Formal Verification of Bucket Synchronization by Using Proof Score

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1 Background

Network game is a computer game that is played on network by more than one players. In recent years, network game produces commercial success, and gains acceptance on art and entertainment. However, contrary to market, creating network game is difficult because network game have a aspect of complex computer software. From the software standpoint, Network game is a distributed system, and Network game also has some problems of distributed system. Such problems contain Causual-Ordering problem.

A node send events to network by some order and another node don't accepts events same order such problem called Causual-Ordering problem. In general, nodes cannot keep consistency of informations if the problem happen.

Causual-Ordering protocol keeps order of events accepting on all nodes connected distributed system for to solve Causual-Ordering problem. And, keeping order of events accepting is called Causual-Order guarantee.

Network game constructs as game states decidable by only player operations to reduce necessary of communication band. This makes all nodes can keep game states consistency by sending player operations as events and keeps Casual-Order guarantee. In the result, Network game can play on household use internetwork line.

Also, in general, computer game must show game states to player by animation. A time of game state has informations to render a image. But animation is implemented by periodically image rendering. If deviancy of rendering cycle length is large, then animation collapses and player may get suffering or cannnot operate games. Thus, preferably, game states should update fixed cycle. This fixed cycle called frame, and game states update in

response to frame is called frame updates. But, frame update claims all necessary events to update game states.

Because of these conditions, in network game, event accepting needs following.

- All nodes have same event accepting order.(Causual-Order guarantee)
- Event accepting cycle is guaranteed as well as player can tolerate.(Frame length constancy)
- A frame that is happen a event and another frame that accept the event always have same frame update count.(Opeation stability)

Causual-Ordering can guarantee by Causual-Ordering protocol, but frame length constancy and operation stability cannot guarantee by general Causual-Ordering protocol. Bucket synchronization protocol is proposed to try to such needs of network game. The protocol is considered Causual-Ordering protocol and guarantee frame length constancy and operation stability if network delay is less than a constant value. Therefore the protocol is used on network game with a network delay countermeasure protocol.

In earlier study, it is checked by simulation and questionnaire that bucket synchronization protocol have frame length constancy and operation stability. But, it isn't verified that can the protocol guarantee Causual-Ordering. Thus, Mathematical verification of bucket sychronization is needed to create network game safety, and we verify bucket synchronization have Causual-Ordering or not by using formal method.

2 Problem

In this research, We create mathematical model of bucket synchronization and verifiy Causual-Ordering by using formal method.

Bucket synchronization involves game specific time concept that called frame, and real time. Thus, relationship of frame and real time must define on bucket synchronization model. But, the relationship is frame length is equal to some random real time length. That is, we should define model how long time or what time frame update is unknown.

3 Approach

We define model by OTS/CafeOBJ. In our model, we consider each transition have hidden non-determinal real time passing, and we don't write real time behavior in model definition. This way, model definition only depend on frame, and we can consider frame and real time independent on the model.

4 Conclusion

In this research, we modelize network game and bucket synchronization. And, we verify bucket synchronization guarantee Causual-Ordering.