Requirements Engineering
Project 1

Audio and Video Streaming in Autonomous Cars

Group Members: Crystal Kwok, Matteo Ponza, Tettey-Nartey Samuel
Lecturer: Claus Pahl

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Task 1: Issues with Project Basis

With the evolution of autonomous vehicles, these are the assumptions on which the project is based on:

- ★ Vehicle
    - ✓ Level 4 autonomy (high driving automation)
    - ✓ Steering wheel is present
    - ✓ Driver should intervene only at critical moments
    - ✓ 5-seater
- ★ Screen
    - ✓ 13-16 inches
    - ✓ 3 screens

1. Ambiguity in Video Buffering Requirements

1.1 Issue description

According to the project description, it is mentioned that:

Stuttering in the playback of videos affects user satisfaction the most.

However, it is not clearly defined what is an acceptable stuttering frequency and duration for the user. Example: In a 2h long movie, one 6s buffer episode in the middle of the movie is acceptable but stuttering for 0.5s every 10 minutes may not be acceptable.

1.2 Options

To determine which scenario is more acceptable, the viable options are:

- Conduct user research to obtain clarity on what is preferred
- Interview network expert on which approach is more efficient
- Obtain feedback from video or film producers on suggestions on which approach audiences might prefer

1.3 Decision and rationale

The decision is to proceed with the user research. Given that the users are the main stakeholders and that stuttering of videos is a significant factor in Quality of Experience (QoE), their opinions should be strongly considered.

2. Ambiguity Regarding Video Quality

2.1 Issue description

It is mentioned that:

The clearness of the picture and audio quality also play a significant role.

The requirements for video quality are ambiguous. A list of the formats and framerates the system should support should be defined and agreed on.

2.2 Options

- Research with car manufacturers on the maximum resolutions and frame rates currently supported by the screens in vehicles
- Online research regarding which are the resolution and frame rates supported by the major streaming providers

2.3 Decision and rationale

The decision is to conduct online research on which video formats are supported by the major streaming provider. At the same time, ensure that the highest quality formats as well as the lower ones are all supported by the application. Even if the screens in vehicles may not be able to display the highest existing quality, it is likely that the future screens will be able to support those formats.

3. Conflict Between Expected Video Quality and Network Capability

3.1 Issue description

The following requirements may conflict with one another from the technical point of view:

1. *Streaming service needs to avoid buffering interruptions while considering high-resolution video files.*
2. *Achieving such a stable connection with a high data rate is especially challenging in border regions.*

In some cases, the network bandwidth/coverage may not be sufficient for displaying the video content at the maximum quality. When that happens, it is unclear how the system should behave: trying to maintain the higher quality of the video but introducing more buffering or reducing the quality of the image to avoid buffering.

3.2 Options

- Consult the solution architect on whether it is possible to build a functionality to allow the user to select the preferred video quality
- Check with the network engineers what are the bandwidth/coverage requirements for providing uninterrupted high-quality service
- Research online on the optimal balance between high resolution and buffering and investigate how existing providers manage this issue

3.3 Decision and rationale

All the proposed options should be implemented since this problem affects the user quality of experience in a significant way. It is also critical that the requirements are realistic and technically sound, hence the need for expert opinions.

4. Incomplete User Experience Requirements

4.1 Issue description

For the most pleasant user experience (UX), the video streaming platform interface should be seamless and user-friendly. UX is important to ensure the ease of use and understanding of the application, as well as to engage and appeal to the user. However, requirements on the look and feel of the interface are not specified.

4.2 Options

In this aspect, some options include:

- Referencing from successful video streaming models like Netflix and Disney Plus on the most intuitive and familiar application flow for users
- Consult UX experts on popular frameworks on the market
- Develop preliminary prototypes and allow for user feedback through questionnaires and shadowing

4.3 Decision and rationale

The decision is to reference from successful platforms on the application flow. Since the users are aware and familiar with the popular applications on the Internet, they are more likely to associate and draw parallels with those sites. A deviation too large from the standard might render the video streaming platform non-intuitive.

