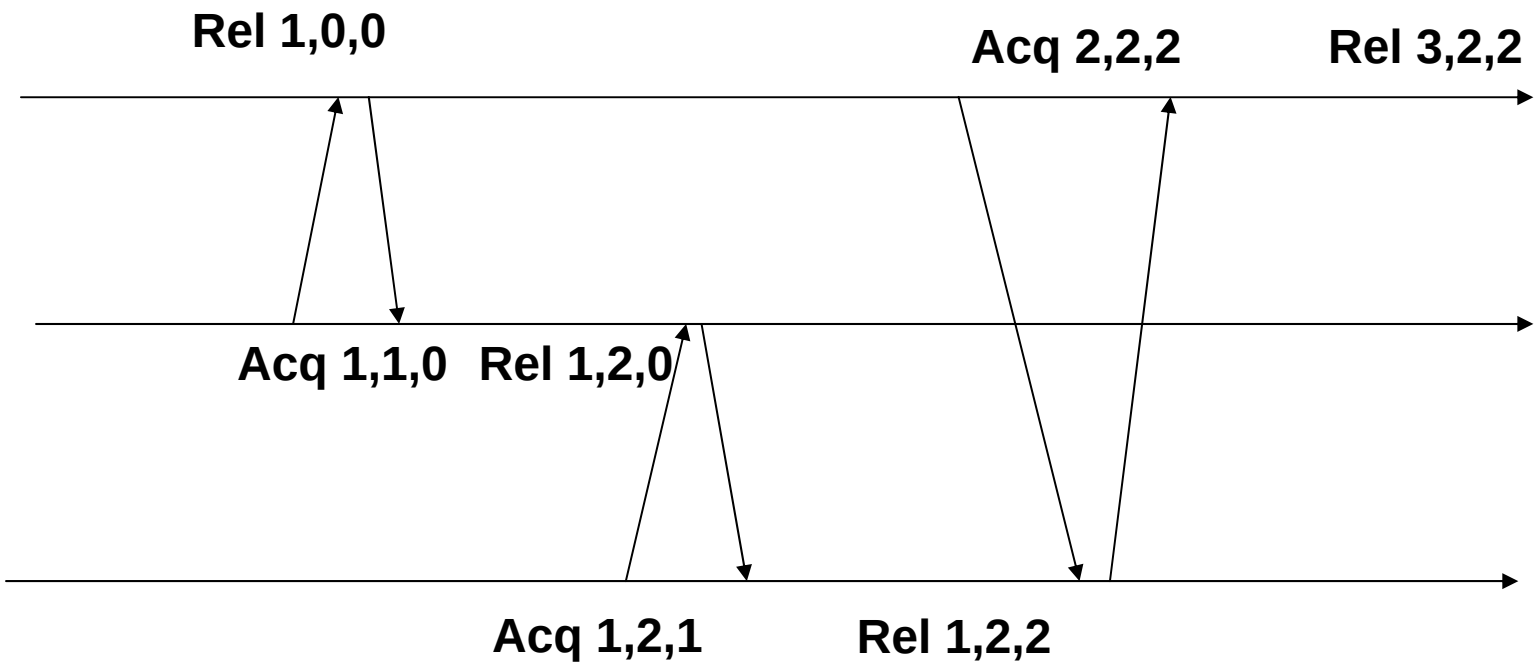
Eager/ lazy release consistency – at release/ acquire



- Lazy Release consistency Implementation

- divide execution of each process into interval

- use vector timestamp



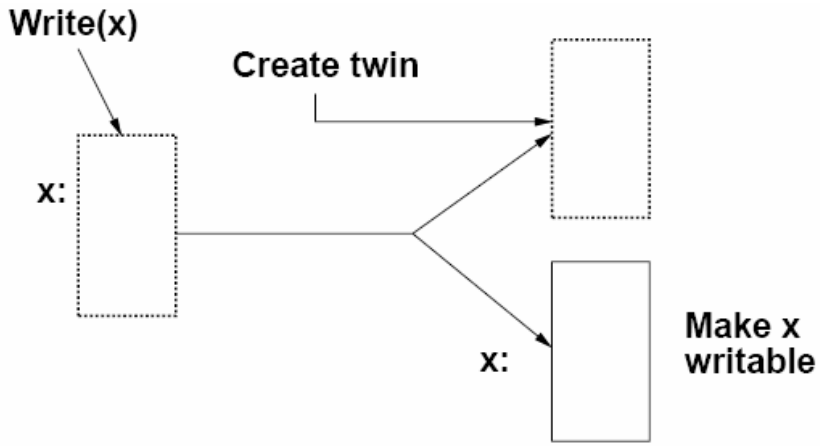
q piggy back message with write notice for all intervals in current vector without from requester p

