Flash Bids: A Live Flash Auctioning System

1st Arsalan Anwar
MS Computer Science
New York University
New York, US
ax2134@nyu.edu

2nd Affan Arif Khamse
MS Computer Science
New York University
New York, US
ak10529@nyu.edu

3rd Aditya Mittal
MS Computer Science
New York University
New York, US
am13294@nyu.edu

4th Jugal Pumbhadia
MS Computer Science
New York University
New York, US
jp6988@nyu.edu

Abstract—**Flash Bids is a Live Flash Auctioning System that is designed to revolutionize online auctions by providing a low-latency, real-time bidding experience. Built to address common issues such as latency, unfair bidding practices, and lack of scalability, this system introduces synchronized countdown timers, sniping prevention mechanisms, and robust notification systems. Utilizing a scalable architecture based on Amazon Web Services (AWS), the system ensures seamless user engagement even during peak traffic periods. This paper outlines the system's architecture, features, and future potential while comparing it to existing solutions.**

Index Terms—**Auctions, WebSockets, Cloud, Scalability, AWS, Analytics, EventBridge, DynamoDB, AutoScaling**

I. PROBLEM STATEMENT

Online auctions face severe challenges, including disrupted user trust and poor user experience. High latency disrupts real-time bidding, while unfair practices like "sniping"-a practice where users win auctions with last-second bids-frustrate participants of such auctions. Most of the platforms also lack scalability, leading to poor performance during high traffic. These challenges limit the adoption of online auctions as a trusted and efficient means for buying and selling goods.

II. MOTIVATION

With today's technology, online auction platforms incorporate a lot of pain points. Participants experience lag especially when the most crucial moments when every timely bid is crucial may get sniped, are unaware by users, and there is not much scalability, making scalability extremely hard for the platform whenever demands increase. Live Flash Auctioning System addresses these aspects that make the user experience even more interactive, build trust in end users, and foster fair bidding. It leverages advanced technology in executing real-time engagement, scalability, and fair online auctions.

III. EXISTING SOLUTIONS

Several platforms attempt to provide real-time auction experiences, but they have limitations

- **eBay Live Auctions:** While popular, this platform often faces latency issues and lacks sniping prevention features.
- **Invaluable:** Offers live bidding but does not implement dynamic auction extensions to counter last-second bids.
- **LiveAuctioneers:** Hosts global auctions but struggles with scalability and peak traffic handling.

These platforms highlight the need for an advanced solution that prioritizes real-time responsiveness, fairness, and scalability.

IV. FEATURES

a) Real-Time Bidding Interface:: The system provides a user-friendly, real-time bidding interface where auctioneers can easily set up product details, including the auction start date, time, and overall duration. Once the auction is live, participants have immediate access to product listings scheduled for the given time. They can view the total number of bids already placed, monitor how the bidding dynamics evolve, and actively participate by placing their own bids. The interface is designed to ensure that all users receive consistent and prompt updates, creating an immersive and engaging environment.

b) Bidding Mechanism:: At the core of the system is a robust, low-latency bidding mechanism powered by Web-Sockets. This technology supports instant bid submissions and updates, even when thousands of participants act simultaneously. The system ensures that every incoming bid is processed accurately, maintaining fairness and transparency. By the close of the auction, the highest bidder is clearly identified, making the entire process straightforward and trustworthy.

c) Dynamic Countdown Timer:: A synchronized, real-time countdown timer ensures that every participant sees the exact same remaining time, fostering a level playing field. Leveraging WebSockets, the timer's updates are broadcast instantly, eliminating discrepancies caused by network delays or device differences. As a result, all users share a uniform sense of urgency, enhancing the excitement and fairness of the bidding experience.

d) Auction Notifications:: The platform integrates seamlessly with Amazon Simple Email Service (SES) to keep users informed about critical events before, during, and after the auction. Personalized email notifications deliver comprehensive product details and precise timing information. Once the auction concludes, winners receive confirmation emails, allowing participants to stay updated without needing to constantly check the platform.