5. Incomplete User Interface Requirements

5.1 Issue description

Another key aspect in ensuring the overall satisfaction of the video and audio streaming platform is the user interface (UI) of the site. The user should feel comfortable looking at and using the application, especially on a moving vehicle. However, this requirement is not clearly specified in the description.

5.2 Options

- Since the size of the screen is a crucial factor in determining the design of the application, consultations can be conducted with the car manufacturer to understand more about the hardware that supports the platform
- Research online on well-established look and feel of applications as well as how colors and positions of components affect user's psychology
- Conduct user research on their favorite applications and then study those with higher popularity

5.3 Decisions and rationale

As knowledge of the screen hardware is indispensable, consultation with the car manufacturer is chosen. At the same time, for the platform design, online research is preferred over user research as it allows for more creativity and imagination.

6. Foreseeable Problems

6.1 Domain Requirements

- Laws regulating in-vehicle media devices are not identified
- Data protection law is not mentioned

6.2 Non-functional Requirements

- Security requirements of user details are not specified

6.3 Functional Requirements

- User interface features and functionalities are not listed

Task 2: Requirements Elicitation

Identified stakeholder: End user of audio/ video streaming service

User Type and Classification

1. How often do you consume the following streaming media services?

Streaming Media	Multiple times per day	Once a day	2-3 times per week	1 time per month	Less than once per month	Never
Video streaming	○	○	○	○	○	○
Audio streaming	○	○	○	○	○	○

Motivation – User Classification: To classify the user based on frequency of use.

2. Which types of content do you consume on a weekly basis? [Multiple options can be selected]
   - ❑ Movies
   - ❑ Series
   - ❑ Documentaries
   - ❑ Music
   - ❑ Podcast
   - ❑ Audio books
   - ❑ Others: Please Specify

Motivation – Content Preferences: To understand the amount of resources needed for each content type.

3. Are you usually the driver or passenger of personal transport? [Select 1 option]
   - ○ Driver
   - ○ Passenger
   - ○ No personal transport

Motivation – User Identification: To identify the type of user.

User Interface and Interaction

4. How would you like to control the streaming service while commuting in your personal transport? [Multiple options can be selected]
   - ❑ Touch screen
   - ❑ Voice control
   - ❑ Steering wheel control
   - ❑ Remote control – Infrared
   - ❑ Remote control – Wired
   - ❑ Others: please specify

Motivation – User Interaction Preferences: To determine the preferred control mechanisms for the entertainment system.

5. How intuitive do you find the following streaming service's interface?

Streaming Service	Not intuitive	Slightly not intuitive	Neutral	Slightly intuitive	Intuitive	Never used
Netflix	◯	◯	◯	◯	◯	◯
Disney Plus	◯	◯	◯	◯	◯	◯
Hulu	◯	◯	◯	◯	◯	◯
Amazon Prime Video	◯	◯	◯	◯	◯	◯
Apple TV	◯	◯	◯	◯	◯	◯
Others: Please Specify	◯	◯	◯	◯	◯	◯

Motivation – User Interface Preference: To gain insights into their preferred interface design.

Application Features and Functionalities

6. How would you rank the following search functionalities in order of importance? (1 being most important and 5 being least important)

Functionalities	Rank
Searching for media by title	Dropdown 1-5
Searching for media by producer	Dropdown 1-5
Searching for media by artist	Dropdown 1-5
Searching for media by year	Dropdown 1-5

Motivation – Feature Prioritization: To understand which feature should be built first.

7. How valuable would the following features be for you?

Features	Not valuable	Slightly not valuable	Neutral	Valuable	Very valuable
Suggestions of popular media	◯	◯	◯	◯	◯
Personalized content recommendations	◯	◯	◯	◯	◯

Motivation – User Customization Preferences: To understand the value of content personalization in enhancing their experience.

8. In case of critical situations during the journey, how useful would the following notification formats be?

Notification Format	Not useful	Slightly not useful	Neutral	Slightly useful	Useful
Screen pop-up	◯	◯	◯	◯	◯
Audio message to personal earpiece	◯	◯	◯	◯	◯
Broadcast audio alert	◯	◯	◯	◯	◯
Others: Please Specify	◯	◯	◯	◯	◯

Motivation – Emergency Features: To assess how the system should respond during emergencies.

