ASE Project Report - GROUP 2

Advanced Software Engineering

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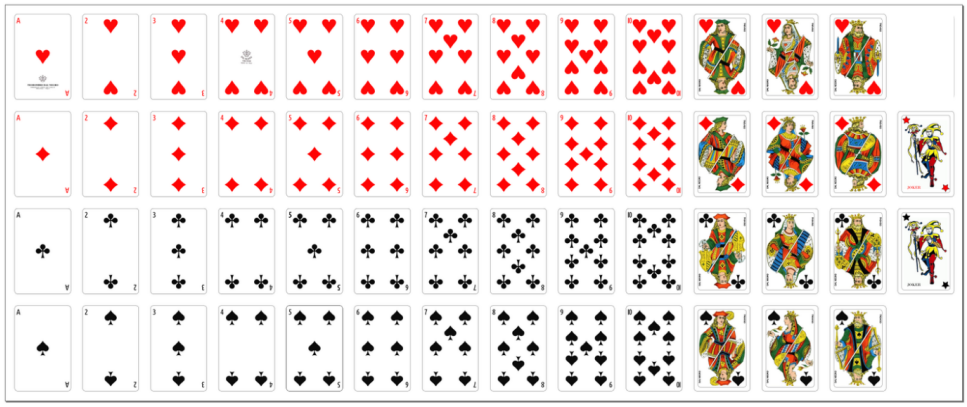
Contents

1 Cards Overview

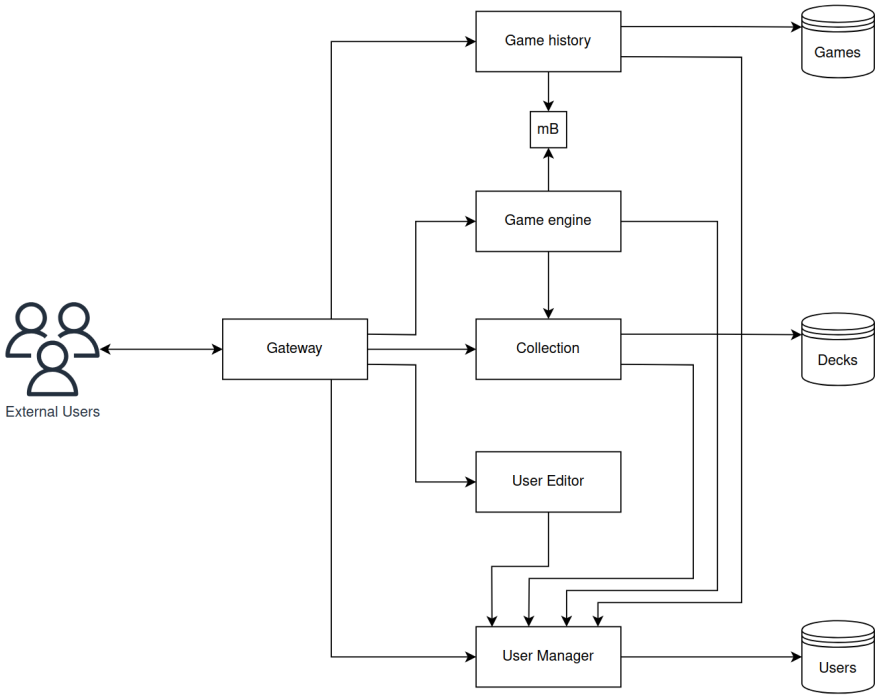
As cards we used the classical 52 + Joker deck.
As anyone could expect, the two features assigned to those cards are the number and the suit, while the Joker is a special card with no features, that beats any other card.



2 System Architecture

2.1 Architecture schema and main microservices

Below is the high-level architectural drawing of the system, illustrating the interactions between microservices.



All microservices are containerized using Docker and are written in Python. Some of them use the Flask framework and some FastAPI.
Here is a list of the main microservices of the system:

Microservice	Framework	Description
Game history	Flask	Stores and retrieves past game data
Game engine	Flask	Handles the game runtime
Collection	Flask	Handles cards and users decks
User Editor	FastAPI	Manages user profiles and settings
User Manager	FastAPI	Manages user authentication and authorization
Gateway	FastAPI	Routes requests to appropriate microservices

