

High Throughput, Byzantine Fault-Tolerant Web Services Using Layer 2 Blockchain

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Abstract—abstract placeholder

Index Terms—layer 2 blockchain, web services, Byzantine fault tolerance, scalability, rollup

I. INTRODUCTION

Modern web services play a foundational role in mission-critical and multi-stakeholder applications such as logistics, finance, and supply chain management. These services typically follow a centralized request-compute-response model, where a single web server processes client requests and responds accordingly. While straightforward, this architecture is inherently vulnerable to single points of failure and malicious behavior. Simpler faults like those categorized as Crash Fault, where a server becomes unresponsive, can be mitigated through redundancy and failover mechanisms. However, more complex failures, such as those arising from Byzantine Faults, are much harder to address. In a Byzantine Fault, a server may not only fail to respond but may also provide incorrect or misleading responses. Byzantine faults arise from malicious computation or compromised infrastructure, posing a severe risk to the integrity, reliability, and auditability of web-based services. To address this, recent efforts such as DeWS (Decentralized and Byzantine Fault-tolerant Web Services) have introduced a novel decentralized interaction model: request-compute-consensus-log-response. In DeWS, multiple web servers, distributed across organizational domains, independently execute client requests. The responses are then subjected to Byzantine Fault Tolerant (BFT) consensus, and both requests and responses are recorded immutably on a blockchain ledger.

This architecture offers strong guarantees of integrity, auditability, and availability, even in adversarial environments. However, these benefits come at a cost: high end-to-end latency and limited scalability, particularly as the number of consensus nodes increases. DeWS, like most Layer 1 (L1) blockchain-backed systems, struggles to meet the performance demands of high-throughput web services. With the advent of Layer 2 (L2) blockchain technologies, including rollups and sovereign sidechains, new possibilities emerge for scaling decentralized services while preserving trust assumptions. These techniques offload transaction processing and state transitions to an auxiliary layer, while committing periodically to a secure L1 blockchain. By doing so, they significantly improve

throughput and reduce latency, without discarding the fault tolerance and finality guarantees provided by the underlying BFT consensus. In this paper, we propose an extension to DeWS that leverages L2 blockchain mechanisms to improve throughput and responsiveness, while still inheriting the strong BFT guarantees of the L1. Specifically, we integrate Rollkit, a sovereign rollup framework compatible with CometBFT and the Cosmos SDK, as an L2 execution environment for DeWS. This hybrid design allows asynchronous batching and processing of client requests, followed by periodic anchoring to a secure and decentralized L1 ledger. Our evaluation shows that this architecture can double the transaction throughput under load, with substantial reductions in latency during peak demand.

The contributions of this paper are threefold:

- We identify the scalability bottlenecks of DeWS and motivate the need for a layered BFT architecture.
- We design and implement a two-layer *DeWS++* framework that combines sovereign rollups with BFT-backed finality.
- We empirically evaluate the latency and throughput improvements of our architecture, demonstrating its applicability to high-demand decentralized web services.

II. EASE OF USE

A. Maintaining the Integrity of the Specifications

The IEEEtran class file is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

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Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections III-A–III-E below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not number text heads— \LaTeX will do that for you.

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
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- Use a zero before decimal points: “0.25”, not “.25”. Use “cm³”, not “cc”).

C. Equations

Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \quad (1)$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not “Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

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Please use “soft” (e.g., `\eqref{Eq}`) cross references instead of “hard” references (e.g., (1)). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don’t use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

Please note that the `{subequations}` environment in \LaTeX will increment the main equation counter even when there are no equation numbers displayed. If you forget that,

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\LaTeX does not work by magic. It doesn’t get the bibliographic data from thin air but from .bib files. If you use \LaTeX to produce a bibliography you must send the .bib files.

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- The word “data” is plural, not singular.
- The subscript for the permeability of vacuum μ_0 , and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
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- In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
- Do not confuse “imply” and “infer”.
- The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the “et” in the Latin abbreviation “et al.”.
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An excellent style manual for science writers is [?].

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The class file is designed for, but not limited to, six authors. A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

G. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

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a) *Positioning Figures and Tables:* Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

TABLE I
TABLE TYPE STYLES

Table Head	Table Column Head		
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^aSample of a Table footnote.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of



Fig. 1. Example of a figure caption.

quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

ACKNOWLEDGMENT

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REFERENCES

Please cite all your references [1], [2]. References are stored in a bibtex file “references.bib”. You can use Mendeley or Jabref for your reference manager.

REFERENCES

- [1] S. Bhawal, H. Patel, K. Hatua, K. Vasudevan, and S. Bhattacharya, “Solid state transformer based on naturally cell balanced series resonant converter with cascaded h-bridge cells switched at grid frequency,” *IEEE Transactions on Power Electronics*, pp. 1–14, 2023.
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