Transparent and Efficient Shared-State Mangement
for Optimistic Simulation on Multi-Core Machines

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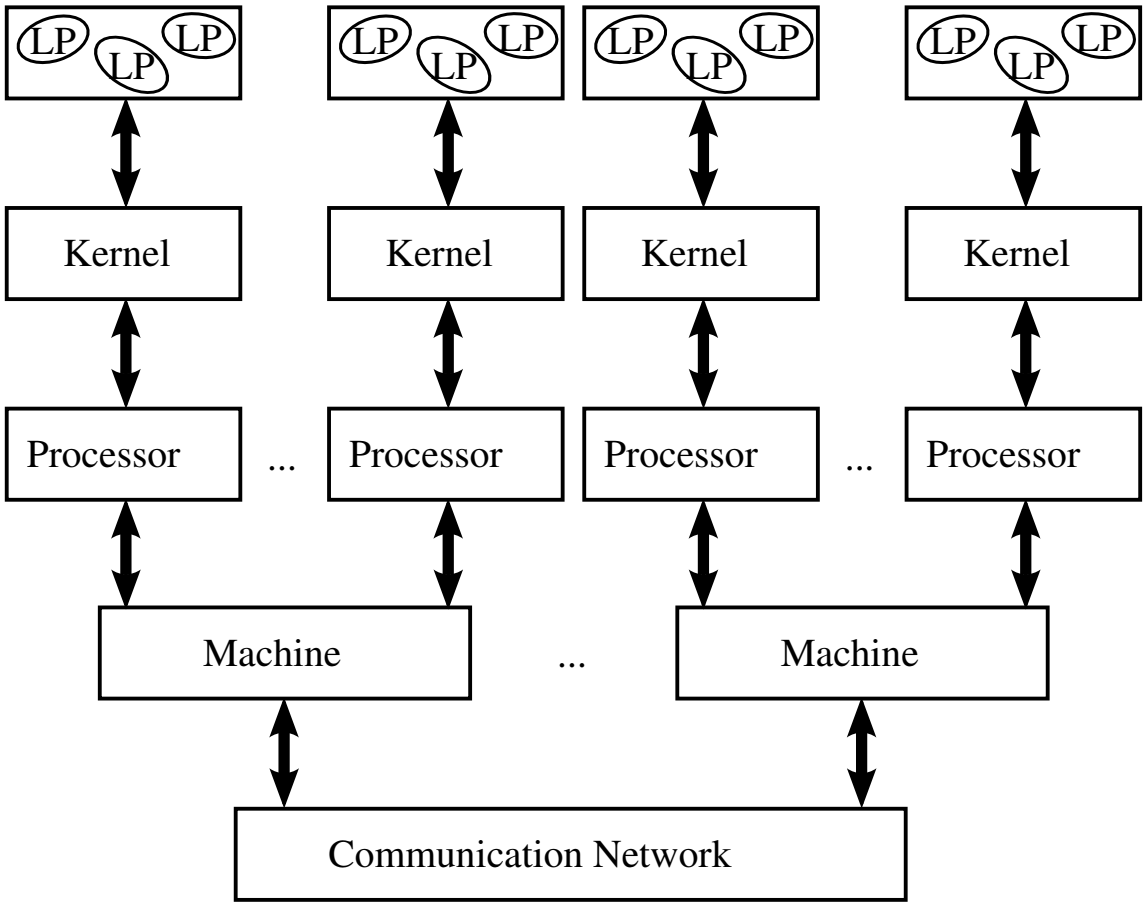
Rationale (1)



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Goal:

- Enable the application programmer to access both the LP's private state and the global portion
- Introduce a specifically-targeted Shared State Management Subsystem(SSMS)

Targets and Technical Supports

- Time Warp Synchronization protocol
- Shared-Memory Architectures

- Implement shared state as multi-versioned variables
- Propose an extended rollback scheme
- Rely on non-blocking algorithms for data synchronization
- Use software instrumentation for transparency

Read/Write Detection (1)

- Variables' accesses must be explicitly intercepted
- Actual machine-code instructions are modified at linking time
  - A specifically-targeted Instrumentation Tool is used
  - i386/x86-64 instructions are parsed
  - ELF executables can be handled

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- Two main APIs are exposed by SSMS:
  - `write_glob_var(void *orig_addr, time_type lvt, ...)`
  - `void *read_glob_var(void *orig_addr, time_type my_lvt)`