Subscriptions and Accounts

9. Would you prefer a subscription-based or free advertisement-supported streaming service within the vehicle? [Select 1 option]
   - Subscription-based
   - Free with advertisement
   - No preference

   Motivation – Subscription or Free Service: To understand their preference for the service model.

10. Would you like to have different profiles for different users in the same account? [Select 1 option]
    - Yes
    - No
    - No preference

    Motivation – Usability: To understand the preferences of the user on using the system.

Quality of Experience

11. During periods of low network connectivity, for example in a tunnel, which would be more acceptable? [Select 1 option]
    - High quality video streaming service with buffering
    - Uninterrupted streaming with quality reductions
    - No preference

    Motivation – Network Connectivity: To understand the trade-off between consistent connectivity and high-quality streaming.

12. Which video resolution format is the minimum requirement for you?
    - 480p (Standard Definition)
    - 720p (High Definition)
    - 1080p (Full High Definition)
    - 1440p (Quad High Definition)
    - 2160p (4K Ultra High Definition)
    - No preference

    Motivation – Network Connectivity: To understand the minimum bandwidth required.

13. Do you have any further suggestions or comments on video streaming or audio streaming services in vehicles?

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    Motivation – Space for user to provide feedback not covered above.

Task 3: Completed Specification

1. User Interaction

1.1 Problem

With the advancement of video and audio streaming technology, user expectations of the services have increased. From understanding the application, to using it and being engaged, interactive elements of the applications should be well-designed to remain competitive in the industry. A non-intuitive interface may render the user frustrated, leaving the service entirely.

1.2 Goals

- The user should be able to use the application with ease and comfort
- The application should be enjoyable for the user
- The application should keep the users engaged

1.3 Requirements

1.3.1 Functional Requirement

Bookmark Content in User Profile

Function	Bookmark Content in User Profile
Requirement	The application shall allow the user to keep track of content that he/she wish to consume in the future or that he/she has partially consumed
Description	When the user clicks on the *bookmark content* button, the content should be added into list of bookmarked content The user can go back to the list of content
State	User must have a personal profile User is logged in
Action	User clicks on the *bookmark content* button
Inputs	Content identifier
Outputs	Success or failure message displayed to user Content is added to bookmarked list
Rationale	The timing of travel in personal vehicles can be unpredictable due to road and traffic conditions. It would be satisfying for the user to be able to return to the same content in their next travel or keep track of content he/she wishes to consume in the future. According to research and reference from popular streaming services, allowing user to bookmark the content is a good solution to this problem.

Table 1 Bookmark Content in User Profile Functional Requirement

Function	Search by Title Feature
Requirement	The application shall include a search by title feature for the user to search for video or audio by its name
Description	When the user searches in the search bar, the application shall search from the database of videos or audios with titles that contain the words that the user input
State	User navigates to search bar User inputs a value into search bar
Action	User types into search bar
Inputs	Search parameter
Outputs	Content(s) displayed to user or "No content found" displayed to user
Rationale	Search function is the most common and indispensable feature on any application as it greatly eases user interaction. The user can quickly understand if the content is available on the application. From the questionnaire, it was identified that search by title feature is the most important search feature.

Table 2 Search by Title Feature Functional Requirement

The table below shows an example of search input and output

User Input	Application Output
Home	Movies: 1. Home (2015) 2. Home Alone (1990) 3. Home Alone 2: Lost in New York (1992) 4. Home Alone 3 (1997) 5. Home on the Range (2004) Audio: 1. Take Me Home, Country Roads by John Denver 2. Home by Michael Bublé 3. Sweet Home Alabama by Lynyrd Skynyrd
Home Alone	Movies: 1. Home Alone (1990) 2. Home Alone 2: Lost in New York (1992) 3. Home Alone 3 (1997)
Home Alone 2	Movies: 1. Home Alone 2: Lost in New York (1992)

