

## Architecture

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### **Introduction and Tools:**

The system architecture for *Escape from University* was modelled using the Unified Modelling Language (UML). This language allowed us to provide a formal description of the structural and behavioural aspects of the game. UML is standardised notation for representing classes, components and their interactions in object-oriented and entity-component-system designs.

The architecture shows how the game's core modules work together to deliver gameplay and their alignment with the user and system requirements.

Structural diagrams were created using PlantUML. This is a text based tool that uses source descriptions to automatically produce class and component diagrams. This allowed the team to iteratively improve architecture diagrams alongside implementation and ensure version control by using GitHub. During early discussions, we also used Lucidchart to make small component diagrams.

Behavioural aspects of the system were represented using UML sequence and state machine diagrams. These tools were used to model message flows between key objects during gameplay events. This includes player movement, collision handling and event triggering. These diagrams help to support traceability and they show runtime behaviour by connecting interactions with requirements.

All diagrams and interim versions were produced following an Agile/Scrum workflow. This ensures that architectural models evolve alongside each sprint. Our approach was an iterative, tool-supported approach, which allows the team to visualise dependencies and communicate design choices while ensuring that the implemented architecture matched the functional and non functional requirements.

### **Structural Architecture Diagrams:**

The architecture follows a modular object-oriented design built on the LibGDX framework. There is a clear separation between presentation, game logic and entity management. This structure emphasises composition over inheritance and also utilises LibGDX's screen-based architecture for managing game states.

### **Layered Architecture:**

This structure separates any concerns between presentation, game logic and framework responsibilities, allowing changes to user interface elements without disrupting core gameplay mechanics.

<b>Layer</b>	<b>Components</b>	<b>Responsibilities</b>
Presentation layer	MenuScreen, GameScreen, WinScreen, GameOverScreen, TutorialScreen	Handles all user-facing elements such as screen transitions and menu navigation. Converts inputs into game actions

Game Logic layer	Player, Dean, NPC, Locker, BusTicket, GameTimer	Contains the core game rules and entity behaviours. Manages player movement, enemy movement, item interactions and game timing
Framework layer	LibGDX Engine, SpriteBatch, OrthographicCamera, TiledMap	Provides the foundational services such as rendering and screen lifecycle control through LibGDX's framework

### Class Relationships:

The core game entities follow a composition based design where GameScreen acts as the central coordinator. Each entity encapsulates its own state and behaviour whilst GameScreen manages their interactions and rendering order. The Player class provides character movement and direction, the Dean class implements pursuit AI while the interactive objects like Locker and BusTicker manage their own state transitions.

### OOP UML Component Diagram

Our final component diagram represents the implemented architecture where GameScreen serves as the central coordinator, directly managing all game entities and systems. The architecture employs composition-based relationships rather than deep inheritance hierarchies with each entity encapsulating its own state and behaviour while GameScreen handles their interactions and rendering order. This design supports our core requirements: FR\_MOVEMENT through direct input handling, FR\_ANTAGONIST via the Dean's pursuit AI and the three event types (FR\_POSITIVE\_EVENT, FR\_NEGATIVE\_EVENT, FR\_HIDDEN\_EVENT) through specialised entity interactions. The final OOP component diagram for the game's architecture can be found on the website [Architecture Appendix. | Escape from University!](#)

### Behavioural Architecture Diagrams:

The behaviour architecture models the dynamic interactions between core components at runtime. These sequence diagrams illustrate message flows in response to player actions and automated system events using three primary gameplay interactions.

#### Use Case 1 - Player movement:

This sequence models how the system processes player movement and validates moves within the maze environment. UML sequence diagram available on the website [Architecture Appendix. | Escape from University!](#)

#### Actors and Components:

- Player: entity receiving movement commands
- GameScreen: central coordinator processing input and game state
- TiledMap: provides collision data through tile properties [Process Summary](#):
- When the player inputs movement, GameScreen.handleInput() processes the command, checks collision via isCellBlocked() and updates the player position if their

move was valid. The camera follows the player and the rendering system updates the display.

#### Use Case 2 - Dean's Pursuit:

This sequence describes the AI logic controlling the Dean's automatic movement through the maze. The UML sequence diagram is available on the website [Architecture Appendix. | Escape from University!](#)

#### Actors and Components:

- GameScreen: triggers entity updates each frame
- Dean: AI-controlled entity pursuing the player
- Player: target entity providing position data Process Summary:
- For each frame, GameScreen updates the Dean which calculates direction towards the player, checks for valid movement and updates the Dean's position accordingly. Collision detection occurs in GameScreen, triggering reset logic when the player is caught by the Dean.