2.2 Design choices and microservices interactions

- **Centralized Authorization:** every microservice connects to the User Manager to verify the token header, this is for two main reasons:
  - The users can change their usernames that are stored in the User-DB, this is a way for microservices to verify they have the updated username.
  - In the future we may want to add token revocation, having a single microservice handle that would make it easier.
- **Shared persistance smell solutions:**
  - We connected a single microservice to each database (Games, Decks and Users).
  - Since as cards we've choosen the classical French-suited deck, that we don't expect to change, we've decided to hard-code their behavior and their images in the microservices, without relying on databases.
- **Game History -> User-Manager:** Game History needs to connect to User Manager also to get a list of (updated) usernames from a list of user-ids to represent the leaderboard.
- **User Editor:** We've separated the user profile editing endpoints from the user manager to keep the user manager smaller and allow horizontal scalability. The User Editor then connects to dedicated endpoints of the User Manager that allow it to update user information in the DB User-DB.
- **Separated in-game logic:** The Game Engine microservice, as the name suggest, handles the whole game logic, while delegating to Game History and Collection the handling of old games and decks.
- **Cards and decks:** The Collection microservice allows the users to see all the cards, their images and to handle their decks.
  The Game Engine will connect to this microservice to get the deck selected from the user: the user provides the deck's number and the Game Engine asks for the corresponding cards to the Collection.
- **Game History and Leaderboard:** The Game Engine delegates the Game History to store finished games. How this is handled is discussed in detail in the Additional Features section.
  This microservices then allow users to see their old matches, and allows everyone to see the leaderboard (think about a website that shows the best players to unauthenticated users).

3 User Stories

- Account

1. Create an account SO THAT I can participate to the game
   - /users/register (Gateway → User Manager → MongoDB → User Manager → Gateway)
2. Login into the game SO THAT I can play a match
   - /users/login (Gateway → User Manager → MongoDB → User Manager → Gateway)
3. Check/modify my profile SO THAT I can update my information
   - /userseditor/modify/change-username (Gateway → User Editor → User Manager → MongoDB → User Manager → User Editor → Gateway)
   - /userseditor/modify/change-password (Gateway → User Editor → User Manager → MongoDB → User Manager → User Editor → Gateway)
   - /userseditor/modify/change-email (Gateway → User Editor → User Manager → MongoDB → User Manager → User Editor → Gateway)

   Note: Profile checking is handled via token validation or login response.
4. Be safe about my account data SO THAT nobody can steal/modify them
   - Implemented via JWT Authentication, Password Hashing (Argon2) in User Manager, and HTTPS communication.

- Cards

5. See the overall card collection SO THAT I can think of a strategy
   - /collection/cards (Gateway → Collection → File System [cards.json] → Collection → Gateway)
6. View the details of a card SO THAT I can think of a strategy
   - /collection/cards/card_id (Gateway → Collection → File System [cards.json] → Collection → Gateway)

- Game

7. Start a new game SO THAT I can play
   - /game/match/join (Gateway → Game Engine → Matchmaking Queue → Game Engine → Gateway)
8. Select the subset of cards SO THAT I can start a match
   - /game/deck/game_id (Gateway → Game Engine → Game State → Gateway)
   - Alternatively for deck creation: /collection/decks (Gateway → Collection → MongoDB → Collection → Gateway)
9. Select a card SO THAT I can play my turn
   - /game/play/game_id (Gateway → Game Engine → Game Logic → Game State → Gateway)
10. Know the score SO THAT I know if I am winning or losing
    - /game/state/game_id (Gateway → Game Engine → Game State → Gateway)
11. Know the turns SO THAT I can know how many rounds there are till the end
    - /game/state/game_id (Gateway → Game Engine → Game State → Gateway)
12. See the score SO THAT I know who is winning
    - /game/state/game_id (Gateway → Game Engine → Game State → Gateway)
13. Know who won the turn SO THAT I know the updated score

    - /game/state/game_id (Gateway → Game Engine → Game State → Gateway)

14. Know who won a match SO THAT I know the result of a match
    - /game/state/game_id (Gateway → Game Engine → Game State → Gateway)
15. Ensure that the rules are not violated SO THAT I can play a fair match
    - N/A (Enforced by Logic): Handled internally by Game Engine during /game/-play/game_id execution.
    - (draft) zero trust for game engine and collection,

- Others

16. View the list of my old matches SO THAT I can see how I played
    - /history/matches (Gateway → Game History → MongoDB → Game History → Gateway)
17. View the details of one of my matches SO THAT I can see how I played
    - /history/matches (Gateway → Game History → MongoDB → Game History → Gateway)

    extitNote: The list endpoint returns match details.
18. View the leaderboards SO THAT I know who are the best players
    - /history/leaderboard (Gateway → Game History → MongoDB → Game History → Gateway)
19. Prevent people to tamper my old matches SO THAT I have them available
    - N/A (Security): Implemented via internal service isolation (only Game Engine writes to History via RabbitMQ/Internal API) and Database access controls.