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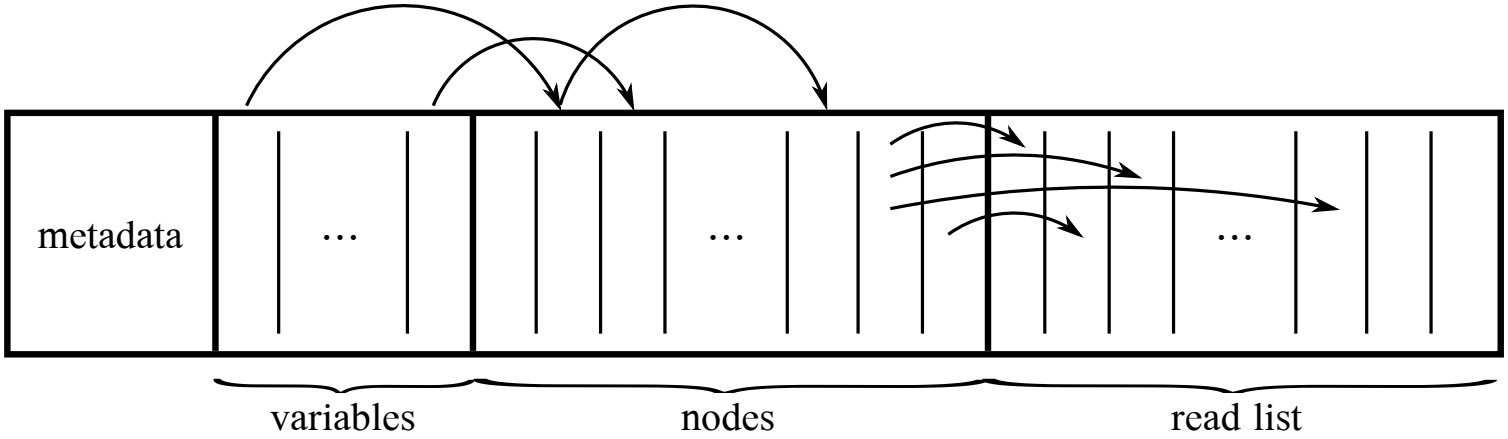
- Memory access via pointers:
  - A call to a `monitor` routine is placed before these instructions,
  - The destination address is fastly computed
  - A custom linker script is used to place boundaries on global variables
  - If the pointer falls within this area, SSMS is triggered

Read/Write Detection (3)

- To efficiently support runtime execution, an exact number of multi-versioned global variables must be installed
- At linking time the `.symtab` section is explored, to find global variables in the executable
- A table of $\langle name, address, size \rangle$ tuples is built
- At simulation startup, the correct number of multi-versioned variables is installed

Shared Memory-Map Organization



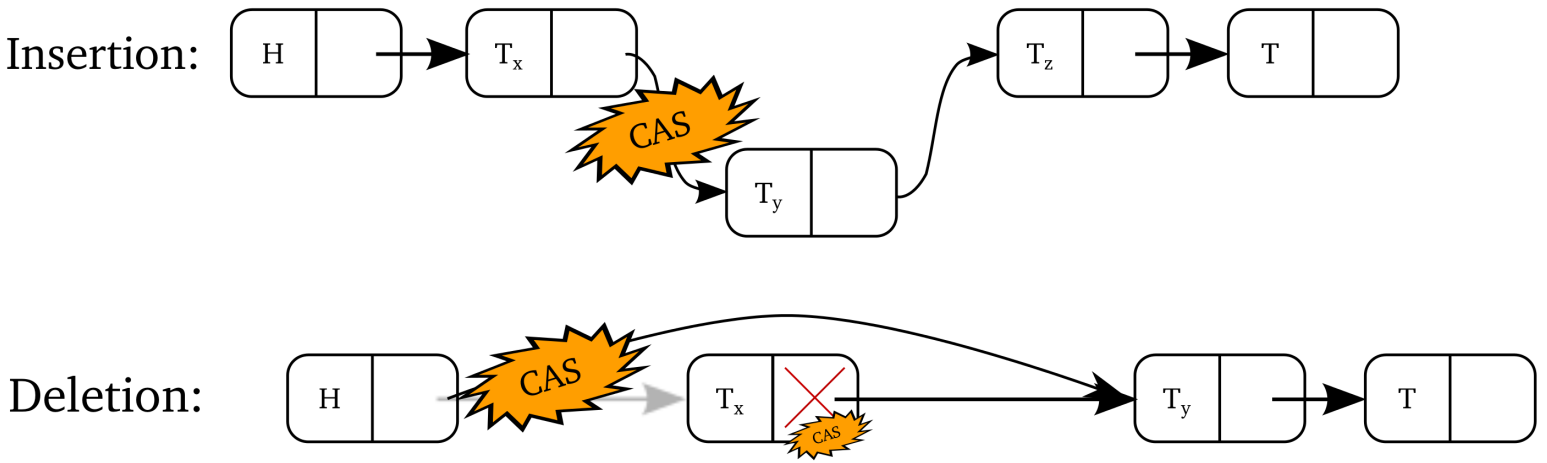

```
typedef struct _globvar_node {
  volatile int alloc;
  time_type lvt;
  unsigned char value[MAX_BUFF];
  spinlock_t read_list_spinlock;
  long long next;
} globvar_node;
```