#### Use Case 3 Player Searching Objects:

This sequence outlines system behaviour when the player interacts with game objects. UML sequence diagram available on the website [Architecture Appendix. | Escape from University!](#)

#### Actors and Components:

- Player: initiates interactions via the E key being pressed
- GameScreen: manages interaction flow and state changes
- Interactive Objects = BusTicker, Locker, NPC Process Summary:

When the player presses E near interactive objects, GameScreen checks proximity and triggers appropriate responses: collecting items, activating boosts or displaying dialogue.

#### Justification and Design Rationale:

##### Why Object-Oriented Architecture with LibGDX Screens?

We selected a pure object-oriented architecture built on LibGDX's screen pattern because it provided the optimal balance between structure and framework integration. The screen-based architecture naturally fits the game's state transitions (menu -> game -> win/lose screens), while OOP design patterns made the codebase accessible to our team and maintainable throughout development.

##### Why UML and PlantUML?

UML diagrams helped standardise team communication and ensured shared understanding of system architecture. Using PlantUML allowed us to maintain diagrams in version controlled text format which allowed for easy updates and traceability throughout development. This workflow provided both clarity for design discussions as well as accurate documentation of the implemented system.

##### Support for Maintainability, Scalability and Testability

The screen-based OOP architecture improves maintainability by isolating different game states into separate classes. Each screen manages its own lifecycle and resources,

preventing interference between game states. Scalability is supported through LibGDX's robust framework which handles asset management and rendering efficiently. Testability is enhanced by well-defined class responsibilities with clear interfaces which allow for targeted unit testing of individual game entities.

### Trade-offs

The main trade-off in our architecture is the central role of GameScreen as a coordinator as this creates some coupling between systems. However, this is offset by the clarity and simplicity of having a clear central point for game logic. By keeping entities well-encapsulated and using composition, we maintained flexibility while leveraging LibGDX's proven architectural patterns.

### Evolution/Iteration Evidence:

Our architecture evolved significantly from the initial concepts to the final implementation. All interim architectural versions, including early ECS diagrams, OOP transition plans and CRC cards are available on our project website at [Architecture Appendix. | Escape from University!](#)

### Initial ECS Exploration -> Final OOP Implementation:

Initially, the team explored the idea of using an Entity-Component System (ECS) architecture (available on the website [Architecture Appendix. | Escape from University!](#)) and created component diagrams modelling entities as compositions of data components. However, after evaluating team expertise and project scope, we transitioned to the more familiar, traditional OOP approach using LibGDX's established patterns. This decision prioritised development efficiency and framework alignment over architectural innovation.

### Screen Architecture Refinement:

Early designs used a monolithic game controller but we evolved to LibGDX's screen-based architecture after recognising the fact that it better fit our game state management. This change improved separation of concerns and simplified state transitions.

### Entity Management Evolution:

Initially, we planned separate manager classes for collision, input and physics but later decided to consolidate these responsibilities into GameScreen after finding out that LibGDX's integrated approach reduced complexity without sacrificing any clarity.