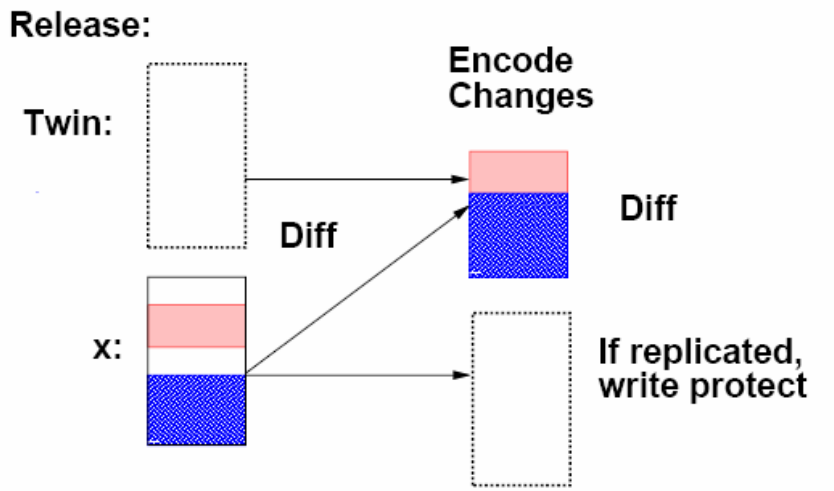
- multiple-writer protocol

-create a local twin copy when write

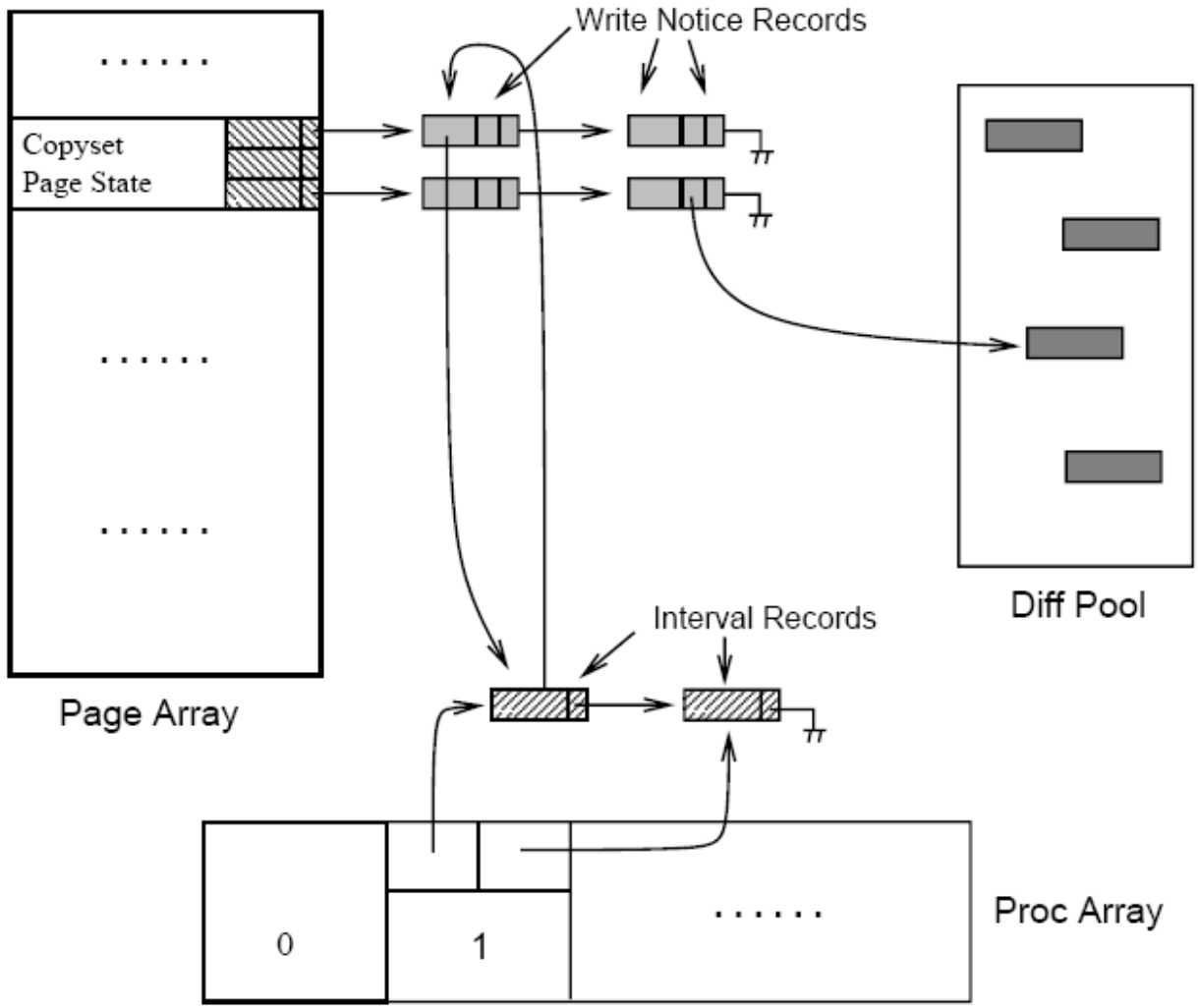
-compare word-by-word and create a diff at barrier