Concurrent Allocator

```
 1: procedure ALLOCATE
 2:     m ← generate_mark()
 3:     slot ← first_node_free
 4:     while true do
 5:         alloc ← vers[slot].alloc;
 6:         if alloc ∨ ¬ CAS(vers[slot].alloc, alloc, m) then
 7:             slot ← next slot in circular policy
 8:         else
 9:             break
10:         end if
11:     end while
12:     atomically update first_node_free
13:     return slot
14: end procedure
```

Version Lists

- Multi-versioned variables are implemented as version lists
- Each node represents one variable's value at a certain lvt
- Insert/Delete operations are implemented as non-blocking operations by relying on the `CAS` primitive



Read Operation

```
1:  procedure READ(addr, lvt)
2:      slot ← hash table's entry associated with addr
3:      if slot ∈ AccessSet then
4:          version ← AccessSet[slot]
5:      else
6:          version ← FIND-NODE(slot, lvt)
7:          AccessSet[slot] ← version
8:      end if
9:      return vers[version].value;
10: end procedure
```

Write Operation

```
1:  procedure WRITE(addr, lvt, val)
2:      slot ← hash table's entry associated with addr
3:      if slot ∈ AccessSet then
4:          version ← AccessSet[slot]
5:          vers[version].value ← val
6:      else
7:          version ← INSERT-VERSION(slot, lvt, val)
8:          AccessSet[slot] ← version
9:      end if
10: end procedure
```

Synchronization and Rollback (1)

- To strengthen the optimism, we allow interleaved reads and writes on a version list
- We explicitly avoid a freshly installed version to invalidate any version related to a greater lvt

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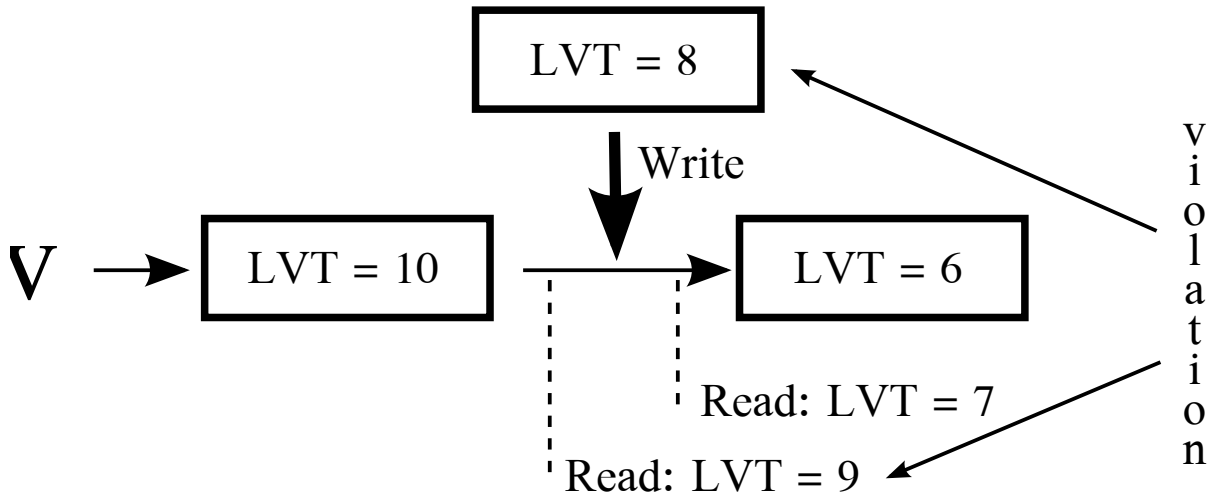