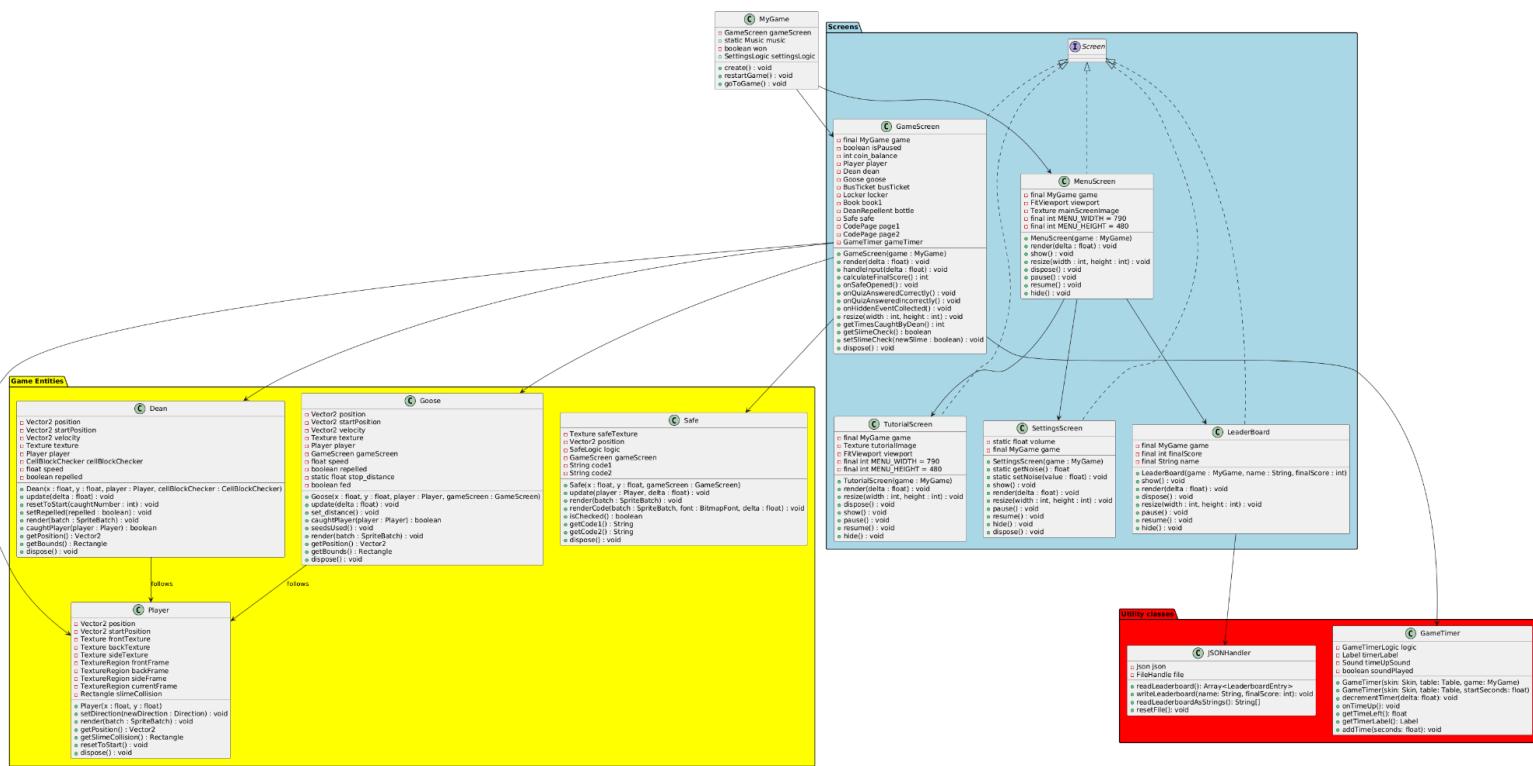
### Final OOP Architecture:

The final OOP component diagram for the game's architecture can be found on the website [Architecture Appendix. | Escape from University!](#)

### Architectural Extensions

After taking over the project, the new team extended the existing game architecture by adding an achievement tracking and leaderboard system. New classes for these additions were added without heavily modifying the core structure of the code. Changes integrated with the existing architecture through the pre-existing classes like GameScreen and WinScreen.