e) Sniping Prevention:: To counter last-second "sniping" tactics, the system extends the auction's duration if a bid arrives in the final minutes. For example, if a bid is placed within the last few minutes, an automatic time extension (e.g., five additional minutes) is triggered. This extension is
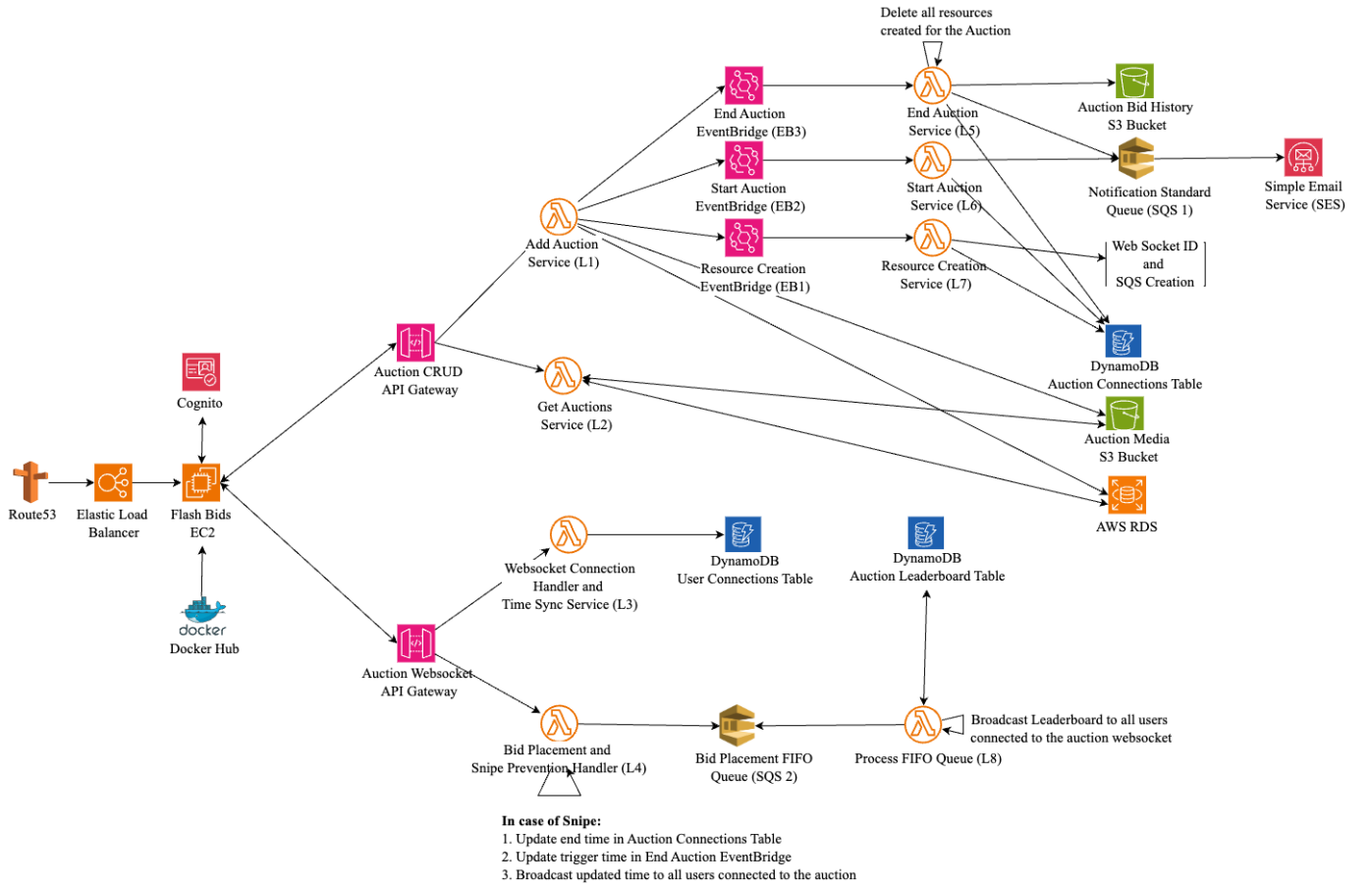
Fig. 1. System Architecture Diagram

communicated to all users immediately, giving everyone a fair opportunity to respond. This approach promotes a balanced environment where the winning outcome reflects genuine engagement rather than last-moment advantages.

f) User Authentication:: The platform leverages AWS Cognito for secure user authentication and account management. This ensures that only verified users can participate in bidding, enhancing overall trust and maintaining a safe marketplace environment.

g) Auction Bid History and Post-Analytics:: When an auction concludes, the system triggers an AWS EventBridge event to compile the complete bidding history and export it as a CSV file to an Amazon S3 bucket. This archival process supports post-auction analytics, allowing stakeholders to examine bidding patterns, participant engagement levels, and other metrics. Such insights drive continuous improvement, helping optimize future auctions and refine the platform's features.

h) Scalability:: To handle variable user loads, the system employs AWS EC2 instances with auto-scaling groups. As user traffic fluctuates, additional computing resources spin up or down automatically, ensuring optimal performance during peak usage and cost-efficiency during quieter periods. This dynamic scaling capability maintains a seamless user experience

regardless of demand.