4 Rules of the Game

4.1 Deck Building Constraints

Each player constructs a **personal deck** of exactly **9 cards**. The deck must adhere to the following constraints:

- **Composition:** The deck must contain exactly **1 Joker** and **8 Suited Cards**.
- **Suit Distribution:** You must include exactly **2 cards** from each suit (♥, ♦, ♣, ♠).
- **Cost Limit:** For any suit, the total point value of the two cards **must not exceed 15**.

Card Point Costs

When calculating your deck limits, use the following costs.

Card Type	Ranks	Cost per Card	Example Pair Limit
Numbers	2 – 10	Face Value	10 + 5 = 15✓
Ace	A	7	A + 8 = 15✓
Jack	J	11	J + 4 = 15✓
Queen	Q	12	Q + 3 = 15✓
King	K	13	K + 2 = 15✓

4.2 Combat Hierarchy

When two cards are played, the winner is decided by the following hierarchy.

1. The Combat Triangle The core mechanics function like Rock-Paper-Scissors:

- **Numbers (2–10)** beat **Aces**.
- **Aces** beat **Face Cards (J, Q, K)**.
- **Face Cards (J, Q, K)** beat **Numbers**.

2. The Joker The **Joker** beats all other cards automatically. (If both players play a Joker, it is a tie).

3. Tie-Breakers If the combat rules above do not determine a clear winner (e.g., Number vs Number, or Face vs Face), compare the specific ranks:

1. **Higher Rank Wins:** (e.g., 9 beats 6, King beats Jack).
2. **Equal Rank → Suit Priority:** If ranks are identical (e.g., ♥9 vs ♦9), check suits:

   ♥ > ♦ > ♣ > ♠

3. **Mirror Match:** If players play the *exact same card* (Rank and Suit), both players win the round and gain a point.

4.3 Gameplay Flow

1. **Setup:** Both players shuffle their pre-built decks.
2. **Initial Draw:** Each player draws **3 cards** to form their starting hand.
3. **The Round:**
   - **Draw Phase:** At the end of every turn, each player draws **1 card** to get back to **3**.
   - **Battle Phase:** Both players play one card **face down**, then reveal it at the same time.
   - **Scoring:** Determine the winner based on the Combat Hierarchy. The winner earns **1 point**. If it's a tie, both players earn **1 point**.
4. **Victory:** The game ends immediately when one of the players reaches **5 points**.

4.4 Example of a Match

Alice's Deck: ♥A, ♥7, ♦A, ♦7, ♣K, ♣2, ♠K, ♠2, Joker.
Bob's Deck: ♥2, ♥3, ♦2, ♦3, ♣3, ♣4, ♠2, ♠3, Joker.

5 API Calls of the Game Flow

5.1 Deck Building Phase

We've separated the deck building from the game (More information in Cloud Storage of Decks)

Turn	Alice	Bob	Result Reasoning	Score (A-B)
1	♥A	♣K	**Ace beats Face** (Special Rule)	1 – 0
2	♦A	♦3	**Number beats Ace** (Special Rule)	1 – 1
3	♣K	♣3	**Face beats Number** (Special Rule)	2 – 1
4	♠K	♠2	**Face beats Number** (Special Rule)	3 – 1
5	♥7	♣4	Both Numbers: 7 > 4	3 – 2
6	♦7	♠3	Both Numbers: 7 > 3	3 – 3
7	♣2	Joker	**Joker beats Everything**	3 – 4
8	Joker	♥2	**Joker beats Everything**	4 – 4
9	♥7	♠3	Both Numbers: 7 > 3	**5 – 4**

5.2

6 Threat Model

7 Use of Generative AI

During the project development we've made extensive use of various AI models, experimenting with them and learning how to use those tools as efficiently as possible. We've mainly taken advantage of what was given to us for free as students: GitHub Copilot Pro and Gemini Pro. We've used them in the following two areas.

