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# INTRODUCTION

Efficient cost management is essential for the deployment and growth of any program. For this project, forecasting user growth, comprehending scaling necessities, and assessing cost implications are essential to maintaining system sustainability as user demands escalate.

This document provides a comprehensive analysis of:

1. Predicted user growth over two years under various scenarios.
2. Scaling thresholds for technologies used in the architecture, with associated cost implications.
3. Predictive models of running costs in R for best-case, worst-case, and mean growth scenarios.
4. Recommendations for alternative technologies to mitigate costs when system limits are reached.

# PREDICTED USER GROWTH

Predictive growth analysis is crucial for comprehending the evolution of user uptake and system demand over time. Modelling user growth across various scenarios — best-case, worst-case, and mean-case — enables the anticipation of resource needs and expenses related to application scalability. This data informs budgeting and guarantees the application architecture can respond to fluctuating user activity levels.

This analysis not only informs budgeting but also ensures that the application architecture can adapt to varying levels of user activity. In this document, user growth is projected over a two-year period, with monthly increments, enabling detailed predictions of resource utilisation and cost implications under each scenario. Such predictive modelling provides a foundation for proactive planning, ensuring the application remains responsive, scalable, and cost-efficient as its user base expands.

**Assumptions:**

1. The application starts with **65 users**, including Admins, Coaches, and Clients.
2. Growth rates vary based on adoption:

* **Best Case**: 10% monthly growth.
* **Worst Case**: Minimal growth (2–3 new users monthly).
* **Mean Case**: 5% monthly growth.

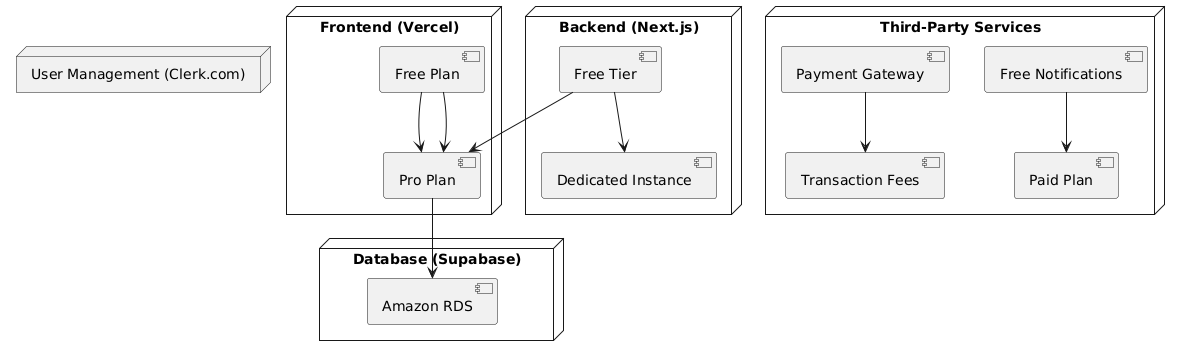
1. Growth factors include marketing efforts, word-of-mouth, and seasonal activity.

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Best Case (Users)** | **Worst Case (Users)** | **Mean Case (Users)** |
| Month 1 | 65 | 65 | 65 |
| Month 6 | 106 | 85 | 95 |
| Month 12 | 226 | 100 | 163 |
| Month 18 | 490 | 115 | 305 |
| Month 24 | 786 | 130 | 460 |

# SCALING POINTS OF EACH TECHNOLOGY

As user adoption grows, the application’s architecture must accommodate increasing demand, particularly with the integration of Clerk.com for user management. Identifying the scaling points of each component — frontend, backend, database, user management, and third-party services — is critical for ensuring smooth performance and cost-effective resource utilisation. Each technology in the stack has specific thresholds, beyond which additional capacity or alternative solutions may be required. This section analyses these thresholds, linking them to projected user growth and usage patterns, ensuring optimal performance while minimising disruptions and controlling costs. By proactively planning for scalability, the application can remain responsive as demand increases.

## Considerations



(PlantText, 2024)

**Frontend (React Vercel)**

* **Scaling Point**:
  + Free plan handles **100,000 requests/month**.
  + Upgrade required for sustained traffic above this limit.
* **Cost**:
  + Pro Plan: **R 400/month per user**.
  + Enterprise Plan: **R 2,000/month per user** for high traffic.

Note: The pricing was obtained from the official website (Vercel, 2024).

