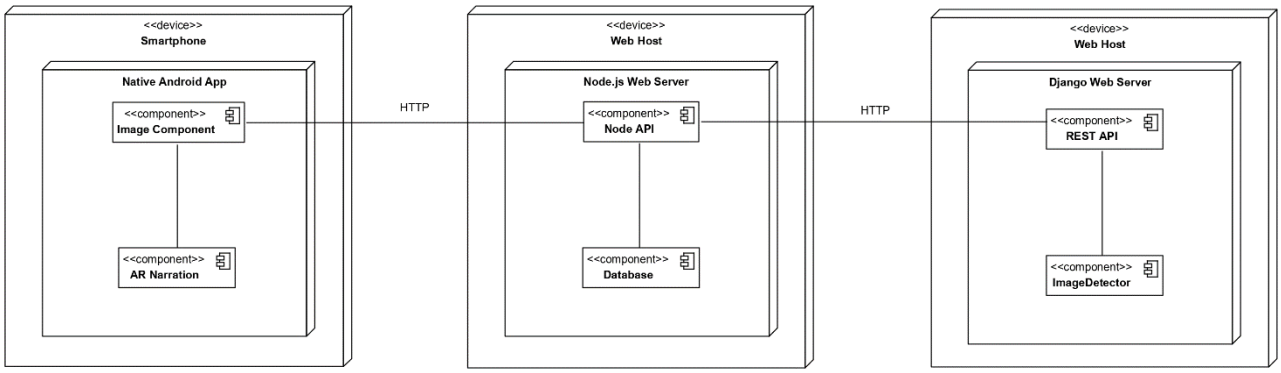
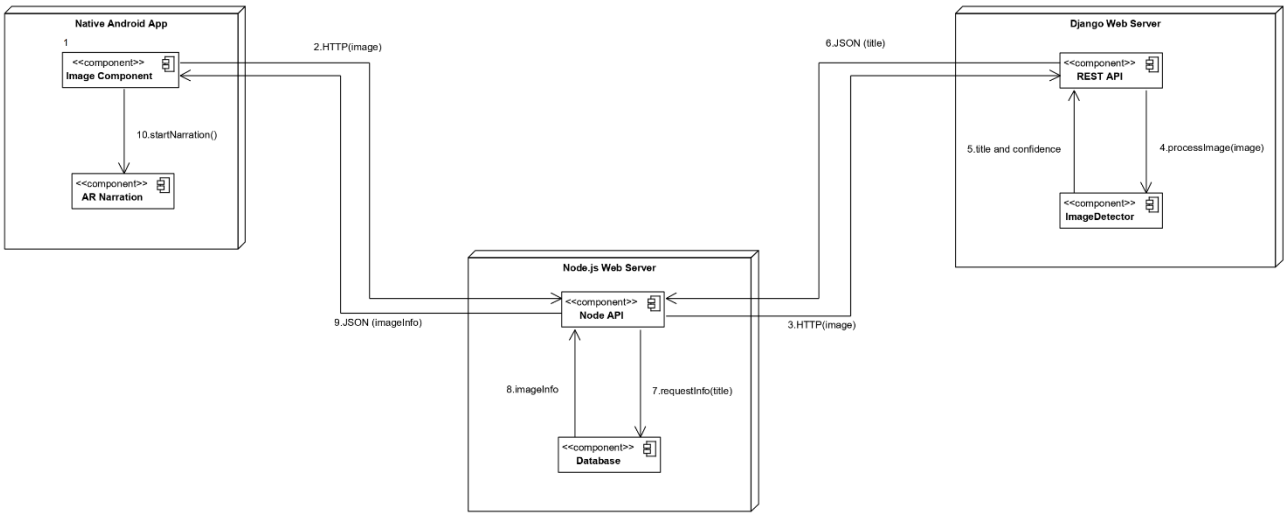
1. HARDWARE/SOFTWARE MAPPING



1.1 IMAGE PROCESSING



1. User starts up the application and captures and image with the smartphone's integrated camera.
2. The captured image is sent to the Node.js server, using an HTTP multipart data request.
3. Once received, the image is forwarded from the Node API to Django server, via the exposed REST API.
4. The Django server receives the image and processes it via the underlying neural network, in the ImageDetector component.
5. A title and a confidence score are output for the received image by the neural network. It then passes it to the REST API component.
6. Response is then sent back to the Node.js server as a JSON object containing the two fields.
7. The Node.js server retrieves the information associated to the identified painting from a MongoDB relational database.
8. Any retrieved information is sent to the Node API component.
9. The information is sent back to the Android client.
10. The control is finally sent to the AR Component, which proceeds with the narration of the painting.

