STM Concurrency Control for Embedded Real-Time Software with Tighter Time Bounds

Mohammed Elshambakey

ECE Dept., Virginia Tech

Blacksburg, Virginia

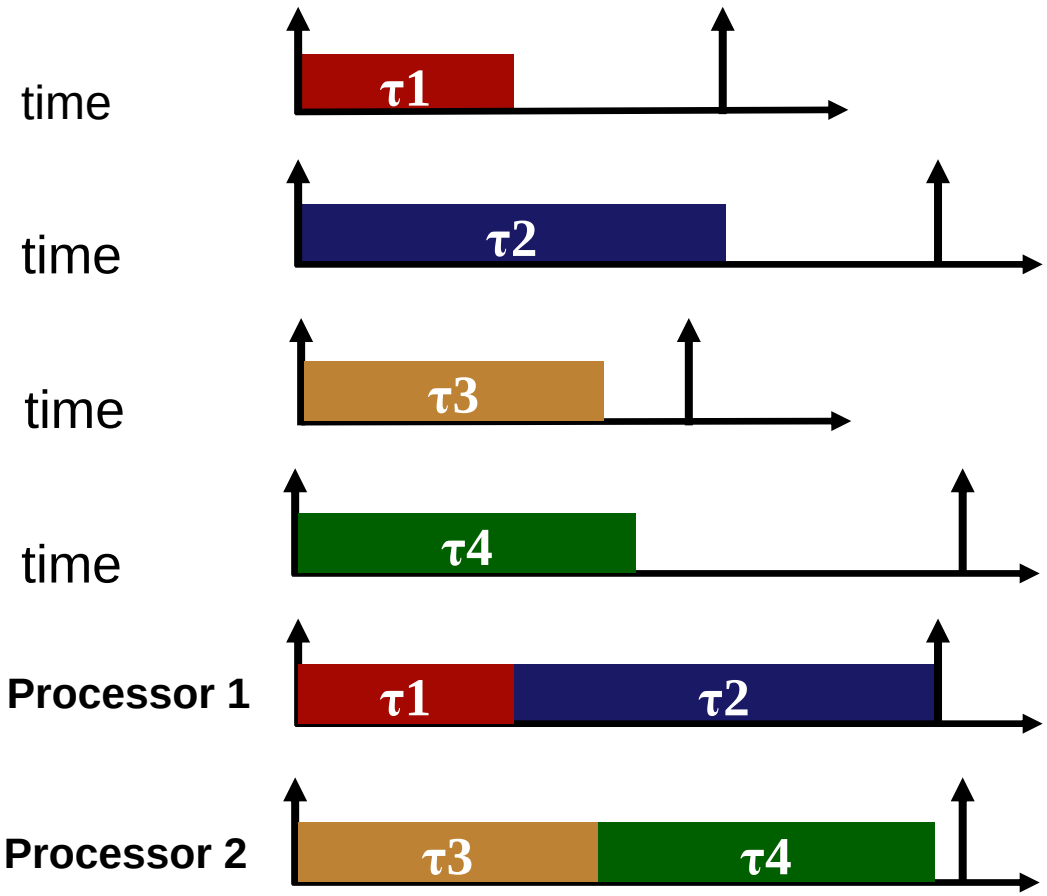
shambake@vt.edu

http://www.real-time.ece.vt.edu

*Joint effort with Binoy Ravindran (Virginia Tech)