-when multi-writer synchronized, modify is informed to processor, when page accessed later, page fault happen, and page is updated applying diff

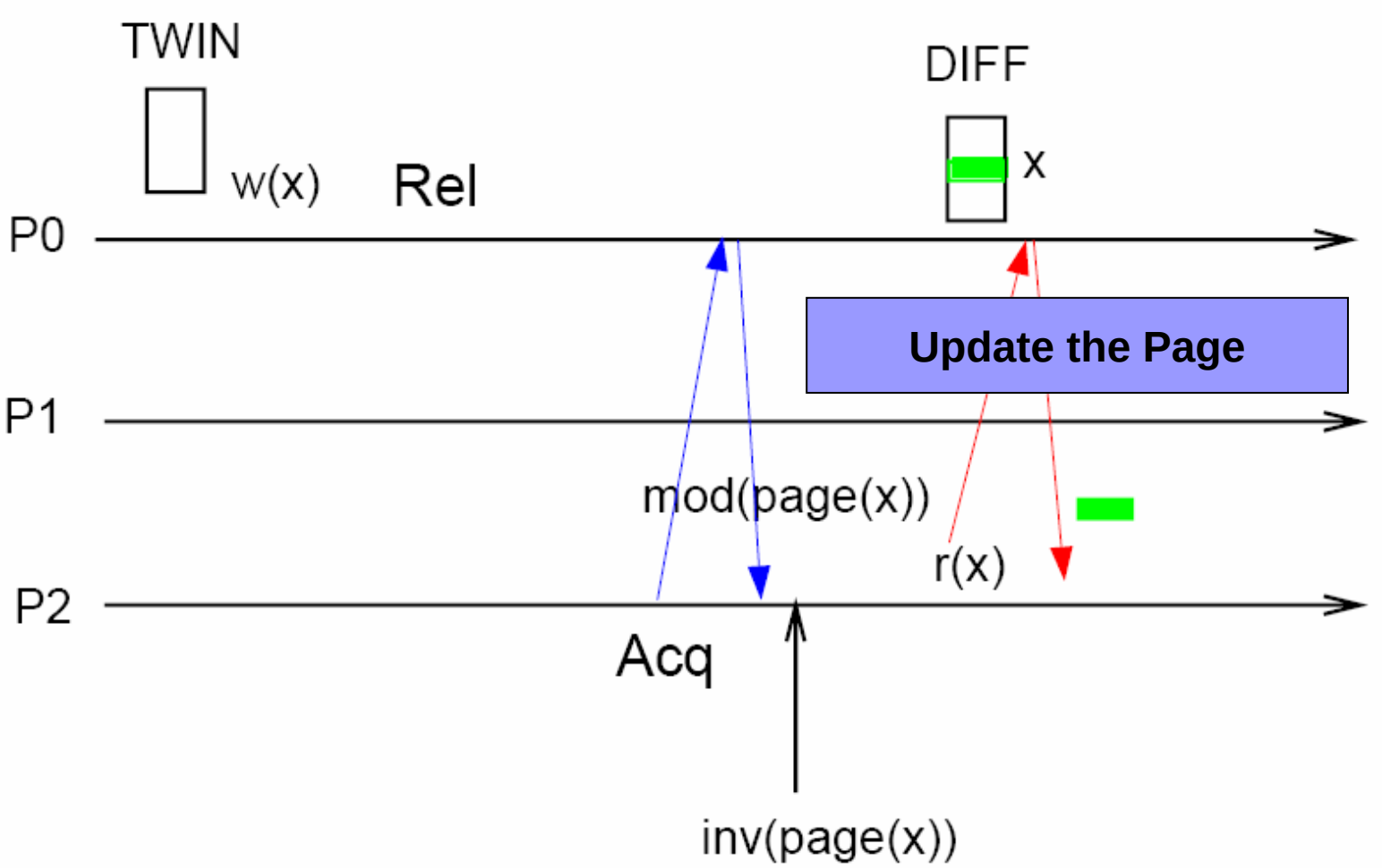




- Treadmark Data Structure



- Protocol action for Treadmark



- TreadMark System

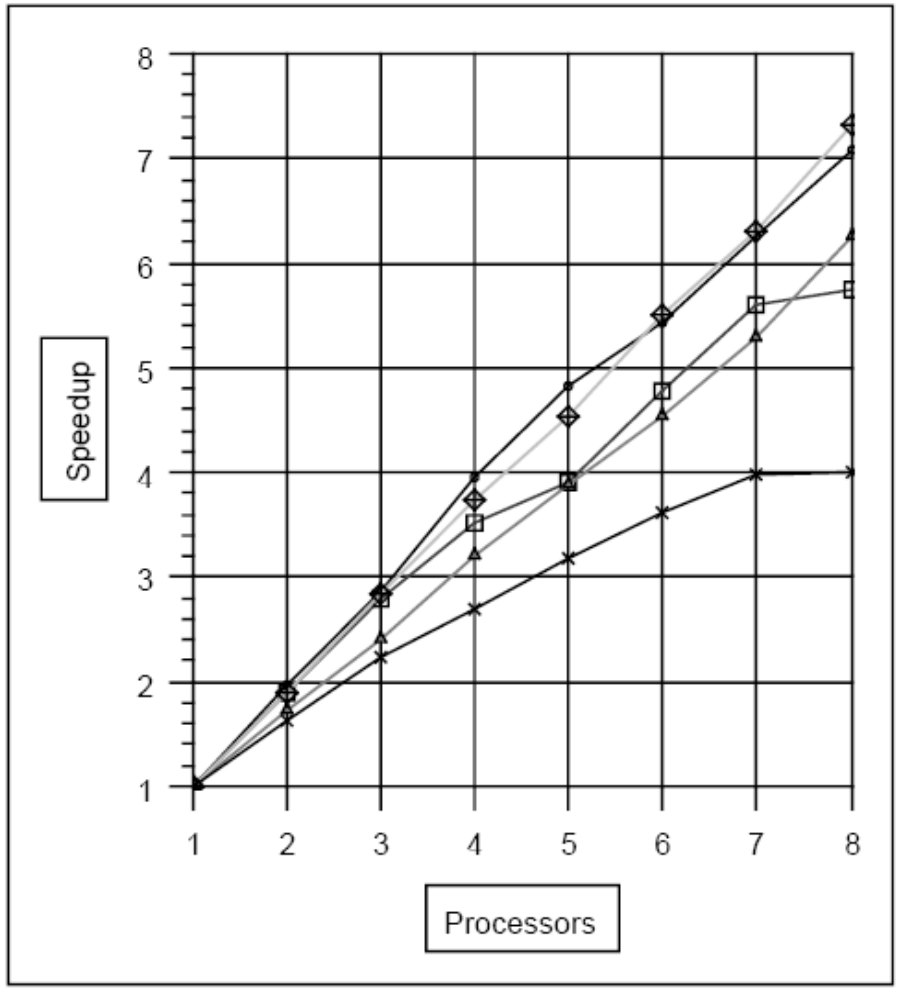
