

DIGANTARA

New-age Space Cartographers

Question 2 (Descriptive):- The web application mentioned in Question 1 has to be improved and up -scaled to a comprehensive 3D map of space objects. Explain and address the bottlenecks of scaling the web_application to the following level:

- 1 million objects - fetching position data from back-end
- Smooth rendering of data at 60 FPS
- Advanced UI
- 20+ Analytics

Answer 2:- Scaling a web application to a comprehensive 3D map of space objects with 1 million objects and 20+ analytics can pose several bottlenecks that need to be addressed. Some of the most significant bottlenecks are:

1. **Performance Bottlenecks:-** One of the major bottlenecks that may arise is the performance of the web application. With 1 million objects, the back-end system needs to be optimized for quick and efficient data fetching. The data needs to be processed and rendered at 60 FPS to ensure smooth animations.
2. **Hardware Limitations:-** Another bottleneck is hardware limitations. Collecting and processing analytics for 20+ metrics can be a challenge. Rendering a 3D map of space objects with advanced UI and 20+ analytics requires high-end hardware.
3. **Data management:-** Storing and managing data for 1 million objects can be complex and requires a scalable database architecture that can handle large volumes of data.
4. **Network Latency:-** Fetching position data from the back-end can be a bottleneck, especially with a large number of objects.
5. **Scalability:-** The web application should be designed to handle a large number of concurrent users. If we will not focus on this, then our model can crashed or may be damaged.
6. **Security:-** With large amounts of sensitive data, security is a crucial aspect that needs to be addressed. The system should be designed to ensure secure data transfer and storage.
7. **User Experience:-** The advanced UI should be intuitive and easy to use. The 3D map of space objects should be interactive, allowing users to explore and manipulate the data. An advanced UI is essential for providing an immersive experience to the users. It requires a good understanding of the user's needs, preferences, and device capabilities.

To address these bottlenecks, the following approaches can be taken:---

1. **Performance Bottlenecks:-** To handle this, the back-end should be optimized for efficient data retrieval, with caching and indexing mechanisms to minimize the number of queries and reduce response times. This requires careful optimization of algorithms, use of efficient data structures, and careful resource management.
2. **Hardware Limitations:-** This can include powerful CPUs, GPUs, and large amounts of RAM. Therefore, the system needs to be designed to work optimally on different hardware configurations, including low-end systems. It requires an efficient data collection mechanism and scalable data processing pipelines.
3. **Database Management:-** Use a distributed database architecture that can scale horizontally and handle large volumes of data. To storing and retrieval the data of 1 million objects is not easy so we need to use scalable database for example Google Map use the Bigtable database for storing the data as a coordinates.
4. **Network Latency:-** The system should be designed to minimize network latency and optimize data transfer between the front-end and back-end.
5. **Scalability:-** The system should be scalable and able to handle spikes in traffic. This can be achieved through the use of load balancers, clustering, and other scalability techniques.
6. **Security:-** security of data is crucial for space agencies to maintain confidentiality, ensure data integrity, comply with regulations, and achieve their mission objectives.
7. **User Interface:-** Use responsive design techniques to provide an advanced UI that can adapt to different device sizes and capabilities. To create a positive user experience, it's important to address the above issues (which are mention in UI bottlenecks) and optimize the application for performance, navigation, responsiveness, mobile devices, and accessibility.

To overcome these bottlenecks, the system needs to be designed carefully, with a focus on performance, scalability, and security. The use of efficient algorithms, data structures, and hardware optimization techniques can help ensure smooth rendering at 60 FPS. The system should be designed to handle large amounts of data and be scalable to handle spikes in traffic. A user-friendly interface and intuitive design can improve the user experience, making it easier to explore the 3D map of space objects.

Overall, scaling a web application to a comprehensive 3D map of space objects requires a combination of efficient algorithms, scalable architecture, and optimized software design.

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