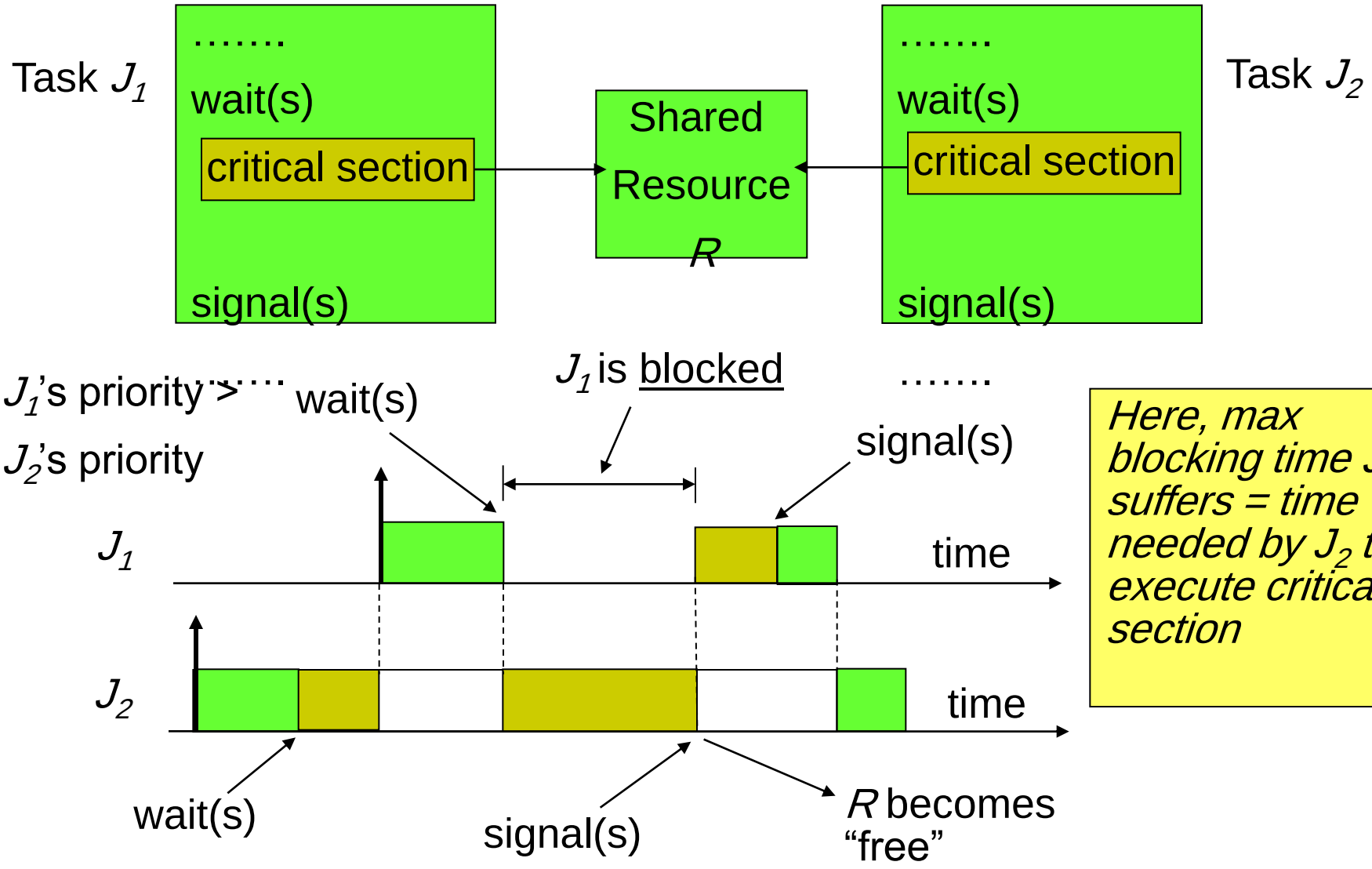
Virginia Tech

Real-Time Scheduling on Multicores



- G-EDF: Global Earliest Deadline First
- G-RMA: Global Rate Monotonic Algorithm

Real-Time Concurrency Control



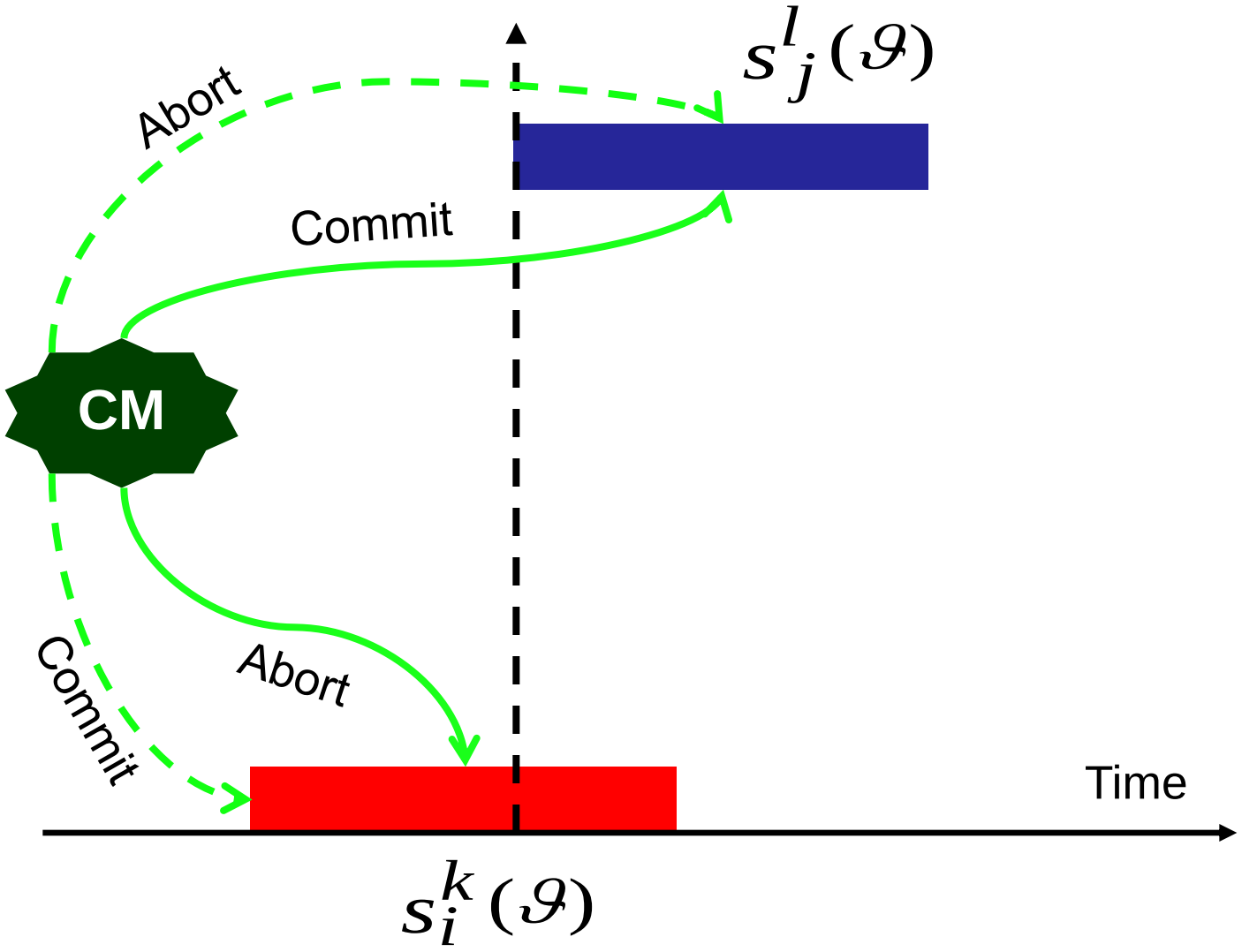
Here, max blocking time J_1 suffers = time needed by J_2 to execute critical section

Real-Time Concurrency Control

- Real-time locking protocols
  - PIP, PCP, SRP
- Lock-free and wait-free
- (Software) Transactional Memory (S)TM
  - Like database transactions
  - Atomicity, Consistency, Isolation and Durability properties
  - Easier to program
  - Fine-grained performance
  - Composable
- STM uses Contention Manager (CM) to resolve conflicts