- implemented as a user-level library

- communication using UDP/IP

- use SIGIO signal handler handle request message

- use SIGSEGV signal handler access shared page

Speedup obtained on Treadmark



- Execution Time Breakdown

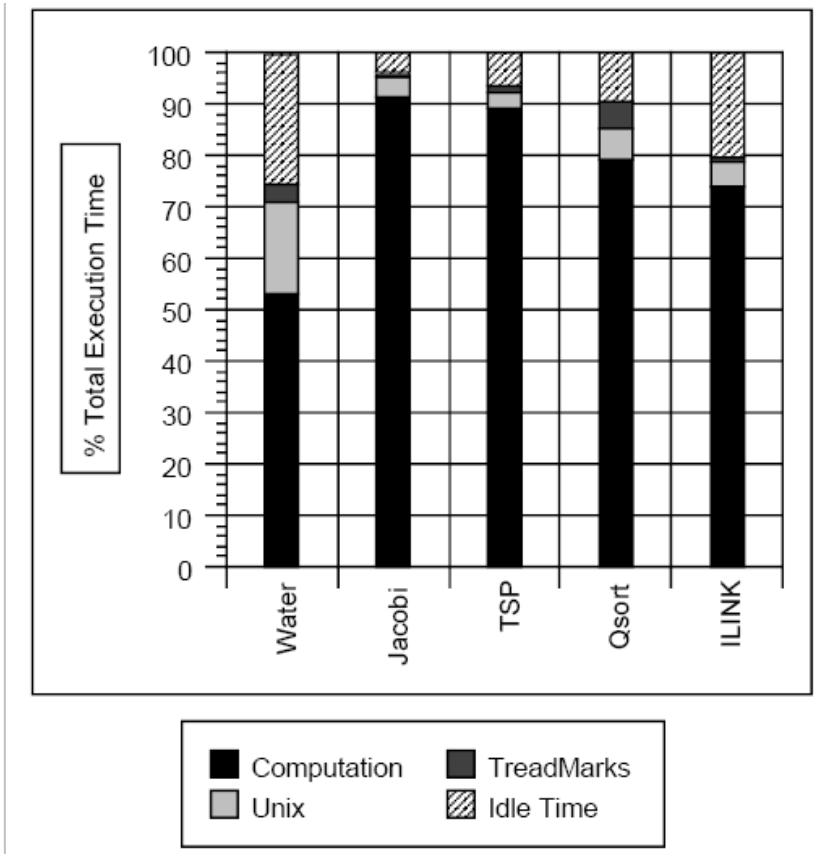


Figure 5 TreadMarks Execution Time Breakdown

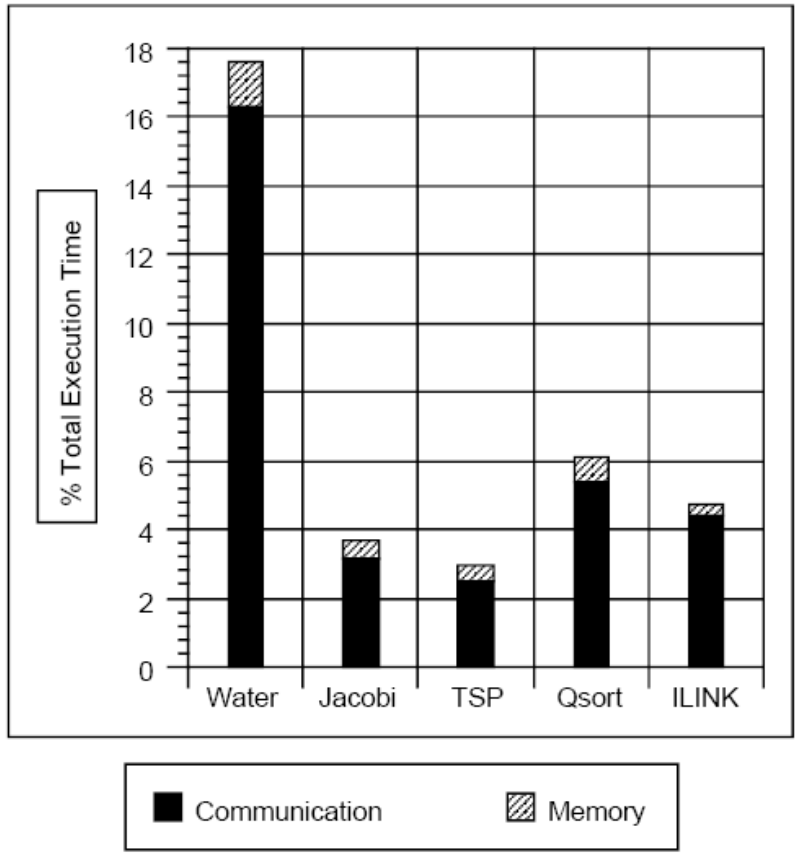


Figure 6 Unix Overhead Breakdown

- Alternative Approach

- Entry Consistency (Midway)

  each shared data object be associated with a synchronization object, using update protocol

- Structured DSM System (Linda)

  a shared space of objects instead of linear array

- Hadware Shared Memory Implementation (DASH)