Causal Order Broadcast Considering Timeliness for Mobile TV based on P/S

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Abstract. In this paper, we present deadline-constraints causal order protocol respecting $\Delta$ based on P/S architecture for broadcast of real-time collaborative applications in social networks to guarantee causally ordered messages delivery from brokers to subscribers. Every broker disseminates a broadcast message with a 1-Scalar, the time-stamped information that represents the maximum gossip round, that is the deadline (lifetime) of the immediate message of it, to subscribers because all messages disseminated by brokers have the same lifetime (deadline) as the maximum number of gossip rounds.

Keywords: social networks, real-time collaborative applications, gossiping, scalability, message delivery order

1 Introduction

Multiple sensors on a mobile phone have become more real-life sensors and this makes sensor networks ubiquitous environments for us to live in [2]. Sensor networks collaboratively detect events and make attempts to extend a simple communication to the social context-sharing by using mobile phones especially on social networks [7]. And many social applications such as a real-time collaborative video watching application [1] should allow people to collaborate in real-time around the same videos played on their sensor network infrastructure, their different locations and the type of devices. So, the social network based on sensor networks should provide an adequate communication infrastructure to alleviate hot spots and elastically scale in and out for better exploiting network and computational resources. Recently these networks use a content-based distributed publish/subscribe infrastructure that act as a scalable group communication backbone, such as ASIA [6].

In our proposed protocol, P/S architecture is based on gossip protocols, which seem more appealing in many P/S systems because they are more scalable than traditional reliable broadcast. So, gossip protocols allow a publish/subscriber middleware to be defined timely, which means, timeliness: given a certain time deadline, $\Delta$ [5]. P/S architecture based on gossip protocols is providing suitable consistency guarantees for current social applications, such as replication for data...
safety and high availability but, does not deal with end-to-end message delay and message order-based consistency, which are addressed in real-time collaborative applications [1]. Therefore, in this paper, we present deadline-constraints causal order protocol based on scalable P/S architecture for social networks, such as [6] to guarantee causally ordered messages delivery of collaborative broadcast messages, respecting deadline-constraints from brokers(providers) to subscribers especially for broadcast respecting $\Delta$(a certain time deadline), for a real-time collaborative video watching application [1].

To prevent causal order violation, either message might be forced to wait for messages in their past or late messages might have to be discarded [9]. In real-time collaborative applications, such as [1], it makes more sense to allow messages bypassing their deadlines to be dropped than to force many other causality related messages to bypass their deadlines [9]. So, our proposed protocol is based on gossip protocols giving preferences to local members to significantly reduce the number of messages traversing the long-distance network links. In our proposed protocol, because every broker knows about each other, it manages a 2-dimensional vector like in the protocol [9], representing its knowledge, the last message sent by a broker $x$ to broker $y$ has been sent at time $t$. On the other hand, every broker disseminates the broadcast message including a scalar, which size is 1 for one number, the time-stamped information that represents the maximum gossip round, which means its deadline (lifetime), to subscribers only using gossips. From brokers to subscribers, because all messages are based on P/S using gossip protocols and dependent on each periodic gossip round in which only one member can generate and send a message and the maximum number of gossip rounds is deadline(lifetime), all messages disseminated by brokers have same lifetime(deadline) as the maximum number of gossip rounds. And the time-stamp of the generated gossip round is as same as the one of the maximum gossip round because every message is dropped when the deadline is. Therefore, the proposed protocol implemented for P/S paradigms based on gossip protocols results in very low communication overhead.