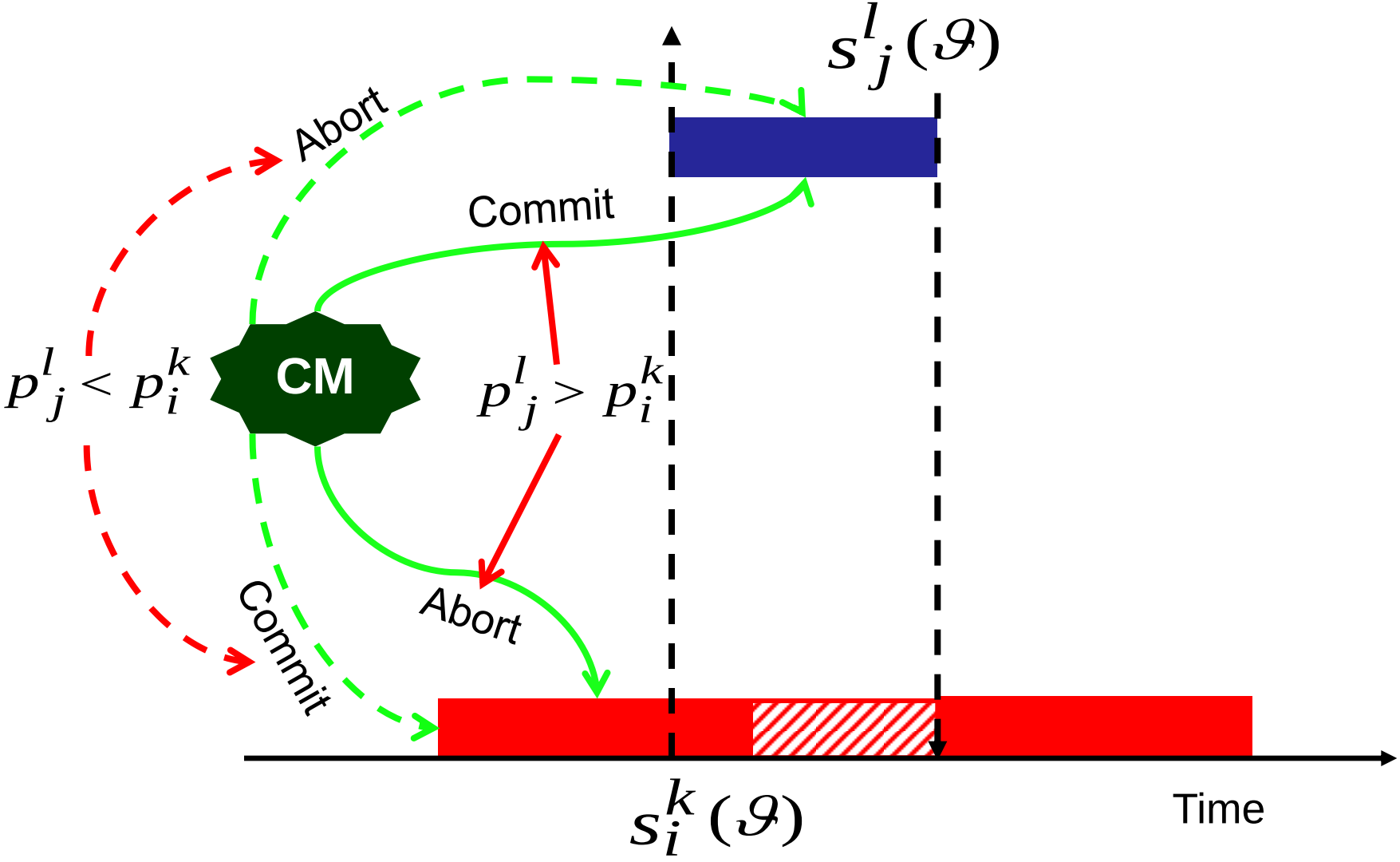
```
public boolean add(int item) {
  Node pred, curr;
  atomic {
    pred = head;
    curr = pred.next;
    while (curr.val < item) {
      pred = curr;
      curr = curr.next;
    }
    if (item == curr.val) {
      return false;
    } else {
      Node node = new Node(item);
      node.next = curr;
      pred.next = node;
      return true;
    }
}
```

Real-Time STM Concurrency Control



$s_i^k(\vartheta)$: K[th] transaction of task *i* that accesses object θ

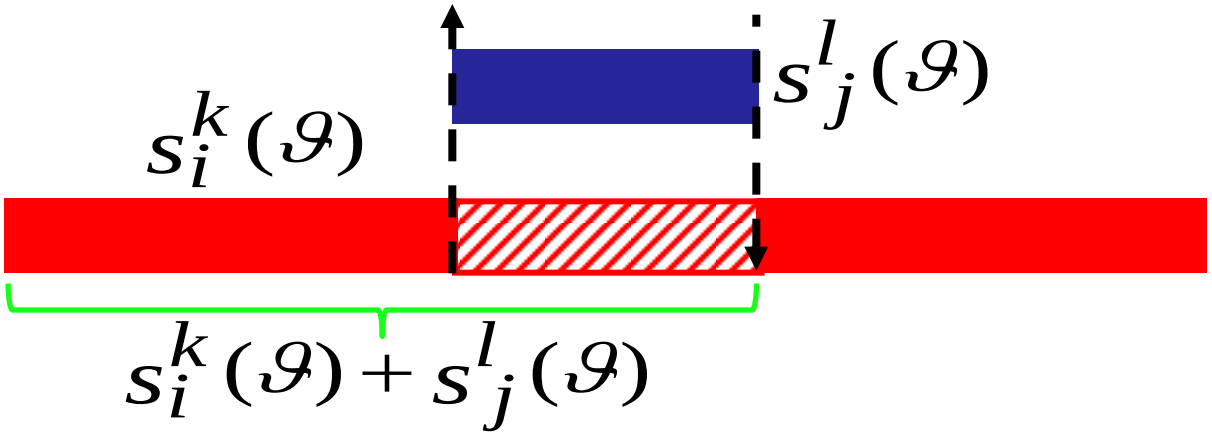
Earliest Deadline (ECM) and Rate Monotonic (RCM)