Synchronization and Rollback (2)

- Processes which reads a version node must leave a mark, i.e., visible reads are enforced.
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- After each *Write* operation, the *ReadList* of the previous node is checked to see if an anti-message must be scheduled to some LPs

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- A *ReadList* is maintained, to keep track of versions reads
- After each *Write* operation, the *ReadList* of the previous node is checked to see if an anti-message must be scheduled to some LPs
- When an antimessage is received because of an inconsistent read, version nodes related to that particular event must be removed
  - This is done by connecting every node in the *message queue* with version nodes installed during an event execution

Experimental Results (1)

- We have run our model on top of the ROme OpTimistic Simulator (ROOT-Sim), an open-source, general-purpose simulation platform developed using C/POSIX technology

`http://www.dis.uniroma1.it/~hpdcs/ROOT-Sim/`

- As a test-bed, we have used Personal Communications Service (PCS), a suite of differently parameterized simulation models of wireless communication systems adhering to GSM technology
- Global variables handle global statistics, i.e. the total number of calls, the total number of handoffs, and the global cumulated power

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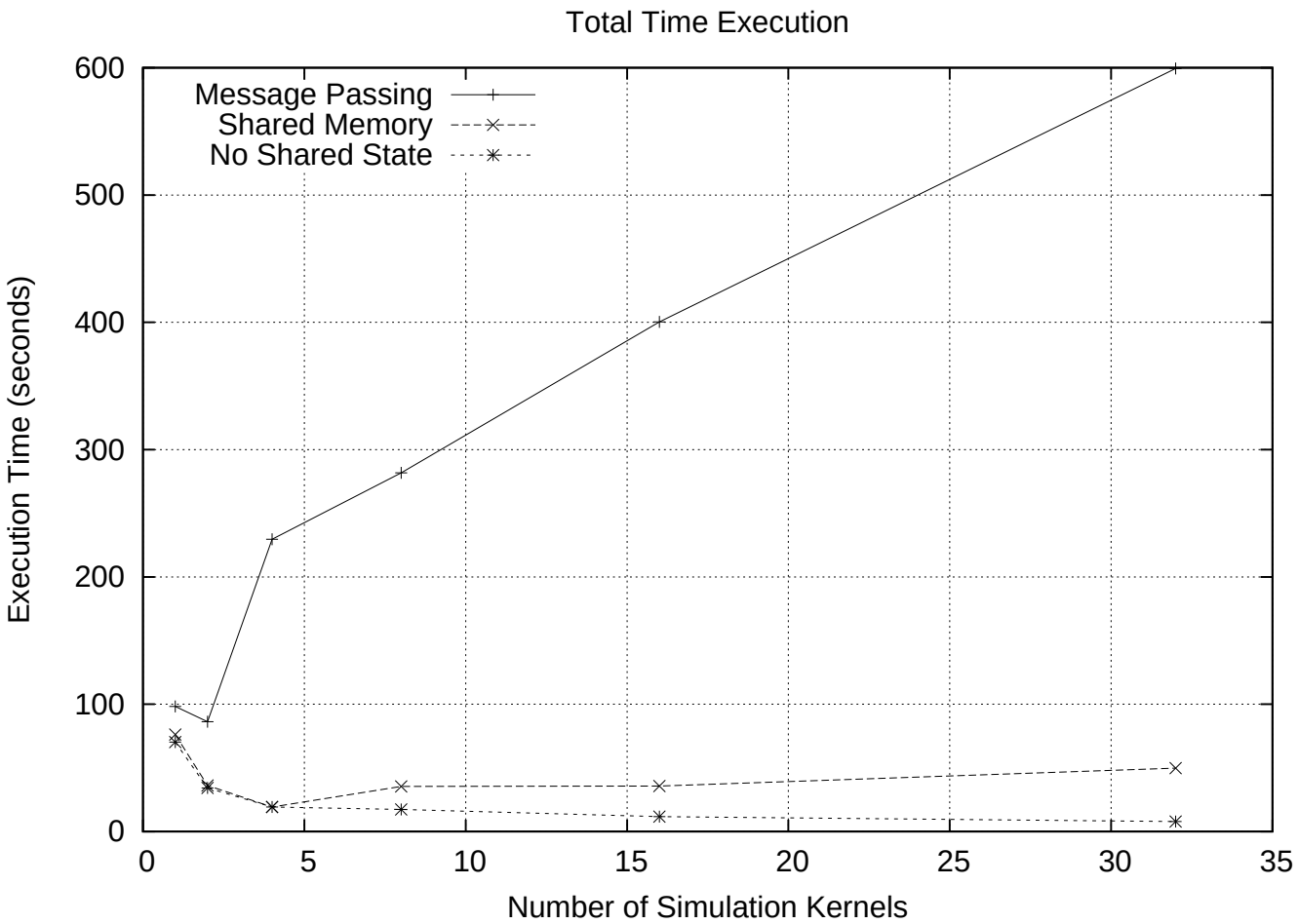