2 The proposed protocol

In this proposed protocol, when a broker disseminates broadcast messages to its subscribers there are two cases, 1) the messages might be delivered or 2) the messages might have to be discarded. Let us a description of the protocol shown in figure 1 (lines RMS2) for 1) delivering a message and an example in figure 3. This is the case of message red$_{33}$ arrived at subscriber $S_3$. If the predicate Del$_{ok}$ = $\text{deadline\_color}_m > \text{deadline\_color}_i \lor \text{logical\_deadline}_m = (\text{current\_color} = \text{min}({\text{Deadline\_arr\_succ}_m})) \land \text{deadline\_color}_\text{min} = \text{current\_color}_\text{min}$ is true. This is the case of message red$_{33}$ arrived at subscriber $S_3$ not receiving $B_1$. In the current red round, message red$_{33}$ should be delivered because the color of its deadline round is as same as the color of the current round. And also, if the predicate $\text{logical\_deadline}_m > \text{min}({\text{Deadline\_arr\_succ}_m})$ is true, message $m$ should be delivered. This is the case of deliveries of yellow$_{A1}$ and blue$_{B2}$ at subscriber $S_3$. Upon the deadline of
message red\textsubscript{3} at subscriber S\textsubscript{3}, the logical deadline of messages yellow\textsubscript{A1} and blue\textsubscript{B2} becomes the deadline of red\textsubscript{3} in order not to violate causal order. As an example, upon the arrival of message m\textsubscript{4} at destination D, the logical deadline of messages m\textsubscript{2} and m\textsubscript{3} becomes deadline\textsubscript{m4}.

For 2) discarding a message, when deadline\textsubscript{color} \textsubscript{m} ≤ deadline\textsubscript{color} \textsubscript{m'}, at subscriber S\textsubscript{i}, deadline\textsubscript{color} \textsubscript{m'} have been arrived and deadline\textsubscript{color} \textsubscript{m} are not yet delivered to the application layer. This means that if the two messages are represented in the same color, then the one, \textsubscript{m} was generated in \(|\log N+1|-\text{rounds}\) ahead of the gossip round of the other, \textsubscript{m'}. So, \textsubscript{m} has bypassed deadline\textsubscript{m} and if its delivery violates causal order, then it should be discarded. In figure 3, this is the case of message red\textsubscript{B1} arrived at subscriber S\textsubscript{3}. On receiving message red\textsubscript{B3}, subscriber S\textsubscript{3} delivers yellow\textsubscript{A1}, blue\textsubscript{B2} and red\textsubscript{B3} to the application layer in order not to violate deadline-constraints causal order. So, if red\textsubscript{B1} has bypassed deadline (lifetime)=\(|\log N+1|\) rounds ahead of the current gossip round, red\textsubscript{B1} should be discarded because its delivery violate causal order. Let us a description of the protocol shown in figure 5 (lines RMS1) for 2) discarding message red\textsubscript{B1}. If the predicate too\textsubscript{late}(deadline\textsubscript{color} \textsubscript{m} < current\textsubscript{color}) or Del\textsubscript{viol_CO} ≡ (deadline\textsubscript{color} \textsubscript{m} ≤ deadline\textsubscript{color} \textsubscript{m'}) is true, then m is discarded. The case of red\textsubscript{B1} is that the predicate too\textsubscript{late} is true. Message red\textsubscript{B1} was generated in the gossip round, \(|\log N+1|-\text{rounds}\) ahead of the current gossip round and it has bypassed deadline\textsubscript{m}=\(|\log N+1|=3\). And also, the latest message for all destinations is updated after deliveries of yellow\textsubscript{A1}, blue\textsubscript{B2} and red\textsubscript{B3} in order not to violate deadline-constraints causal order. So, red\textsubscript{B1} should be discarded.

![Fig. 1. An example of messages with 1-Scalar from brokers to subscribers](image)

3 Conclusion

This paper proposed deadline-constraints causal order protocol respecting \(\Delta\) based on scalable P/S architecture consisting of a cluster of stable brokers for
broadcast of real-time collaborative applications in social networks to guarantee causally ordered messages delivery from brokers to subscribers. In between brokers, because collaborative broadcast messages are based on IP-Multicast and gossip protocols, their messages have their unique deadline (lifetime). But, from brokers to subscribers, all messages disseminated by brokers have same lifetime (deadline) as the maximum number of gossip rounds because all messages are based on P/S architecture using gossip protocols, in which every round is fixed and periodic. So, the maximum number of gossip rounds is the deadline (lifetime) of all messages sent by every broker. From brokers to subscribers, the maximum gossip rounds, deadline represented in colors as the lifetime of the immediate message is piggybacked on each broadcast message and transmitted to subscribers. And if a message has bypassed its deadline and if its delivery violates causal order, then it should be discarded. The proposed protocol needs a 1-Scalar because one color of the lifetime represents the deadline of the last messages of each broker.

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