Table 3 Example of Search Results

Function	Personalized Content Recommendations
Requirement	The application shall recommend media genres that are similar to the media previously consumed by the user based on tabular specification in Table 5
Description	When the user clicks on *Recommended for me* button, the application shall suggest a list of content to the user
State	User is logged in
Action	User navigates to recommendation page
Inputs	History of tags
Outputs	Recommended content
Rationale	With the vast amount of content online, it may be overwhelming for the user to choose. With content recommendations based on user's preferences, he/she can avoid the paradox of choice, reducing decision fatigue and having a more enjoyable experience on the platform. Based on the user questionnaire, a personalized feed increases the value of the service for the user.
Additional Points	During the creation of profile, the application shall ask the user for his/her favourite media type and genres, which will be stored as tags

Table 4 Personalized Content Recommendation Functional Requirement

Table 5 below shows an example of recommendation metrics using the movie *Home Alone. Home Alone* has the five following tags: *Comedy, Family, Christmas, Adventure and Slapstick.* There is a set of movies with tags that are the same as *Home Alone*. Movies are recommended based on the priority, derived from the number of tags that are the same as the chosen movie, *Home Alone*.

Movies	Number of Same Tags	Priority in Recommendation
Home Alone 2: Lost in New York (1992)	*5 (Comedy, Family, Christmas, Adventure, Slapstick)*	First
Elf (2003)	*5 (Comedy, Family, Christmas, Adventure, Slapstick)*	First
The Santa Clause (1994)	*4 (Comedy, Family, Christmas, Adventure)*	Second
Night at the Museum (2006)	*4 (Comedy, Family, Adventure, Slapstick)*	Second
The Grinch (2018)	*3 (Comedy, Family, Christmas)*	Third
Toy Story (1995)	*2 (Comedy, Family)*	Fourth
Rush Hour (1998)	*1 (Comedy)*	Fifth

Table 5 Example of Movie Recommendation Based on Tags

1.3.2 Non-functional Requirements

Accessibility for the Visually Impaired

As the application aims to be inclusive and accommodate users with diverse abilities, accessibility is a priority. To eliminate barriers that hinder access, a range of user interaction modes shall be available for users. The requirements are as follows:

- The application shall include touch screen capabilities for intuitive navigation
- The application shall include voice control capabilities for inclusiveness

In order to determine the success criteria, the following metrics is used:

- Voice control and touch screen should have a feature parity of 90%. That is, for every 10 navigations made on touch screen, at least 9 of the navigations shall work with voice control

2. Content Quality

2.1 Problem

For an optimal user experience on a streaming platform, the content streaming quality is extremely important.

2.2 Goals

- The application should provide high quality streaming
- The application should be adaptive to reduce buffering and interruptions during periods of low bandwidth
- The user should be able to decide his/her preferred content quality

2.3 Requirements

2.3.1 Functional Requirements

High Quality Video Streaming

Function	High Quality Video Streaming
Requirement	The system shall maintain full high definition (1080p) streaming during regular network bandwidth
Description	During regular network bandwidth of 80 Mbps or more, the application shall support video streaming of full high definition (1080p) resolution at the minimum
State	Application is running
Action	Application streams content
Inputs	Current network bandwidth
Outputs	Streaming content
Rationale	In the current day and age, high definition video streaming is becoming the new normal. According to the user questionnaire, users would like to have a minimum of high definition or full high definition resolution videos. To ensure that the user is able to fully enjoy the video streaming experience, the system shall provide a minimum of full high definition video streaming quality during periods of regular network bandwidth.

Table 6 High Quality Video Streaming Functional Requirement

Adaptive Content Quality and Buffering

Function	Adaptive Content Quality and Buffering
Requirement	The system shall dynamically adjust content quality during low network bandwidth
Description	In order to reduce the buffering of audio or video during period of low bandwidth below 80 Mbps, the system shall adjust the content quality in real-time to match the current network conditions.
State	Application is running
Action	Application receives lower network bandwidth
Inputs	Current network bandwidth
Outputs	Streaming content with adjusted quality
Rationale	From the user questionnaire, most users prefer to continue enjoying the content with less interruptions despite lower quality. To provide a consistent and uninterrupted streaming experience for the user, the system shall adapt the content quality to the changing network conditions to prevent buffering. This ensures a seamless streaming experience.