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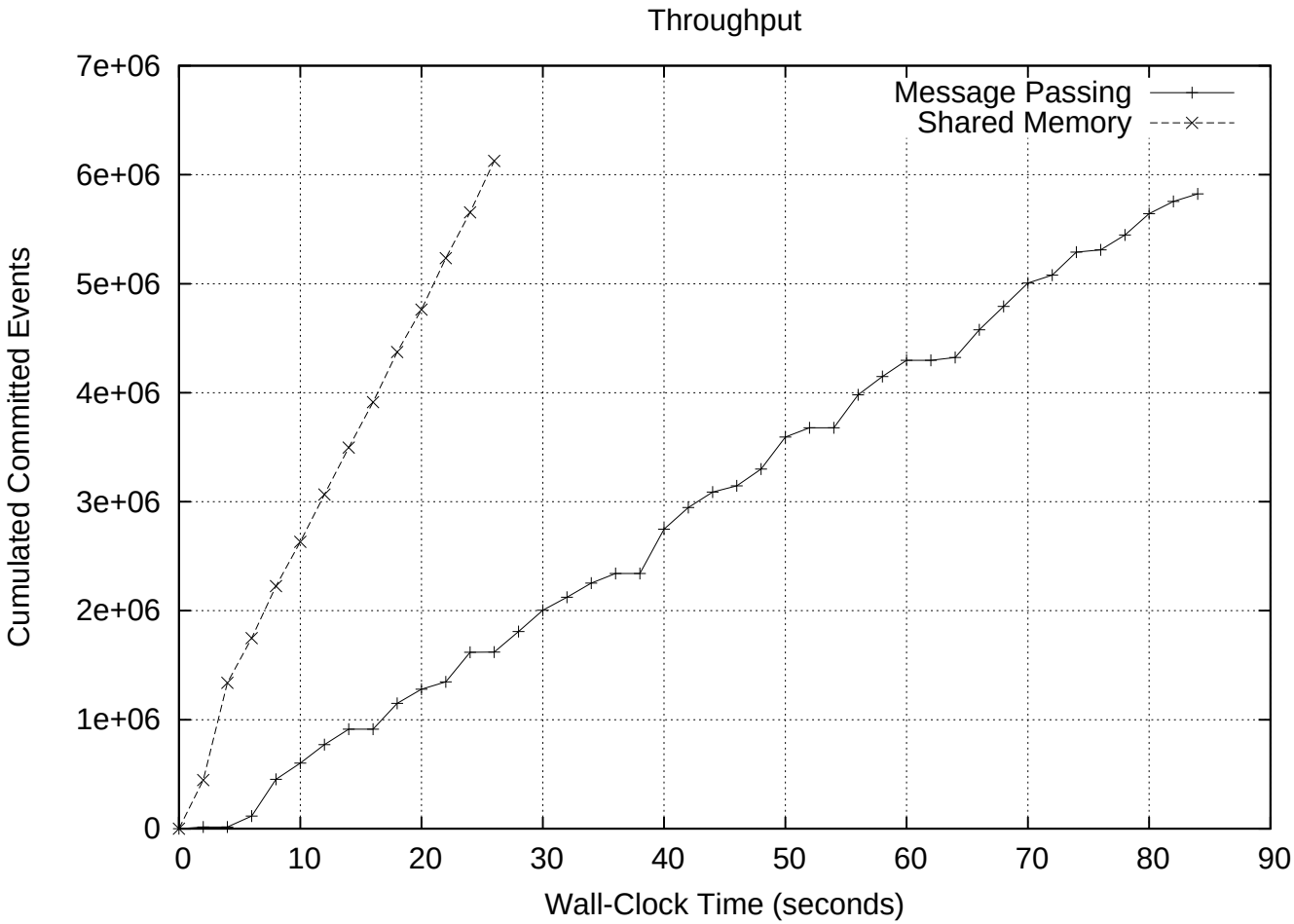

Thanks for your attention

Questions?

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