V. SYSTEM ARCHITECTURE

The Live Flash Auctioning System is built with a robust and scalable architecture, with a broad set of AWS services to ensure low latency, scalable, and fair processing of bids during live auctions. Each plays an important role in the overall system, making it reliable and real-time.

A. WebSockets

WebSockets form the backbone of real-time communication in the Live Flash Auctioning System. The continuous, low-latency, bidirectional connection provided by WebSockets keeps the users updated about the current highest bid, leaderboard changes, and extensions in the countdown timer. These WebSocket APIs handle critical actions such as user connections, disconnections, and auction-related requests like placing bids or fetching auction details. It also ensures instant pushing of user updates for great interactivity and flow in bidding through WebSocket. Such a service would basically be impossible to refuse in any real-time synchronized updates-a cornerstone ingredient, if there is one-when considering live auctions.

B. Amazon DynamoDB

AWS DynamoDB provides the backbone to function as the primary data storage device for maintaining the system of auctions metadata, bid details, or user connections.

- **Auction metadata:** The `auction-connections` table contains auction information, like the beginning and ending time, the sniping setup, and even the current status of an auction. In this regard, this will be highly helpful in the dynamic control of auction events.
- **Leaderboard Data:** The `AuctionLeaderboards` table keeps the log of the bids, which also include information about users and bid amounts along with the time of the bids. It helps in efficient leaderboard generation along with real-time updates.
- **User Connections:** `user-connections` table maps WebSocket connections to users and auctions, making it possible to communicate real-time with a particular user in an auction.

Hence, DynamoDB ensures that such real updates are appropriately availed via low-latency reads and writes; in turn, the former should support high-concurrency rates in scalability for peak auction activities. Any database not performant at scale, like DynamoDB, results in bottlenecks regarding the retrieval or updating of data. The bottom line is that such action compromises the real-time experience of the system.

C. Amazon SQS FIFO Queue

The FIFO Queue in Amazon SQS plays a pivotal role in ensuring that the bid submission processing is done in a fair and reliable manner. It guarantees strict message ordering with deduplication, something critical in handling concurrent bids within a competitive auction environment.

- Each bid from a user is sent to an SQS FIFO queue by the `WebSocketBidActions` lambda with a unique deduplication ID consisting of the auction ID, user ID, user name, bid amount, and timestamp.
- The `WebSocketProcessPriorityQueue` Lambda trigered by the dynamic auction-specific queue processes these bids one by one to maintain the order of bids precisely.
- The FIFO queue allows the overall system to scale and absorb peaks without interfering with processing fairness by decoupling bid ingestion from processing.

It means this service ensures the integrity and reliability of the bidding process, forming a core role in maintaining users' trusts in the auction system.

D. Amazon S3

Amazon S3 is used to host all the media content, like the images associated with the auctions; these media will be pretty crucial for the users to better represent things that are getting auctioned. S3 ensures:

- High availability and reliability in accessing media files.
- Scalability to support the high volume of media uploads and downloads.

- Affordable-cost-effective in that it includes multi-tiered storage levels that best fit the fluctuating patterns of access required by media related to an auction.

Serving media on S3 allows for better user experience through faster and reliable delivery of content, even at high volumes of traffic.

E. Amazon SES

Amazon Simple Email Service is employed to send the personalized email notifications, which include:

- Notifications of upcoming auctions to aid participation.
- Notifications about the winner and top bidders after the auction has ended.

SES will ensure high deliverability and reliability for sending the emails, thereby permitting effective communication with the users by improving user engagement. At any live auction system, notification is required to be sent on time and in a reliable way; otherwise, user interest will not be maintained.

F. AWS Cognito

AWS Cognito handles user authentication and management to ensure that only authorized users can participate in auctions. Features include:

- Secure authentication mechanisms.
- User management with roles and permissions.

Strong security by Cognito keeps the system safe while creating a seamless login and participation experience for users.

