State Machine Replication using Paxos

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ABSTRACT

This LaTeX document presents our implementation of a State Machine Replication system, which will replicate a simple application whose state is a HashMap, using the Paxos protocol to run consensus among the replicas.

1 INTRODUCTION

ACM's consolidated article template, introduced in 2017, provides a consistent LaTeX style for use across ACM publications, and incorporates accessibility and metadata-extraction functionality necessary for future Digital Library endeavors. Numerous ACM and SIG-specific LaTeX templates have been examined, and their unique features incorporated into this single new template.

If you are new to publishing with ACM, this document is a valuable guide to the process of preparing your work for publication. If you have published with ACM before, this document provides insight and instruction into more recent changes to the article template.

The "acmart" document class can be used to prepare articles for any ACM publication — conference or journal, and for any stage of publication, from review to final "camera-ready" copy, to the author's own version, with *very* few changes to the source.

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2 RELATED WORK

This implementation relies on the Babel framework as well as some notions of Distributed Systems that the reader must know to understand the project itself.

2.1 Babel Framework

Babel is an internal framework developed at NOVA LINCS by:

- Pedro Fouto
- Pedro Ákos Costa
- Jo ao Leit ao

Its function is to allow stacking protocols, where each protocol is a Java class that extends a GenericProtocol class.

Each protocol uses a series of handlers and can consume the following types of events:

- Messages (sent through the network and among protocols)
- Timers
- Requests (that generate Replies)
- Notification

Each type of event also has an abstract class (GenericMessage, GenericRequest...) that it extends.

2.2 YCSB

YCSB, or "Yahoo! Cloud Serving Benchmark" is an open-source program suite that will simulate clients for the experimental evaluation of this project.

Each YCSB instance emulates multiple client by executing multiple threads, being each thread a client.

We won't go too deep into this part of the project because we were already provided with the code needed to use YCSB and the main focus of the project is the protocol implementation.

2.3 State Machine Replication

2.4 Paxos / Multi-Paxos

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2.5 Implementation

The primary parameter given to the "acmart" document class is the *template style* which corresponds to the kind of publication or SIG publishing the work. This parameter is enclosed in square brackets and is a part of the documentclass command:

```
\documentclass[STYLE]{acmart}
```

Journals use one of three template styles. All but three ACM journals use the acmsmall template style:

- `acmsmall`: The default journal template style.
- `acmlarge`: Used by JOCCH and TAP.
- `acmtog`: Used by TOG.

The majority of conference proceedings documentation will use the `acmconf` template style.

- `acmconf`: The default proceedings template style.
- `sigchi`: Used for SIGCHI conference articles.
- `sigchi-a`: Used for SIGCHI "Extended Abstract" articles.
- `sigplan`: Used for SIGPLAN conference articles.

2.6 Template Parameters

In addition to specifying the *template style* to be used in formatting your work, there are a number of *template parameters* which modify some part of the applied template style. A complete list of these parameters can be found in the *LaTeX User's Guide*.

Frequently-used parameters, or combinations of parameters, include:

- `anonymous,review`: Suitable for a "double-blind" conference submission. Anonymizes the work and includes line numbers. Use with the `\acmSubmissionID` command to print the submission's unique ID on each page of the work.
- `authorversion`: Produces a version of the work suitable for posting by the author.
- `screen`: Produces colored hyperlinks.

This document uses the following string as the first command in the source file:

`\documentclass[sigconf]{acmart}`

3 IMPLEMENTATION

PAXOS PSEUDOCODE

Main class HashApp ¡-¿ State Machine Replication State Machine Replication State Machine Replication ¡-¿ Paxos Paxos

4 EXPERIMENTAL EVALUATION

The experimental evaluation focuses mainly on the throughput of the system (number of operations per second) and the latency (delay of answer, in miliseconds)

- Throughput (N^o of clients: Ops/s)
  - 3: 1107.4401520884476
  - 6: 1505.1476048084448
  - 9: 1491.594862947292
  - 12: 1516.7218584898505
  - 15: 1501.8021625951142
  - 18: 1517.2895140121686
  - 21: 1498.8758431176618
  - 24: 1486.134366361844
  - 27: 1464.0788260039922
  - 30: 1516.7218584898505
- Latency (N^o of clients: ms)
  - 3: 1871.4267335055558
  - 6: 2640.9449252426966
  - 9: 4010.093167300246
  - 12: 5248.2858474258865
  - 15: 6636.668101950097
  - 18: 7887.48085871297
  - 21: 9274.812994689279
  - 24: 10757.622081903504
  - 27: 12192.496376283592
  - 30: 13110.51947681645

5 CONCLUSIONS

The title of your work should use capital letters appropriately - https://capitalizemytitle.com/ has useful rules for capitalization. Use the `title` command to define the title of your work. If your work has a subtitle, define it with the `subtitle` command. Do not insert line breaks in your title.

If your title is lengthy, you must define a short version to be used in the page headers, to prevent overlapping text. The `title` command has a "short title" parameter:

`\title[short title]{full title}`

6 ACKNOWLEDGMENTS

Identification of funding sources and other support, and thanks to individuals and groups that assisted in the research and the preparation of the work should be included in an acknowledgment section, which is placed just before the reference section in your document.

This section has a special environment:

`\begin{acks}`

`...`

`\end{acks}`

so that the information contained therein can be more easily collected during the article metadata extraction phase, and to ensure consistency in the spelling of the section heading.

Authors should not prepare this section as a numbered or unnumbered `\section`; please use the "`acks`" environment.

ACKNOWLEDGMENTS

To Robert, for the bagels and explaining CMYK and color spaces.