Table 7 Adaptive Content Quality and Buffering Functional Requirement

Video Quality Selection by User

Function	Video Quality Selection by User
Requirement	The system shall allow the user to indicate video quality preferences
Description	As there are various resolution options that are supported by most videos, the user shall be able to choose from the list of resolutions below: • 480p (Standard Definition) • 720p (High Definition) • 1080p (Full High Definition) • 1440p (Quad High Definition) • 2160p (4K Ultra High Definition)
State	Application is streaming content
Action	User indicates preference
Inputs	Resolution format
Outputs	Content based on user defined resolution
Rationale	Since the streaming experience is dependent on the video type, current bandwidth and the user preference, it would be satisfying for the user to be able to choose his/her preferred video quality independently.

Table 8 Video Quality Selection by User Functional Requirement

2.3.2 Non-functional Requirements

Color Accuracy

The colors displayed by the application should represent in high fidelity the ones of the original content as they are integral part a high-quality video streaming experience. Given the rise in the popularity of high quality screens (smartphone and tablet), users would expect comparable quality in the vehicle media system.

In order to guarantee a satisfying viewing experience, the requirements are as follows:
- The screens shall provide a color accuracy that meets or exceeds industry standards for the sRGB color spectrum
- The application shall support the above definition

Color accuracy test shall be conducted with various levels of ambient luminosity and the measured accuracy shall be greater than the values provided in Table 9 below.

Ambient Light	Minimum Coverage of sRGB Color Spectrum
500 lux	95%
1000 lux	90%
2000 lux	75%

Table 9 Thresholds for Color Accuracy

3. System Security

3.1 Problem

As the system needs to deal with customer data, proprietary media content and interact with vehicles, it is of paramount importance that the system is secure by design.

3.2 Goals

- The interactions between the end user and the system shall be secure
- The interactions between the application and the cloud/content provider shall be secure
- The user data and media content shall be protected

3.3 Requirements

3.3.1 Functional Requirements

User Login

Function	User Login
Requirement	The application shall provide functionality to authenticate the user into the system
Description	The application shall prompt the non-authenticated user a login page, allowing the user to insert his/her credentials. The user can opt to save the login for up to 30 days. In this case, the user would not need to enter the password again in this period.
State	The user is not authenticated or Authentication token exceeded the time limit
Action	1. Application displays the login page on start up 2. Login page allow the user to insert the credentials and login information (User, Password, Save Login Option) 3. Login page transmit the credentials via a secure standard protocol to the backend
Inputs	Login information: - Username: in the form of e-mail address - Password: in the form of an obfuscated text field - Save Login Option: in the form of a checkbox
Outputs	Credentials Verified: - Application loads the homepage - Session Token is stored by the application Credential Rejected: - Application displays login failed message - Application stays on the login page
Rationale	This function is the entry-point of the system, it ensures that user has the right to access the media content and the rest of the functionalities. The "save login up to 30 days" option ensures the balance between security and usability of the application.

Table 10 User Login Functional Requirement

Security Updates and Patch Management

Function	Security Updates and Patch Management
Requirement	The system should be able to install security updates
Description	The application should check at the startup and periodically every 60 minutes for security updates as they are released by the software maintainer. When a new update is discovered, the application should install if it can without interrupting the user's activity, otherwise depending on the criticality of the security update the user shall be allowed to postpone the update for a limited period of time.
State	Application is running
Action	1. The application should contact the server for security update check - Check should run on the background without interrupting user experience 2. Application discover that a security update is released 3. If update do not require an application restart, update is installed immediately. Application resumes activity. 4. Otherwise, if update requires a restart: - The system evaluates whether the postponement is allowed based on the rules specified in Table 12 below - User is prompted a dialog window notifying about the new update and possible actions 5. User selects the next action - If the user selects the postpone action: the system should not prompt the user again until the postpone period end - If user selects the install update action: the security update is installed and the application is restarted 6. The application shall resume the activity in progress before the notification was sent
Inputs	Security Update (Version, Severity Level, Requires Restart Indicator) Action from the user (Update Now or Postpone Update with duration)
Outputs	Update installed or postponed
Rationale	Security software updates and patches for the application may be released when new vulnerabilities are discovered. It is important to minimize the time between the vulnerability discovery and the updates, to reduce the opportunities for exploits. Automatic updates should balance between minimizing risk and minimizing interruptions in the user experience.