**Backend (Next.js Vercel)**

* **Scaling Point**:
  + Free plan handles **10,000 requests per second** but struggles with sustained loads over 1 million requests/month.
* **Cost**:
  + Pro Plan: **R 400/month per user**.
  + Enterprise Plan: Starts at **R 3,000/month**.

Note: The pricing was obtained from the official website (Vercel, 2024).

**Database (Supabase)**

* **Scaling Point**:
  + Free tier supports **50,000 active users** and **1 GB storage**.
  + Pro Plan required beyond these limits.
* **Cost**:
  + Pro Plan: **R 500/month**.
  + Enterprise Plan: Custom pricing (e.g., R 2,000+).

**Third-Party Services**

1. **Payment Gateway**:
   * Fees are **2.9% + R 5** per transaction.
   * For 1,000 transactions, costs are **~R 3,000/month**.
2. **Notification Service**:
   * Free tier supports **10,000 notifications/month**.
   * Beyond this, charges are **R 0.20/notification**.

Note: The pricing was obtained from the official website (Supabase, 2024).

**Clerk.com User Management**

* **Scaling Point:**
  + Free plan supports 10,000 monthly active users (MAUs).
  + Upgrade required for more users or advanced features like single sign-on (SSO).
* **Cost:**
  + Pro Plan: Starts at R 800/month for up to 10,000 MAUs.
  + Enterprise Plan: Custom pricing for higher usage or additional features.

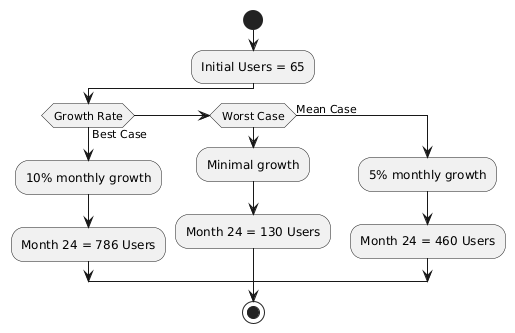
Note: The pricing was obtained from the official website (Clerk, 2024)

## Scalability within the Free Plan

Based on the current sizing and projected growth scenarios, the free tiers of Vercel (frontend and backend) and Supabase (database) should adequately support the application’s requirements for the foreseeable future. These plans provide generous allowances for requests, storage, and database rows, which align with the predicted user activity levels. However, the payment gateway is an exception, as its costs are directly tied to transaction volumes. As the user base grows and booking transactions increase, the payment gateway fees will scale proportionally. Monitoring transaction volumes and optimising processes will ensure the free plans for other services remain sufficient while managing payment-related costs effectively.

## 3.3. PREDICTIVE MODELS FOR USER GROWTH AND COSTS

Predictive growth modelling is a vital tool for forecasting user adoption and system demand over time. By examining potential growth scenarios — best case, worst case, and mean growth — this model helps anticipate the application's requirements and scalability over a two-year period. Starting with an initial user base of 65, the model evaluates growth rates of 10% (best case), minimal growth (worst case), and 5% (mean case), projecting user counts at 24 months for each scenario. This analysis provides a clear framework for resource planning, ensuring that the application can adapt to changing user demands while maintaining performance and cost efficiency. These predictions guide strategic decisions for scaling infrastructure and managing running costs effectively.



## 3.4 Assessment of Free Plan Viability

**Frontend and Backend (Vercel):**

**Free Plan Limits:**

* 125 GB bandwidth/month.
* 10 serverless function requests/second (with spikes handled up to 1,000 concurrent requests).
* 100,000 requests/month.

**Current Needs:**

Even under the Best Case scenario (786 users), assuming each user makes 10 interactions per month, the system would process ~7,860 requests/month—well within the free tier's limit.

**Recommendation:**

The free tier is sufficient for the first 24 months across all growth scenarios. No upgrade to a paid plan is required unless user activity increases significantly.

**Database (Supabase):**

**Free Plan Limits:**

* 50,000 rows and 1 GB storage.
* Up to 500,000 requests/month.

**Current Needs:**

* For 786 users, with 5 rows per user (e.g., user data, bookings, notifications), the database would contain ~3,930 rows.
* Storage requirements (~1 KB per row) would amount to ~4 MB.
* Request volume (~10 interactions/user/month) would be ~7,860 queries/month.

**Recommendation:**

The free tier provides adequate capacity for up to ~10,000 users, far exceeding the 24-month growth projection.

**User Management (Clerk.com):**

**Free Plan Limits**:

* **10,000 monthly active users (MAUs)**.

**Current Needs**:

* For 786 users, the free plan is sufficient for **24 months**, as projected user growth remains under the 5,000 MAU limit.