- Researching informations and tools: this has gotten a lot better in the past years, with models combining their knowledge with informations found on the web, providing extensive explanations and sources, while almost never allucinating. Researching using LLMs has definitely almost replaced our reliance on classical search engines.
- Writing Code. To which we've made the following considerations.
  - The non-premium AI models of Copilot Pro (GPT-4.1, GPT-4o, GPT-5 mini, Grok Code Fast 1) were pretty bad and mostly generated bad-quality results we lost time in reviewing and then discarding. This was true even in writing something as simple as latex code, e.g. GPT-4.1 had a hard time understanding what an hyperref was.
  - We tried various AI coding VSCode extensions: Github Copilot, Roo Code, Gemini Code Assist etc. We found the Copilot extension as the most robust implementation of agentic behavior for vscode, and, together with the free premium requests, we ended up using it almost exclusively.
  - We found Claude Sonnet 4.5 as the best premium model for one-shot code generation, it has been useful to generate some initial drafts for the microservices and to re-generate whole functions.
  - We found the Copilot Gemini 3.0 Agent behaving in a more *human* way, trying to get the best result while doing as least work as possible. E.g. for big changes in a single file that meant almost a whole refactoring, it often tried to delete the whole file and start from scratch.
  - The inline suggestions were a dividing topic, while some of us found them useful and kept them on, some others found them distracting and fatigue-inducing, where they suggested mostly wrong code while constantly drawing the attention of the user.
  - Even if ChatGPT models are still the most popular ones, we found them working on par, if not worse, than the others, hence we made less extensive use of them. This resonates with the recent "Code Red" raised by OpenAI after the release of Gemini 3.0.

7.1 Final Remarks

We found experienced and smart human beings better in any way but speed compared to the most powerful AI models that are publicly available. At the moment LLMs can be a useful tool for those people to work faster, but definitely not as a replacement of them.
Reasoning models behaved way better, showing the robustness of more rigid and iterative workflows, applied to the more efficient and smaller MoE (Mixture of Experts) models, compared to one-shot larger models. This resonates with what is shown in the course for cloud services, where decomposing complex tasks (monoliths) into smaller, more easily verifiable tasks (microservices), often yields better results.

8 Additional Features

8.1 Green User Stories

8.2 Cloud Storage of Decks

To allow players to keep their decks stored in the cloud, we added

8.3 Client

8.4 Endpoint-based Service Interaction Smell - Proof of Concept

The project requirements asked to make up for the **Wobbly service interaction** smell. We solved it mainly with timeouts as suggested.
Regarding the **Endpoint-based service interaction** smell, the requirements said to ignore it since it would've been difficult to solve.
We decided to partially solve it anyway in a single interaction between the **Game History** and **Game Engine** microservices as a proof-of-concept.
In this interaction we replaced the timeout with RabbitMQ, a Message Broker, that solved both the **Wobbly service interaction** and the **Endpoint-based service interaction** smells.

8.5 Test-match

9 Build and Run Instructions

This project is a multi-service card game platform designed for two players. It features authentication, deck building, a match-simulation engine, and history tracking. All services are containerized and orchestrated via Docker Compose.

9.1 Prerequisites

Before starting, ensure your environment meets the following requirements:

- **Docker & Docker Compose** (Required for orchestration).
- **Python 3.10+** (Optional, only required for local non-containerized development).

9.2 Quick Start Guide

1. **Clone the repository**

```
git clone https://github.com/ashleyspagnoli/ASE_project.git
cd ASE_project/src
```

2. **Build and launch services** Run the following command to build the images and start the containers:

   ```
   docker compose up --build
   ```

3. **Verify Service Status** Once the containers are running, the architecture exposes the following endpoints:

Service Name	Responsibility	Local URL
User Manager	Authentication & JWT	`https://localhost:5004`
Collection	Deck Management	`http://localhost:5003`
Game Engine	Core Logic & Matchmaking	`http://localhost:5001`
Game History	Match Logging	`http://localhost:5002`

9.3 Development & Testing

9.3.1 Environment Configuration

Each microservice is configured via environment variables. For specific configuration keys, refer to the `Dockerfile` and `requirements.txt` located in each service's directory.

9.3.2 Testing the Workflow

A Postman collection is provided for end-to-end testing. Import `game_workflow.postman_collection.json` into Postman to simulate a full lifecycle:

- User Registration and Login (Token generation).
- Deck creation and validation.
- Matchmaking and gameplay simulation.

9.3.3 Key API Endpoints

Authentication

- `/users/register`: user registration [POST]
- `/users/login`: user login [POST]
- `/users/validate-token`: internal JWT token validation [GET]

Deck Management

- `/collection/cards`: get the collection of cards [GET]
- `/collection/decks`: create a new deck [POST]

Game Engine

- `/game/connect`: connect to start playing the game [POST]
- `/game/matchmake`: manual request to start the match [POST] (TO REMOVE)

- `/game/play/{game_id}`: play a card [POST]
- `/game/state/{game_id}`: get the state of the game [GET]

Game History

- `/leaderboard`: get the whole leaderboard [GET]
- `/matches`: get the history of your played matches [GET]
- `/addmatch`: memorize a new match [POST]

9.4 Maintenance

To stop the application and remove containers/networks, run:

```
docker compose down
```