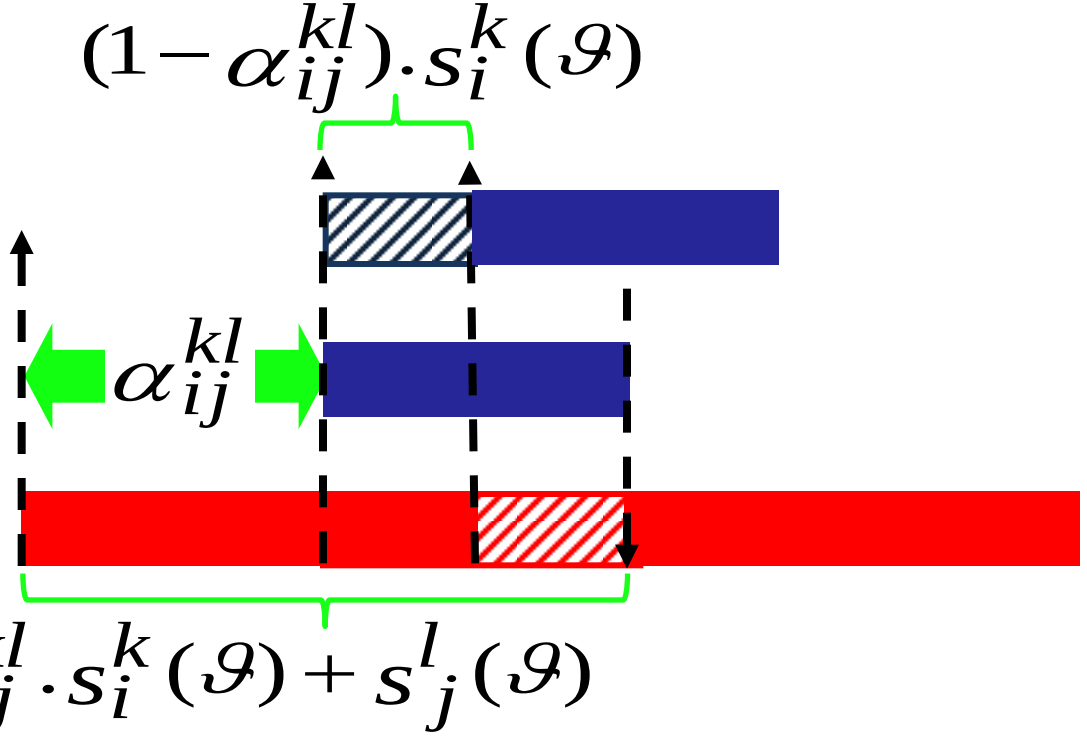
$s_i^k(\vartheta)$: K[th] transaction of task *I that access object* θ

Length-based CM (LCM)