**Recommendation**:

* The **free tier** of Clerk.com is adequate for 24 months. Beyond this, consider upgrading to the **Pro Plan** at R 800/month for up to 10,000 MAUs if growth exceeds projections.

**Notifications:**

Free Plan Limits (e.g., Firebase Cloud Messaging or third-party service):

10,000 notifications/month.

**Current Needs:**

For 786 users sending 10 messages/user/month, the total would be 7,860 notifications/month.

**Recommendation:**

The free tier is sufficient for the 24-month growth projection.

**Payment Gateway:**

**Costs:**

Payment fees are tied to transaction volume: 2.9% + R 5 per transaction.

**Current Needs:**

For 786 users, assuming 500 transactions/month, costs are ~R 15,000/month.

**Recommendation:**

Payment gateway fees are the primary cost driver, as no free tier is available for transactions.

## Cost Predictions

**Best Case: 10% Monthly Growth**

* Users: 786 by Month 24.
* Monthly Costs:
* Frontend: Free.
* Backend: Free.
* Database: Free.
* Notifications: Free.
* User management: Free
* Payment Gateway: R 15,000 (500 transactions).
* Total Monthly Costs (Year 2): R 15,000.

**Worst Case: Minimal Growth**

* Users: 130 by Month 24.
* Monthly Costs:
* Frontend: Free.
* Backend: Free.
* Database: Free.
* Notifications: Free.
* User management: Free
* Payment Gateway: R 780 (26 transactions).
* Total Monthly Costs (Year 2): R 780.

**Mean Case: 5% Monthly Growth**

* Users: 460 by Month 24.
* Monthly Costs:
* Frontend: Free.
* Backend: Free.
* Database: Free.
* Notifications: Free.
* User management: Free
* Payment Gateway: R 6,900 (230 transactions).
* Total Monthly Costs (Year 2): R 6,900.

# ALTERNATIVE TECHNOLOGIES FOR SCALIBILITY

The current technologies employed in the application, including Supabase for the database, Vercel for the frontend and backend, and third-party services for payments and notifications, provide sufficient scalability for the foreseeable future. Supabase offers row-level security, 50,000 rows, and 2 GB of storage in its free tier, which can comfortably accommodate growth for up to two years. Similarly, Vercel's free tier for Next.js supports 125 GB bandwidth and 100,000 monthly requests, which aligns well with projected usage even under the best-case growth scenario.

However, as the application scales beyond the two-year horison, certain limitations might arise. For the database, transitioning to Amazon RDS or Google Cloud SQL would provide advanced scaling capabilities and higher storage thresholds, starting at approximately R 1,800/month. If backend traffic surpasses Vercel's free tier thresholds, AWS Lambda or a Kubernetes cluster could dynamically handle high traffic at an approximate cost of R 4,000/month. Additionally, should frontend bandwidth exceed limits, platforms like Netlify or AWS CloudFront offer global content delivery and caching, starting at R 2,000/month.

While the current stack offers sufficient capacity for projected growth, these alternative technologies ensure the application can seamlessly scale when future demands exceed current limits, enabling long-term sustainability and cost efficiency.

**Database (Supabase)**

* **Limitation**: Exceeds **1M rows** or **8 GB storage**.
* **Alternative**: Use **Amazon RDS** for dynamic scaling.
  + Cost: Starts at **R 1,800/month**.

Note: The pricing was obtained from (Amazon Web Services, 2024)

**Backend (Next.js on Vercel)**

* **Limitation**: Sustained traffic >1M requests/month.
* **Alternative**: Deploy backend on **AWS Lambda**.
  + Cost: **R 4,000/month** for 10M requests.

Note: Pricing was obtained from (Amazon Web Services, 2024)

**Frontend (Vercel)**

* **Limitation**: Traffic >10M requests/month.
* **Alternative**: Use **Netlify** for higher scalability.
  + Cost: Starts at **R 2,000/month**.

Note: Pricing was obtained from (Netify, 2024)

# CONCLUSION

The operational expenses of the program are significantly influenced by user expansion. The complimentary tiers of platforms such as Vercel and Supabase support initial growth, but advancing will necessitate deliberate enhancements. By forecasting expenses under optimal, pessimistic, and average growth scenarios, the project is prepared to address future requirements. Alternative technologies such as Amazon RDS and AWS Lambda provide solutions for managing substantial traffic and extensive datasets. Consistent oversight of system utilisation and anticipatory financial planning will guarantee the application's long-term sustainability and scalability.

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