2. *ANDROID CLIENT*

The AR functionalities are provided by the ARCore SDK, Google's AR solution; when it comes to the handling of the 3D environment, the choice was between a fully-fledged game engine, like Unity or Unreal Engine, and an external Android library, such as Google's Sceneform. We decided for the latter, since this allowed us to keep a higher control over the whole application development; furthermore, this would make future maintenance or additions easier.

In order to handle the Text-To-Speech narration, the integrated android.speech.tts module has been used; since each TTS utterance is executed asynchronously, the narration works by setting up a custom UtteranceProgressListener for the TTS object and using two handlers to receive messages from the its thread during the utterance life cycle. The reason why the messaging is necessary in the first place, is because all operations influencing the augmented elements of the scene must be performed on the main thread on which the application is running.
The first handler, onTtsStartHandler, receives a message as soon as the speak() method on the TextToSpeech object has been called: it proceeds to generate the image corresponding to the segment which is being narrated and animates it forward in the environment. The second handler, onTtsDoneHandler, receives a message when an utterance has been successfully completed, without any errors, and it destroys the previously generated image node in the scene.

In order to provide a better user experience, we decided to implement user interface functionalities to navigate through the narration; these include a pause/resume button and two buttons to move to the previous and next narration segments. Since the native TTS module doesn't provide any pause functionalities we found ourselves with two main alternatives:

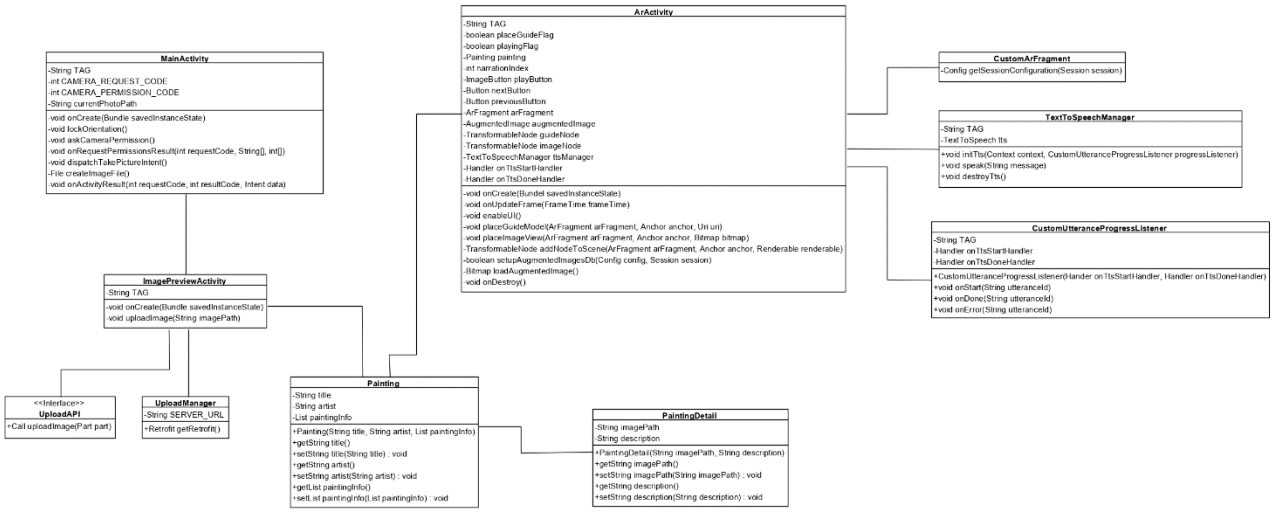
1. Make the TTS object record the narration to an audio file, using the native synthesizeToFile() method, and then use a MediaPlayer object to control the narration;
2. On resume, make the narration start from the beginning of the current segment.

By using the first approach any future implementation of some kind of interaction mechanisms between the user and the virtual guide would require a reengineering of the speech context. We decided to proceed with the latter, by carefully dividing the segments into smaller, independent parts.

Package structure:

```
App
│
├───activities
│        ├───MainActivity
│        ├───ImagePreviewActivity
│        └───ArActivity
│
├───painting
│       ├───Painting
│       └───PaintingDetail
│
├───texttospeech
│         ├───TextToSpeechManager
│         └───CustomUtteranceProgressListener
│
├───network
│       ├───UploadAPI
│       └───UploadHandler
│
└───CustomArFragment
```

Class diagram:



3. *NODE.JS SERVER*

This server acts as a middle-ground between the client and the image recognition component. It manages the database containing the information associated to each painting.

3.1 DATABASE SCHEMA

4. *DJANGO SERVER*

The server uses a REST API, realized via the djangoRestFramework module, to interface itself with the Node.js server.

The neural network is encapsulated in its own class, providing the methods necessary to run a pre-trained inference graph on the received image and output a title and a confidence score. If this confidence score, expressed as the probability of a specific painting being present in the scene, is greater than a pre-set threshold, a positive feedback is sent back to the Node server.