CCTS - Project Report

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Opacity: A Correctness Condition for Transactional Memory

Overview

The paper discusses the importance of formally defining the guarantees that Transactional Memory (TM) implementations should provide for correct and optimal concurrent programming. The authors propose "opacity" as a candidate correctness criterion for TM implementations, which captures the requirements for preventing non-committed transactions from accessing inconsistent states. Opacity is interpreted graph-theoretically and is an extension of classical database serializability. The paper also presents a lower bound on the complexity of TM implementations and highlights a fundamental gap between systems that provide full isolation capabilities and those that lack such capabilities.

Opacity conditions

- All operations performed by every *committed* transaction appear as if they happened at some single indivisible point during the transaction lifetime.
- No operations performed by any aborted transaction are ever visible to other transactions including live ones.
- Every transaction always observes a *consistent* state of the system.

Virtual world consistency: A condition for STM systems (with a versatile protocol with invisible read operations)

Overview

The paper introduces a new consistency condition called virtual world consistency that ensures no transaction reads object values from an inconsistent global state, and presents an STM protocol based on a vector-clock mechanism that guarantees virtual world consistency for atomic read/write objects. It also shows how the protocol can be weakened to provide an STM system that satisfies causal consistency for regular read/write objects.

Intuition

- No transaction (committed/aborted) reads from an inconsistent global state.
- All the committed transactions are serializable.
- Each aborted transaction reads values that are consistent with respect to its past only.

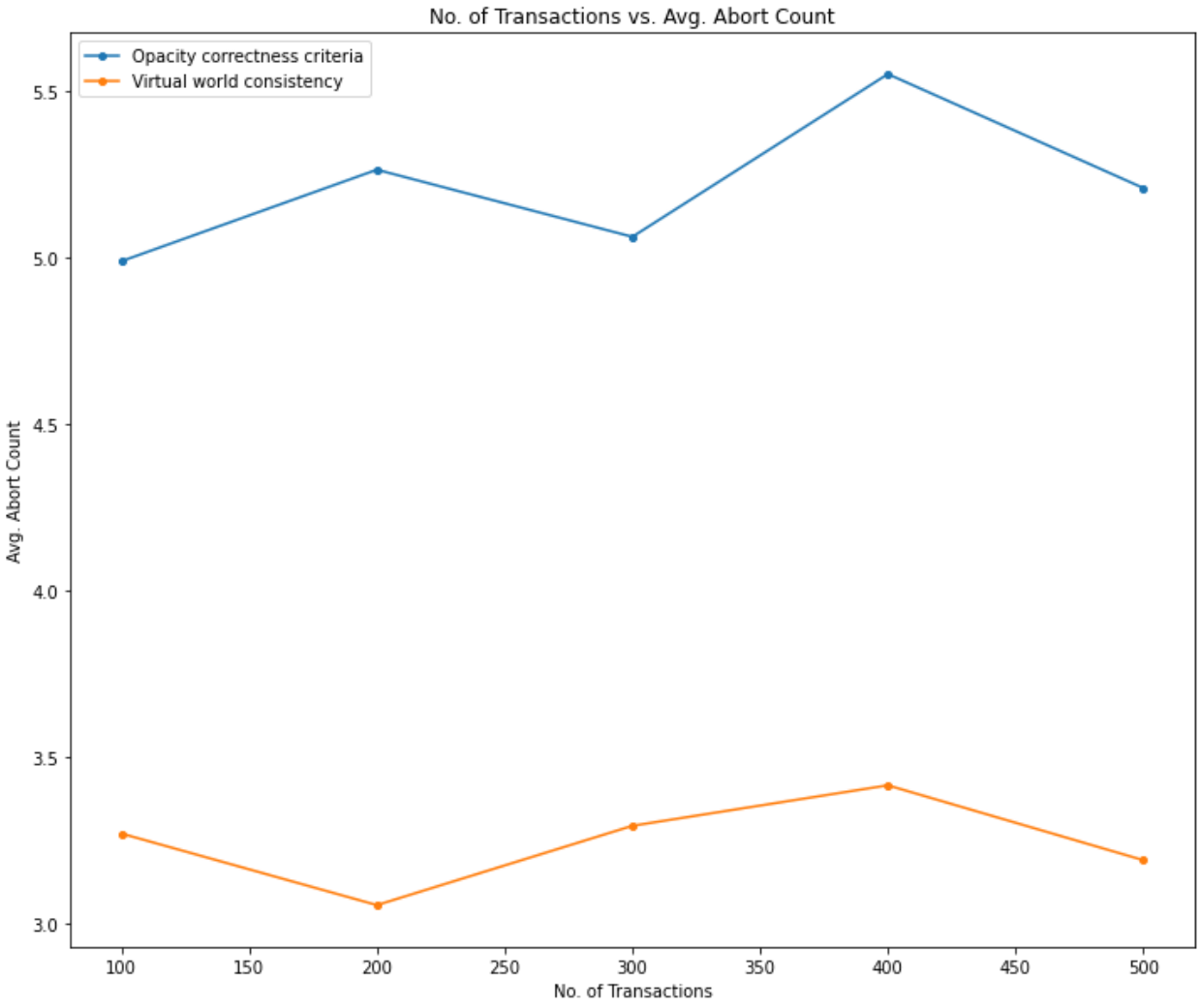
Opacity vs Virtual world consistency

Virtual world consistency ensures that all participants in a distributed system see the same view of a virtual world. This means that all participants have a consistent and up-to-date view of the state of the system, even if there are concurrent updates happening in different parts of the system. This approach is useful for applications that require strong consistency guarantees, such as online gaming and financial transactions.

