

1. Lock-Free Queue & Importance

- A lock-free queue allows multiple threads to add/remove items **without locks**, using atomic operations.
- Important in real-time systems because it **avoids blocking**, reduces latency, and improves throughput.

2. CAS in Enqueue Operation

- CAS atomically compares a pointer's value and swaps it if it matches an expected value.
- For enqueue:
 - Use CAS to link the new node to the current tail's next pointer.
 - Then update the tail pointer with CAS.
 - If CAS fails (due to concurrent changes), retry the operation.

3. ABA Problem & Solution

ABA problem: Memory changes from $A \rightarrow B \rightarrow A$, causing CAS to falsely succeed.

- Solutions:
 - Use version counters or tagged pointers with CAS.
 - Use hazard pointers or other safe memory reclamation methods.