G. Amazon EC2 with Auto-Scaling and Load Balancer

Amazon EC2 instance host the Flash Bids front end application of the auction system. In a system that has a lot of variability in its load, the following will help create consistency:

- **Auto-Scaling:** Automatically scales the number of EC2 instances according to the traffic, ensuring everything will be cost-effective and available.
- **Load Balancer:** Distributes incoming traffic uniformly across instances to avoid bottlenecks and maximize performance.

It is a setup that ensures spikes in user activities, like during peak bidding, do not impair performance.

H. Route53

Amazon Route53 manages domain name resolution and routing for the system, ensuring seamless accessibility. Features include:

- Reliable domain management for the auction platform.
- Low-latency routing for users worldwide, improving user experience.

Route53 ensures that users can access the system reliably and with minimal delays, which is critical for real-time auctions.

I. CloudWatch

Amazon CloudWatch helps in monitoring the system performance and logs all events for troubleshooting. It provides:

- Real-time metrics on system health and performance.
- Alerts for anomalies or failures, enabling proactive resolution.
- Detailed logs for debugging and performance optimization.

CloudWatch plays a crucial role in maintaining the reliability and stability of the auction system by providing actionable insights into its operation.

J. DockerHub

DockerHub is used to store container images for the system's services. These images are pulled by EC2 instances to deploy the system's backend and associated components. By using DockerHub:

- Consistent deployment environments are ensured across development, testing, and production.
- Deployment times are reduced, allowing for faster updates and rollbacks.

This setup enhances the system's scalability and maintainability, making it easier to manage updates and handle high traffic.

K. Interdependencies and Flow

The architecture is seamlessly integrated, with services working in unison to deliver a seamless auction experience. For example:

- A bid placed via WebSocket triggers updates to DynamoDB and SQS.
- SQS ensures ordered bid processing, with updates broadcasted via WebSocket after leaderboard modifications in DynamoDB.
- EventBridge dynamically manages auction timelines, with updates relayed to users in real time.
- EC2 and Auto-Scaling ensure backend services remain responsive under heavy loads, supported by Route53 for reliable access.

This interconnected flow ensures that the system is robust, scalable, and user-friendly, meeting the demands of live auctions effectively.

VI. FUTURE WORK

The Live Flash Auctioning System can be strategically enhanced on different fronts to increase user interactivity, operational efficiency, and broader reach. The suggested developments would involve:

A. Development of Native Mobile Applications

Developing native mobile applications for both iOS and Android increases the reach, consequently increasing accessibility to the target audience. Applications built as natives can offer greater performance and a seamless user experience due to leveraging platform-specific features and optimizations. Native applications have the following advantages:

- **Enhanced Performance:** Native apps are compiled using platform-specific programming languages and APIs, resulting in faster execution and more responsive interfaces. This eventually leads to a smoother user experience, which is important for anything involving real-time auction activities.
- **Security and Reliability:** Applications distributed through app stores need to pass various rigid security checks, which are very assuring for the safety of user data and integrity of the auction process.

Investing in mobile-native applications lets the system gain better outreach to a higher audience with more interactive user experiences that are consistent.

B. Incorporating AI-Driven Insights

It allows the integration of AI into an auction platform to make personalized recommendations, affording it a better insight into the behavior of bidders. The integration of AI within the auction house provides several key benefits:

- **Personalized User Experience:** AI algorithms analyze users' behavior and preferences for item suggestions in auctions so that user satisfaction and engagement are not at stake.
- **Bidder behaviour analysis:** AI can identify behaviors while bidding, enabling the facilitation of anomaly detection.
- **More operability:** Automating frequent operations such as data collection, entry, and analysis frees up staff energy and time to focus efforts on strategic activities.

AI in auction management presents great opportunities for the industry across its value chain. This will, in turn, make the auction environment much more dynamic and responsive to user needs and behaviors driven by AI-powered insights.

C. Globalization Efforts

Expanding the platform's reach to a global audience involves implementing multi-language support and accommodating various local payment gateways. These efforts include:

- **Multi-Language Support:** Providing content in multiple languages ensures that users from different regions can interact with the platform comfortably, thereby broadening the user base.
- **Local Payment Integration:** Supporting region-specific payment methods facilitates seamless transactions for international users, enhancing trust and convenience.
- **Compliance with Local Regulations:** Adhering to regional laws and standards ensures smooth operation across different markets and fosters user confidence.