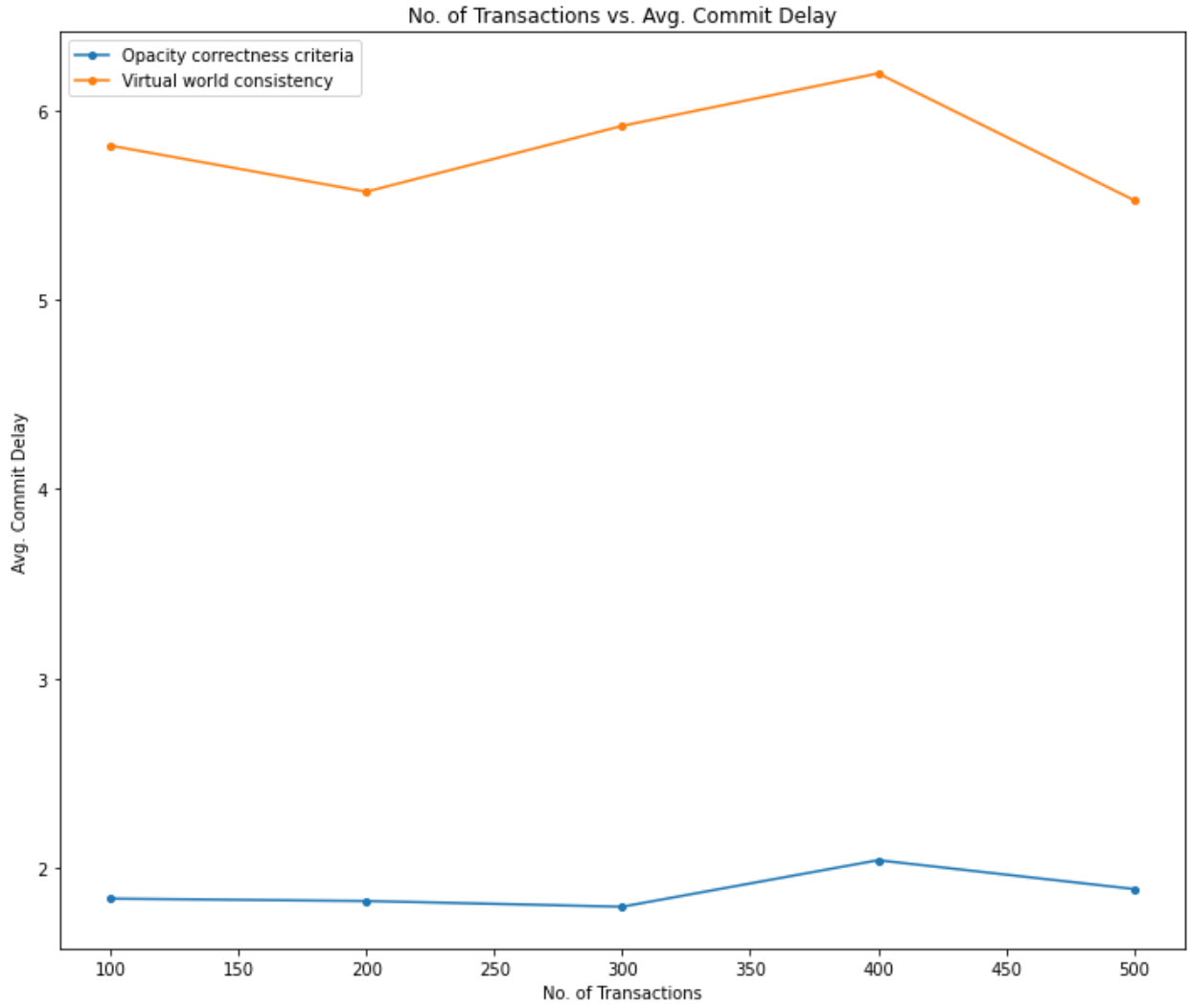
Opacity criteria, on the other hand, allow for some level of inconsistency in a distributed system in order to improve performance and scalability. The basic idea behind opacity criteria is that the system can allow for concurrent updates as long as the effects of those updates are not visible to other parts of the system until they are complete. This approach is useful for applications that can tolerate some level of inconsistency, such as social media or recommendation systems.

In terms of concurrency, virtual world consistency is generally considered to be better than opacity criteria because it provides stronger consistency guarantees. With virtual

world consistency, all participants see the same view of the system, which makes it easier to reason about the behavior of the system and to detect and resolve conflicts. Opacity criteria, on the other hand, can be more difficult to reason about because there can be hidden dependencies between concurrent updates that are not immediately visible.



However, it's important to note that virtual world consistency can come at a cost in terms of performance and scalability. Because all participants in the system need to have a consistent view of the virtual world, updates may need to be serialized or coordinated, which can introduce delays and limit the system's ability to scale. In contrast, opacity criteria can allow for greater concurrency and parallelism, which can improve performance and scalability, but at the cost of weaker consistency guarantees.



References

- Opacity correctness criteria
- Virtual World Consistency