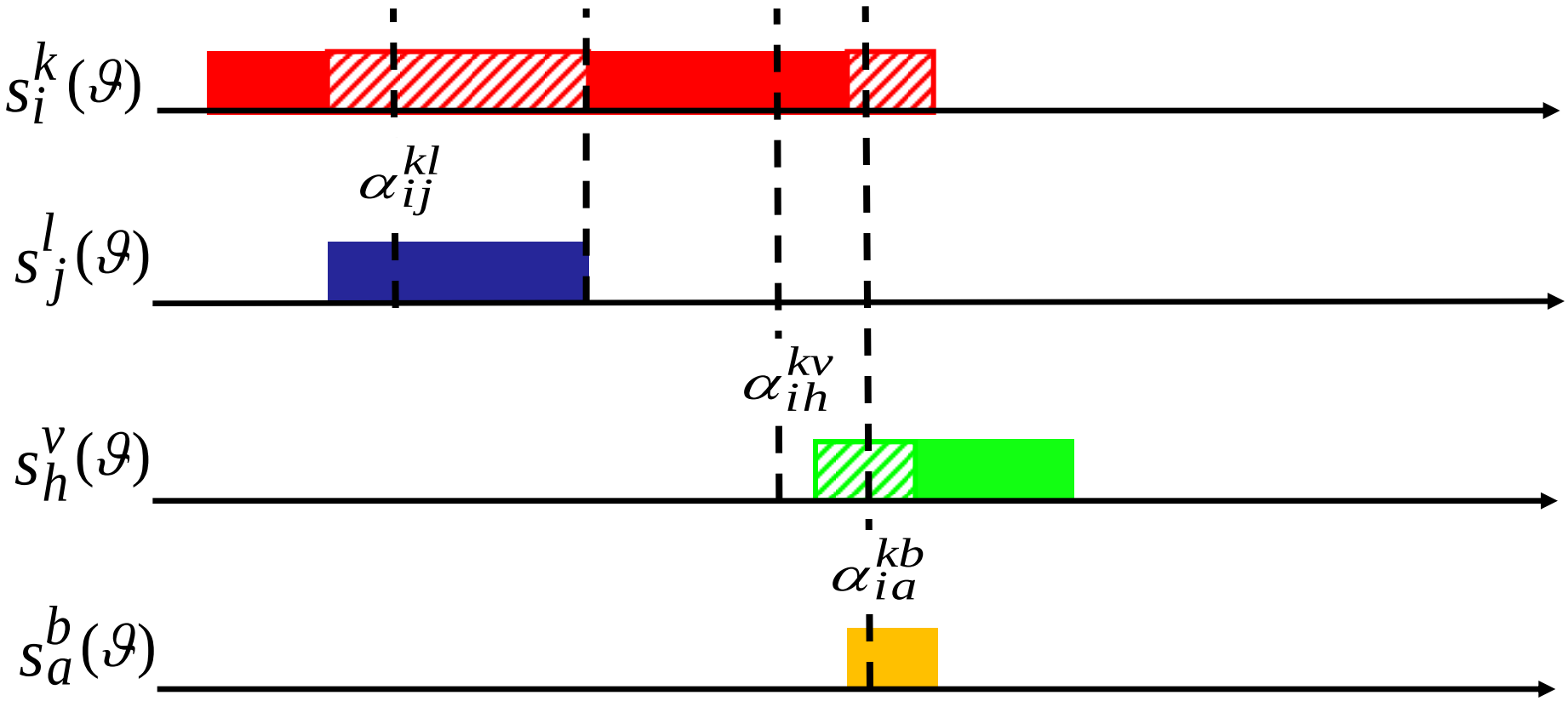
ECM & RCM



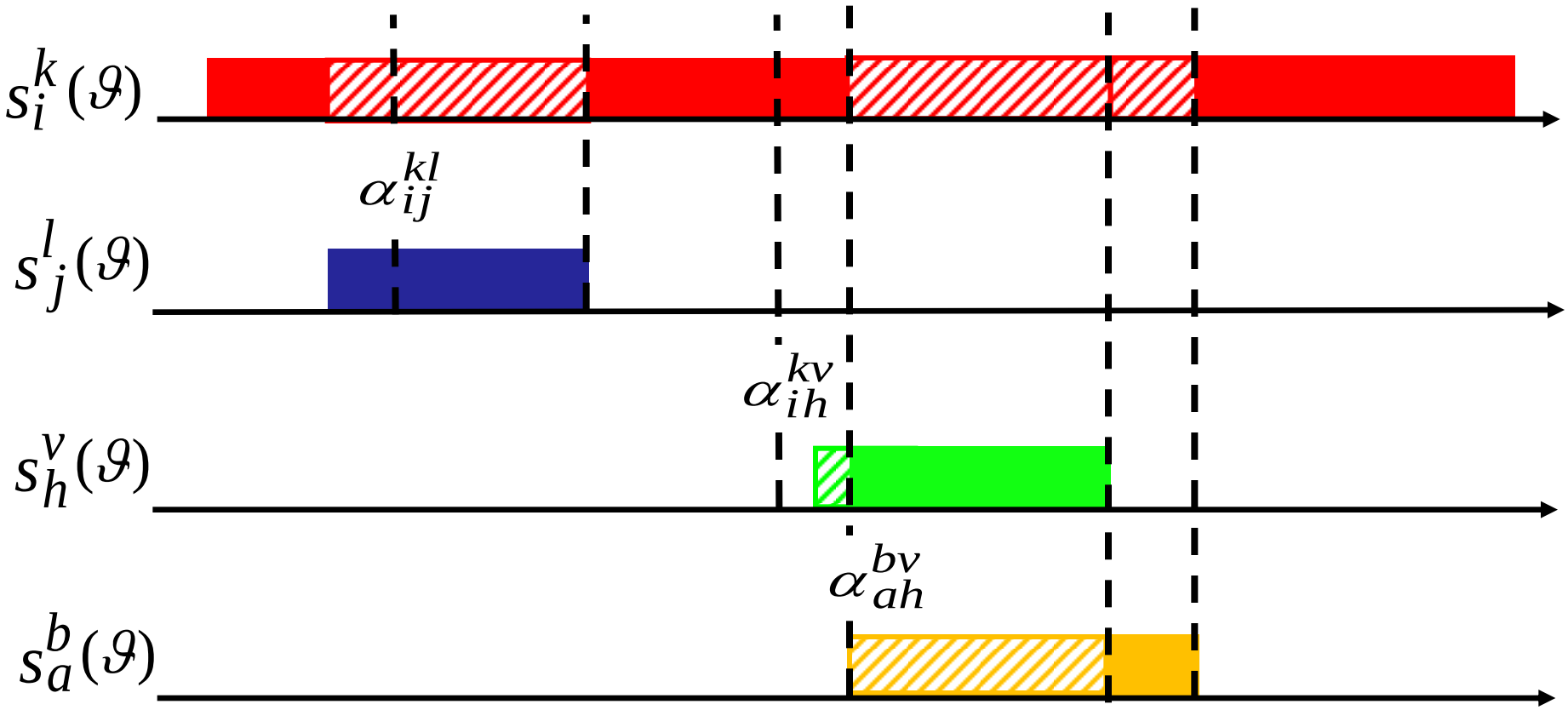
LCM



LCM Example


$s_i^k(\vartheta)$
α_{ij}^{kl}
$s_j^l(\vartheta)$
α_{ih}^{kv}
$s_h^v(\vartheta)$
α_{ia}^{kb}
$s_a^b(\vartheta)$

