A Case Study and Evaluation of Convergent and Commutative Replicated Data Types

In the current increasingly popular context of distributed data stores, replication and partitioning is the fundamental approach to achieve load balancing, scalability and fault tolerance. However, this comes at the cost of synchronization between different replicas of the same object in order to maintain consistency. Convergent or commutative replicated data type (CRDT)[1] is a new concept introduced to alleviate this problem. Given that a set of simple mathematical properties hold, CRDTs ensure eventual consistency and it is provable that replicas converge to a common state, equivalent to a correct sequential execution.

A strong motivation to study this concept comes from our current demands of supporting frequent writes of runtime data to a replicated and distributed store. Because a consensus algorithm for conflicting updates would become a bottleneck, CRDTs are very attractive, as a replica may execute any operation locally. Consistency is achieved through a background asynchronous phase in which all replicas eventually apply all updates.

A second requirement for our system imposes that different pieces of stored data can be logically related in a graph-like manner. CRDTs consist of simple structures (counters, registers, sets) which can be composed to form more complex ones, like graphs.

Finally, we want our system to exhibit the ALPS properties (Availability, low Latency, Partition-tolerance, and high Scalability). Given that the CAP theorem[2] imposes a trade-off between consistency, availability and partition-tolerance, CRDTs are an acceptable solution for our use cases where strong consistency is not a requirement.

Therefore, our objective is to implement and evaluate a proof-of-concept prototype library for graph structures based on CRDTs which will constitute the basis of a future framework used on a large scale inside the company.

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1 Marc Shapiro, Nuno Preguiça, Carlos Baquero, Marek Zawirski. *A comprehensive study of Convergent and Commutative Replicated Data Types*. INRIA Technical Report RR-7506, January 2011.

2 Seth Gilbert and Nancy Lynch. *Brewer's conjecture and the feasibility of consistent, available, partition-tolerant web services*. SIGACT News, 33(2):51–59, 2002.