Table 11 Security Updates and Patch Management Functional Requirement

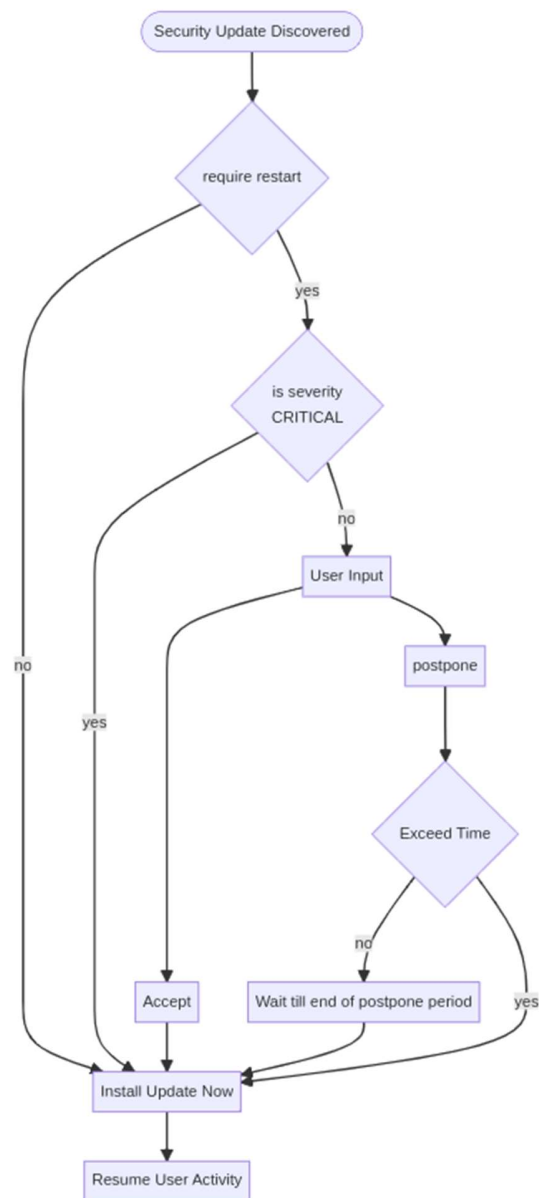| Security Update Severity	Allowed Actions	Maximum Postponement Time
Low	Update Now or Postpone	7 Days
Medium	Update Now or Postpone	2 Days
High	Update Now or Postpone	2 Hours
Critical	Update Now	Not Allowed

Table 12 Security Update Specification

Figure 1 Security Update Flow Chart

3.3.2 Non-functional Requirements

Media Content Data Encryption and Protection

The media content displayed by the application is protected by copyright, therefore measures shall be taken to protect it. Content theft shall be strictly prevented by the design of the system. The requirements are as follows:

- Media content shall be streamed from the back-end system to the vehicle using secure standard network protocols
- Media content shall be stored for buffering in an encrypted form and decoded by the application only when the content is played
- Decryption keys shall be stored using key management services or secure storage solutions
- Decryption keys shall be rotated every 6 to 12 months

According to the security team, Table 13 defines the protocols to be used in the application.

Function	Allowed Protocols
Media Streaming	HLS (HTTP Live Streaming) + AES-128 Encryption
Media Streaming	DASH (Dynamic Adaptive Streaming HTTP) + AES-128
Media Storage	AES-128 Encryption

Table 13 Media Content Protocols

Prevention of Injection Attacks

Injection attacks are one of the most common security vulnerabilities. Measures must be taken in the application backend to prevent injection attacks. The requirements are as follows:

- Input sent from the application to the server shall be validated on the server side
- Eventual interactions with database systems shall be via safe API that prevent such attacks
- Firewall rules to automatically detect and prevent attacks should be enforced

Success criteria: External cybersecurity audit shall be conducted by a certified party before the first public release of the application. The reported number of open vulnerabilities with severity level HIGH or CRITICAL for injection attack must be zero.