LCM Example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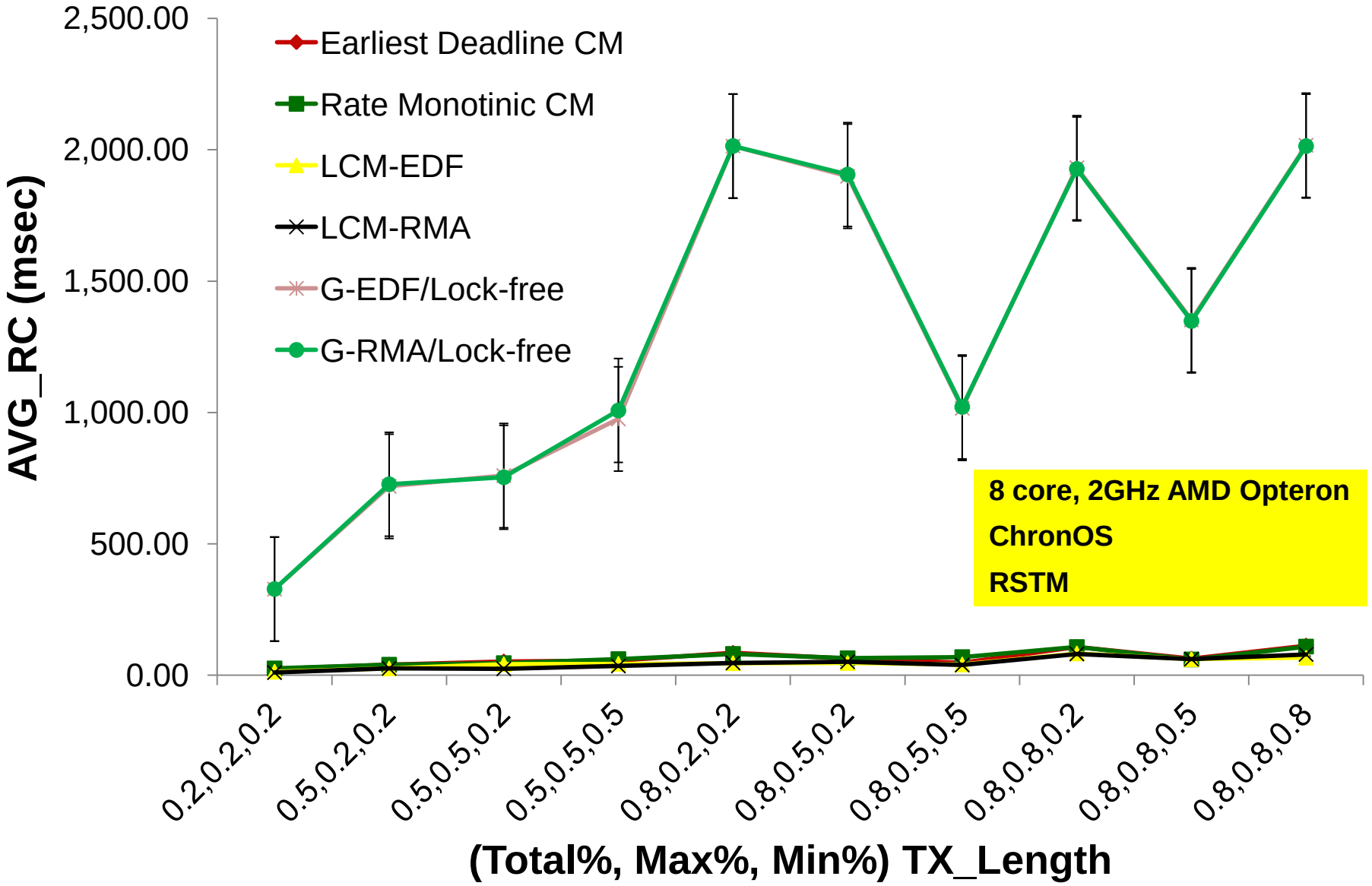
Implementation Results (8 Tasks - 8 Cores)