By addressing these aspects, the platform can effectively cater to a diverse, international clientele, promoting inclusivity and expanding its market presence.

VII. RESULTS

The initial testing phase of the Live Flash Auctioning System has yielded highly promising outcomes, validating the architectural choices and implementation strategies. The

system's performance, reliability, availability, and scalability were rigorously evaluated under simulated conditions, and the results emphasize its robustness and potential for transformative impact in the online auction landscape.

A. Performance: Latency Reduction

Some of the key highlights of the system were sub-second communication latency, owing to the use of WebSockets. This helped in making it extremely responsive during real-time bidding. Unlike typical HTTP-based systems, which would involve a lot of time and latency due to repeated requests and responses, WebSockets establish persistent connections in which bids can be instantly posted or updates made to the leaderboard. The low latency further improved user satisfaction and competitiveness in the bidding process, ensuring a dynamic and engaging auction environment.

B. Reliability: Ensuring Fairness

Fairness regarding the auction process was sufficiently met through its anti-snipe mechanism that would automatically extend the closing time of auctions once a last-minute bid arrived within a recognized sniping window, preventing users from getting an unfair advantage of others due to last-second bids.

C. Availability: Continuous Operation Under High Load

Integration of EC2 with auto-scaling facilitated dynamic resource scaling, and hence continuous operation was experienced even on heavy loads. The load balancer, by distributing incoming requests across a set of instances, avoided possible bottlenecks and loss of system responsiveness.

D. Scalability: Handling Dynamic Traffic Patterns

Another major result of the testing phase was the scalability of the Live Flash Auctioning System. The auto-scaling mechanism, together with the elasticity provided by AWS services, allowed the system to scale either up or down depending on the demands of the traffic. Such scalability ensures that real-world auction events, such as those where traffic is unpredictable, are appropriately handled by the platform to ensure an ideal user experience.

VIII. Conclusion

The Live Flash Auctioning System is setting new standards for online auction platforms effectively by solving some critical challenges like latency, fairness, and scalability. On a robust AWS-based architecture backbone, this system will offer seamless, responsive, nondiscriminatory auctioneering to ensure high user engagement with operational efficiency. The integration of WebSockets for immediate messaging, sniping prevention allowing a guarantee of fairness, and auto-scaling permitting dealing with dynamic traffic patterns put it well ahead in the race compared with most competitors.

Besides, it shows that, given this system can even learn how to accommodate notifications in view of different users' needs. This creates a foundation for what added features include AI-powered insight, blockchain, and global use, but all will be in-house features for when the platform gets enhancements in the future-assuring that wide use covers even more grounds, further cements its position on the very top in the online auction platforms leaderboards.

While top priorities for innovation, user trust, and system robustness set the bar high, the Live Flash Auctioning System not only meets but indeed outpaces modern-day auctioneers' and participants' expectations. A transformational approach of this nature is sure to assure benefits for stakeholders across the spectrum, introducing a new era of transparency, engagement, and operational excellence within the online auction industry.

REFERENCES

[1] "Amazon Web Services Documentation," Amazon Web Services. [Online]. Available: https://docs.aws.amazon.com [Accessed: Dec. 12, 2024].

[2] "Introducing WebSocket APIs in Amazon API Gateway," Amazon Web Services. [Online]. Available: https://docs.aws.amazon.com/apigateway/latest/developerguide/apigateway-websocket-api.html [Accessed: Dec. 12, 2024].

[3] "Amazon SQS FIFO Queues," Amazon Web Services. [Online]. Available: https://docs.aws.amazon.com/AWSSimpleQueueService/latest/SQSDeveloperGuide/sqs-fifo-queues.html [Accessed: Dec. 12, 2024].

[4] "Getting Started with DynamoDB," Amazon Web Services. [Online]. Available: https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/GettingStartedDynamoDB.html [Accessed: Dec. 12, 2024].

[5] "Bidding System: System Design Interview," LeetCode. [Online]. Available: https://leetcode.com/discuss/interview-question/system-design/792060/Bidding-System%3A-System-Design-Interview [Accessed: Dec. 12, 2024].

[6] S. Kutti Kumar, "System Design for an Online Bidding System," Medium. [Online]. Available: https://medium.com/@shiva.kutti.kumar/system-design-for-a-online-bidding-system-adf417f39f44 [Accessed: Dec. 12, 2024].