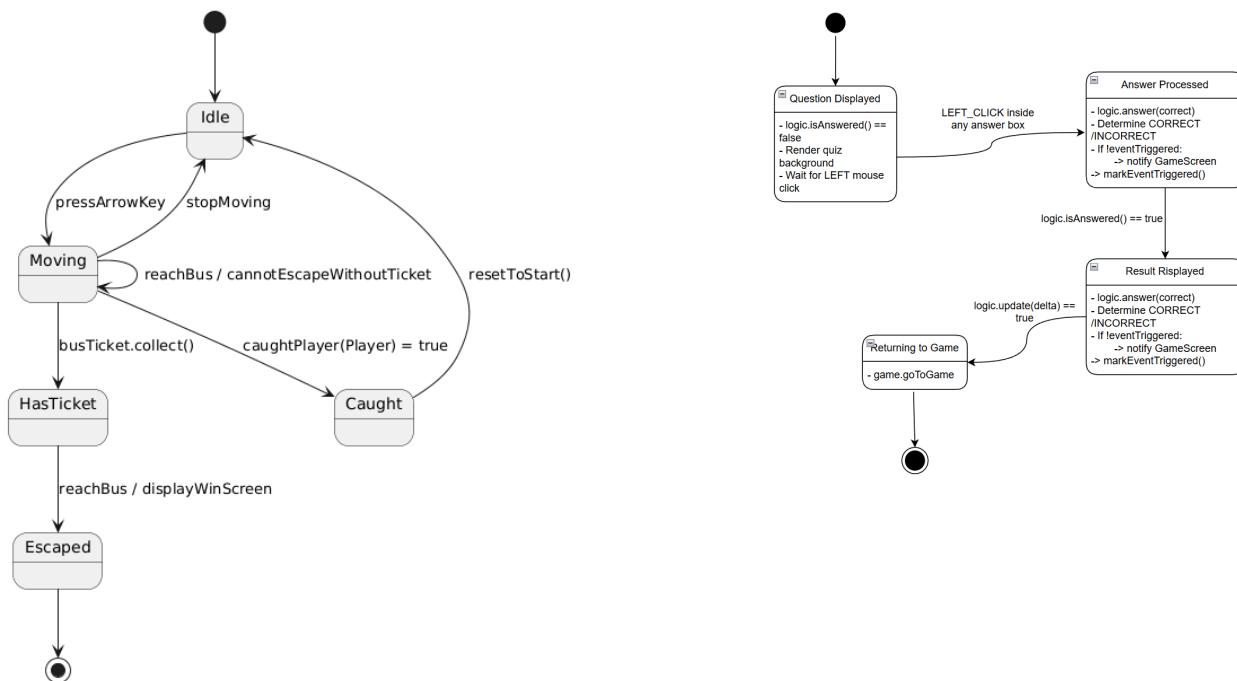
## Structural Diagram



## State Machine Diagrams

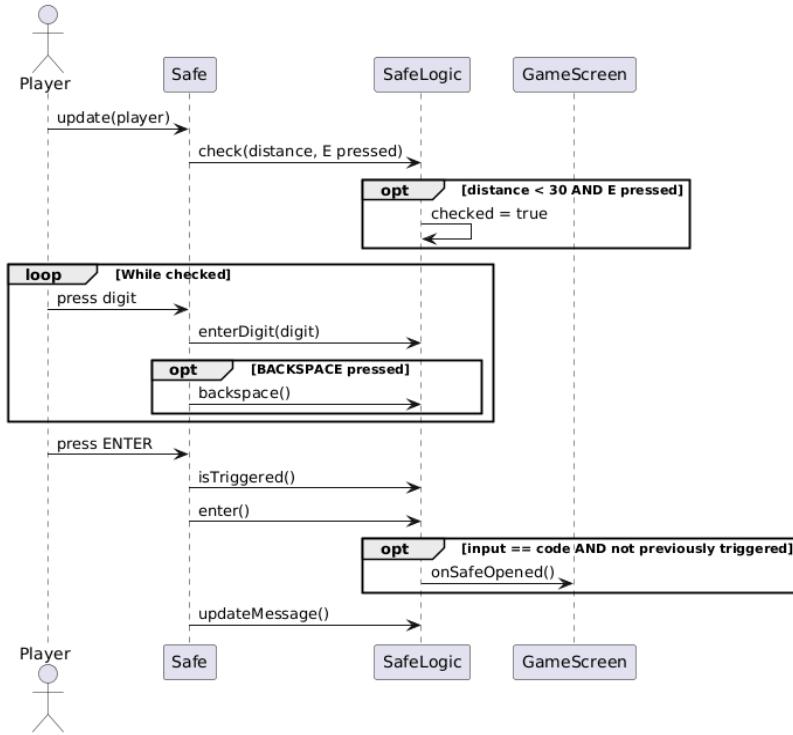
## Player.java

## QuizScreen.java



## Sequence Diagrams

### 'Safe' Event



### CRC Cards:

Class	Responsibilities	Collaborators
GameScreen	Process player input, update game entities, manage collisions, handle screen transitions, coordinate rendering	Player, Dean, BusTicket, Locker, GameTimer
Player	Handle movement direction, maintain position state, manage sprite rendering	GameScreen, SpriteBatch
Dean	Pursue the player using simple AI, update position each frame, reset when catching the player	GameScreen, Player
NPC	Display dialogue when the player interacts with it, manage dialogue visibility, render NPC sprite and message	GameScreen, Player, SpriteBatch
Locker	Provide speed boost when interacted with, manage boost duration timer, display interaction messengers, render locker sprite	GameScreen, Player, SpriteBatch
BusTicket	Manage collection state, render ticket in world when discoverable, render UI icon when collected, handle ticket discovery logic	GameScreen, SpriteBatch, OrthographicCamera
GameTimer	Count down game time from 300 seconds (5 minutes), format time display as mm:ss, update UI label display	GameScreen, uiStage, Skin