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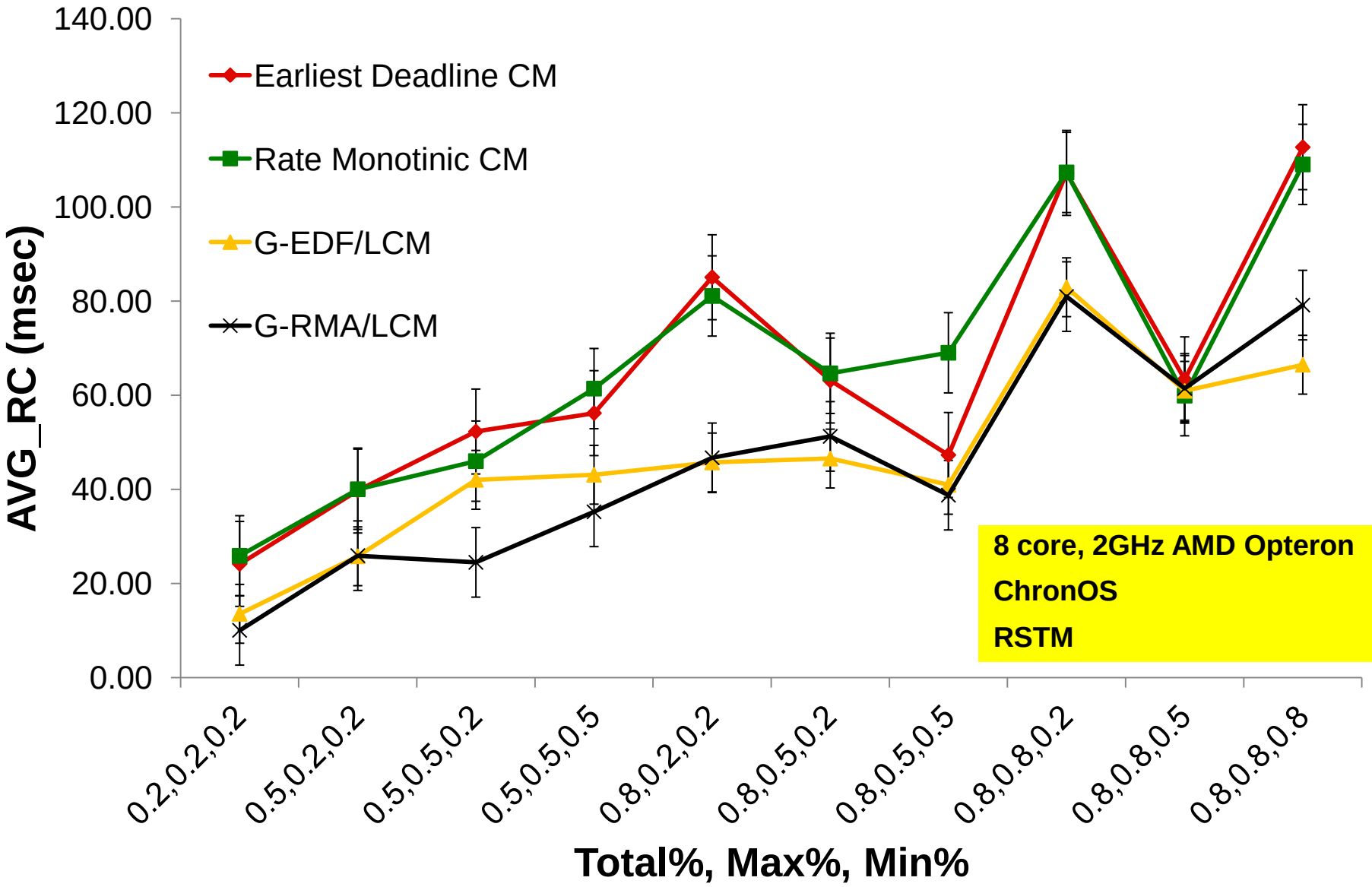

Conclusions

- LCM considers priority, as well as remaining execution length of interfered transaction
- ECM & RCM → Retry cost of $2 \times s_{max}$
- LCM → Retry cost of $(1+ \alpha_{max}) \times s_{max}$
- Higher priority task can be delayed by lower priority task
- By proper choice of α_{max} and α_{min}, schedulability of G-EDF/LCM (G-RMA/LCM) is equal or better than ECM (RCM)
- s_{max}/r_{max} => 0.5 to 2 for better schedulability of G-EDF/LCM than lock-free
- s_{max}/r_{max} => 0.5 Large-values for better schedulability of G-RMA/LCM than lock-free