MenuScreen	Display main menu interface, handle menu navigation inputs, transition to tutorial/game scenes, manage win screen graphics	MyGame, GameScreen, SpriteBatch
WinScreen	Display victory message and final score, show score breakdown with penalties, handle return to menu navigation, render win screen graphics	MyGame, GameScreen, SpriteBatch
GameOverScreen	Display game over message, handle menu return navigation, render loss screen interface, manage screen resources	MyGame, GameScreen, SpriteBatch
TutorialScreen	Display tutorial instructions image, handle progression to main game, manage tutorial resources, render tutorial information	MyGame, GameScreen, SpriteBatch
MyGame	Manage screen lifecycle and transitions, create initial application context, coordinate between different screens, implement LibGDX game interface	All Screen classes, LibGDX framework
Leaderboard	Screen which writes name and final score to leaderboard if the score is greater than 0. Also loads top scores and returns to menu when space is pressed.	MyGame, MenuScreen, JSONHandler, Screen
JSONHandler	Reads and writes leaderboard entries to leaderboard.json. Sorts the scores numerically.	LeaderboardEntry, Gdx.files.local, Json, Leaderboard
LeaderboardEntry	Represents a single leaderboard record. Contains a position, name, and score.	JSONHandler, Json
Achievement	Manages achievement rendering.	SpriteBatch
Book	Detects a player interaction and transitions to the quiz screen.	Player, QuizScreen, MyGame, GameScreen
QuizScreen	Displays a quiz question, takes a user input and shows whether it was correct or incorrect. Returns to the game screen.	MyGame, GameScreen, Gdx.input
BusTicket	Controls discovery and collection of the bus ticket required to complete the game as well as the rendering of the UI icon.	GameScreen, OrthographicCamera, SpriteBatch
DeanRepellent	Handles the player interaction, collection, and usage of the dean repellent.	Player, Dean, GameScreen
Locker	Handles the player interaction with the locker, speed boost, and displaying of messages.	Player, GameScreen

NPC	Handles the interaction with an npc which is a proximity based text display.	Player, GameScreen
BirdSeeds	Stored birdseed state using isBought and isUsed and renders a UI icon when bought.	GameScreen, OrthographicCamera, SpriteCamera
Goose	Follows the player and stops when fed.	Player, GameScreen
Safe	Manages player interaction, code entry, and validation when using the safe.	Player, GameScreen
CodePage	Handles interaction with rendering an enlarged page with text displaying a code.	Player, OrthographicCamera, CodePageLogic, GameScreen

#### Traceability to Requirements:

Requirement ID	Requirement Description	Related Component(s)	Architectural Rationale
FR_MOVEMENT	The system shall allow keyboard inputs to control player movement	GameScreen.handleInput(), Player.setDirection(), Player.getPosition(), GameScreen.isCellBlocked()	Input processed in GameScreen.handleInput() which detects WASD keys, sets player direction via Player.setDirection(), validates movement through GameScreen.isCellBlocked() before updating player position
FR_ANTAGONIST	The system shall include an antagonist who follows the player	Dean.update(), Dean.getPosition(), Dean.resetPosition(), GameScreen.render(), Player.getPosition(), GameScreen.isCellBlocked()	Dean.update() calculates pursuit direction each frame using player position, moves with speed = 0.7f, resets player to start when caught via Dean.resetToStart()
FR_POSITIVE_EVENT	The system shall present a positive event in which the player finds a locker, opens it and gains a speed boost advantage	Locker.update(), Locker.isBoostActive(), GameScreen.handleInput() movement speed logic	Locker.update() detects player proximity and E key presses, activates temporary speed boost, GameScreen doubles movement speed when boost is active

FR_NEGATIVE_EVENT	The system shall present a negative event of the player not being to get on the bus without their bus pass	BusTicket.isCollected(), GameScreen.canEndGame , busInteractionArea Rectangle	Bus boarding is blocked until BusTicket.isCollected() returns true, GameScreen checks rectangle overlap before allowing game completion
FR_HIDDEN_EVENT	The system shall contain a hidden event of the player's bus pass being hidden in a bush which, until triggered, cannot be seen on the map	BusTicket.isCollected(), NPC.showMessage, BusTicket.render() conditional rendering	Bus ticket initially hidden, revealed via BusTicket.discover() when player gets close, NPC provides hint through dialogue message
FR_OFFLINE	The system and all its features shall not require any connection to a network	All asset loading via local files	All textures and maps are loaded from local filesystem without network dependencies
FR_END_SCORE	The system shall display the user's end score when they complete or fail the game	WinScreen, GameOverScreen, GameScreen.calculateFinalScore(), GameTimer.getTimeLeft()	Final score calculated from remaining time minus penalties, displayed when player wins the game
FR_USER_TIMER	The system shall display a timer to the user which displays how long they have been playing for	GameTimer, timerLabel, uiStage	Countdown timer displays remaining time in mm:ss format through Scene2D UI label

FR_LEADERBOARD	The system shall record a final score to a local leaderboard, load the top 5 entries, and display them. It should then allow the user to return to the menu.	Leaderboard.show() Leaderboard.render() JSONHandler.writeLeaderboard(String, int) JSONHandler.readLeaderboardAsString() LeaderboardEntry MyGame.setScreen()	The leaderboard screen writes the score. Loads the top scores from JSONHandler, renders them and returns to menu when space is pressed. LeaderboardEntry objects are stored in leaderboard.json.
FR_ACHIEVEMENT_DISPLAY	The system displays an achievement notification which can be dismissed	Achievement.unlock() Achievement.update() Achievement.draw()	Achievement rendering and dismissal handled by Achievement class.
FR_BOOK_INTERACT	The system shall allow the player to interact with a book when within range by pressing the interaction key, taking them to a quiz screen.	Book.update() Player.getPosition() MyGame.SetScreen() QuizScreen	Interaction detected through proximity check. Triggers screen change.
FR QUIZ DISPLAY	The system shall display a quiz question with four answers which can be	QuizScreen.render() Rectangle.contains()	Quiz questions and answers are rendered using textures. Mouse clicks are detected,



	selected with the mouse input.		taken and checked against preexisting button regions.
FR QUIZ_RETURN	The system shall return the user to the game after an answer is selected.	QuizScreen.render() MyGame.setScreen()	After an answer is chosen, there is a short delay before returning to the game screen.
FR TICKET_COLLECT	The system shall allow the player to collect a bus ticket once they have found it.	BusTicket.discover() BusTicket.render() BusTicket.collect() BusTicket.isCollected()	The ticket is only rendered when isDiscovered is true. Collection is traced internally for the game logic.
FR TICKET_UI	The system shall display a bus ticket icon once it is collected.	BusTicket.renderAsIcon() OrthographicCamera	The ticket icon is rendered as part of the UI.
FR DEAN_REPEL	The system shall allow the player to collect an item when nearby which will alter the dean's behaviour.	DeanRepellent.update() Player.getPosition() Dean.setRepelled(true)	Specific player proximity and key input are required to mark the item as collected. Updates the dean's internal state when collected.
FR REPEL_RENDER	The system shall remove the repellent from the game once it has been collected.	DeanRepellent.render() ReanRepellent.getCollected()	Rendering is disabled once it is collected.
FR SPEED_BOOST	The system shall allow the player to interact with a locker when nearby and apply a temporary speed boost.	Locker.update() Player.getPosition() Locker.isBoostActive()	Specific player proximity and key input are required to interact. Speed boat duration is managed using a timer.
FR LOCKER_MESSAGE	The system shall display a message when the locker is searched.	Locker.render() BitmapFont	Message is rendered for a certain time period after the interaction.
FR NPC_INTERACT	The system shall allow the player to interact with an npc when nearby which displays text for dialogue.	NPC.update() Player.getPosition() NPC.render() BitmapFont	Dialogue text is rendered when the player interacts with the npc.
FR NPC_HIDE	The system shall hide the npc's dialogue when the player moves away.	NPC.update()	Dialogue is removed when the player moves away.
FR_BIRDSEEDS_UI	The system shall display a birdseeds icon when seeds have been obtained.	BirdSeeds.bought() BirdSeeds.renderAsIcon()	UI rendering is conditional on isBought draws the icon on the screen.
FR_GOOSE_FOLLOW	The system shall update the goose position so that it follows the player while it is not fed.	Goose.update() Player.getPosition() GameScreen.isCellBlocked()	Movement is determined by player position.
FR_GOOSE_STOP	The goose shall stop	Goose.update()	Movement is stopped when