

migrant integration cockpits & dashboards D1.3

ICT-Solutions for MICADO



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Executive summary

In order to develop solid, useful and efficient applications, it is central to select components that are up-to-date, reliable, user and developer friendly and suitable for addressing MICADO's topics and questions. As the project doesn't build the applications "from scratch" but utilises existing solutions and technologies, it is essential to find the appropriate components and elements that will constitute the application(s) to be applied in various cities and contexts.

The following document sketches the state-of-the art of available technologies, discusses their potentials and challenges.

The report is divided into three main parts. After a short introduction, Chapter 2 discusses the context of the document, listing a number of existing applications for migrant integration and defining basic user necessities and needs, as well as guidelines for component selection by the developers.

Chapter 3 addresses the technological context, beginning with the roles of Big Data, interactive visualisation and data exchange techniques. Then it sketches a first draft of software architecture, which serves to highlight necessary functions and aspects that serve as a (backend) basis for software development.

Chapter 4 focusses on (frontend-side) client applications, on dashboards, geodata and webmapping, as well as components dealing with skills management.

In Chapters 3 and 4, also concrete software libraries and frameworks are presented, some of which will be implemented during software development in WP4.

Being an early and strategic document, this report does not serve for defining concrete decisions for development questions, for example regarding component selection or application. It serves much more as an explanation of available technologies for all (including non-technical) partners, as well as a basis for discussion and decision-making by the technical partners in the software architecture sketching and development phase.

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1. Introduction

In recent years, technological advancement has deeply changed the ways how we see particular phenomena and how we tackle certain problems and challenges. Through innovative and intelligent application and combination of novel techniques, MICADO aims for a sustainable positive contribution in the topic of migrant integration. Main output of the project should become up-to-date technological solutions and tools that provide a solid and profound assistance for migrant integration in various European cities and contexts.

Modern data preparation and visualisation technologies can help to understand complex phenomena such as migration and integration. More concretely, dashboards and cockpits allow the assessment of existing needs and demands, as well as the evaluation of actions in almost real-time. These solutions, linked with migrant assistance interfaces (including components such as chatbots), can effectively contribute to a successful tackling of challenges MICADO addresses.

Dashboards, cockpits, chatbots and many components MICADO aims to deploy, are not completely new solutions. They have already been exploited in various projects, both in research and in administration. Therefore, MICADO doesn't primarily aim at developing new tools and solutions "from scratch". It is more important to find the most efficient and usable elements and adapt them accordingly to form a reliable and convincing solution, that will be adopted eagerly by all of the project's target groups, namely migrants, the public administration and helping organisations.

The purpose of this document is to present the current state-of-the-art of technologies and solutions MICADO might utilise, list and review possible components and draw up both their potentials and limitations. As technical development will take place in WP4, (at the time of writing this document) no decisions have been made on software architecture, therefore this report makes no claims of making concrete decisions.

This document is a strategic guideline that aims at listing the most important points from a technical development perspective, formulated in an understandable way for non-technical partners and the wider public as a guideline.

2. Background and Scope

2.1. Existing Mobile Applications for Migrant's Assistance

There are several mobile apps for migrants with different focuses. These represent the market competitors that MICADO will have to confront.

These applications will be analysed and examined to understand what is already offered to migrants and how, to look for improving approaches and identify lacking features that will differentiate MICADO.

Most applications are developed for both Android and iOS. A set of these are described below, with special emphasis on the significant aspects, and how the information is presented to the users. All the apps presented below are free for end users.



2.1.1. RefAid¹

This mobile geolocation-based app shows to migrants, refugees and those who help them where service providers are located nearby including information about the opening days and hours. Information is presented on a map with a simple interface. The services listed include legal aid; food; shelter; water; aid for parents and children; unaccompanied children; health; education; and toilets and showers. A web based content management and communication system allows trusted aid organizations to manage and update their services. It also includes push notifications with urgent news.

This app was developed by trellyz², an Information Technology and Services company. 5,000 NGOs and non-profit organisations helping migrants in 22 countries provide information about their services. Some of these trusted organizations are Doctors of the World, Doctors without Borders, Save the Children, the Red Cross, Caritas, among others.



Figure 1: RefAid

The app is currently only available in Europe, the United States and Turkey. The app shows the user what is available within 150 kilometres of where they are. Some services are available in multiple languages including English, Farsi and Arabic. However, the trusted organizations do not provide their services in all EU countries. Mandatory information for registration is an email, gender and if the user is over 13 years old). This app requires the user's location to show available services in their area.



¹ https://refaid.com/

² www.trellyz.com

2.1.2. Love Europe Refugee³

This app will help you find what migrants and refugees need most, both on your journey and when you settle. Users can add helpful locations, local events, but also make yourself available to get connected with a refugee. It also works offline because information about locations and events are stored on the smartphone so the user can navigate to locations using the compass function if she is disconnected from the Internet.

The app contains videos and links about language, culture and more in order to promote the integration of the migrant in the society. The information is provided in two languages, so it can be used as a communication tool. The phrasebook provides many basic phrases you can use in another language. Only information of Germany, the Netherlands, Switzerland and France is available.

No user's information is required. This app needs GPS to be enabled to make phone calls for emergency situations (the app includes a SOS button that allows to call 112, contact with the police or find hospitals).



Figure 2: Love Europe Refugee

The idea and development of the app is initiated by Agape Europe⁴ (https://agapeeurope.org/), a non-profit organization, and developed with the Jesus.net-Foundation.

³ https://love-europe.org/

⁴ https://agapeeurope.org/

2.1.3. Ankommen ('Arriving')⁵

The app serves as a go-to for new refugees arriving in Germany. It gives refugees tips about living in Germany, including shopping and food advice, information on where health services are provided, a step-by-step description of how to use trains and buses in different areas, and how to integrate children through educational opportunities. It also provides information on asylum procedure, vocational training and job opportunities, among others. Refugees can also learn German on this app. Each lesson contains different listening, speaking and writing activities and it allows connecting with volunteers who speak German in order to practice the language.

German authorities released this app and it is available in 5 different languages. As Love Europe Refugee app, it can be used offline. The initial screen does not contain textual information but all the following windows combine textual and graphical information.



Figure 3: Ankommen

⁵ http://ankommenapp.de/APP/DE/Startseite/startseite-node.html

2.1.4. Integreat⁶

This app addresses the lack of information of newcomers in a country and attempts to overcome this decisive barrier to integration through an ICT-tool bridging this gap. The non-profit entreprise "Tür an Tür – Digitalfabrik" whose shareholders are the non-profit association Tuer an Tuer and the Chair of Information Systems of the Technical University Munich (TU Munich) has developed the app Integreat. The software is open source and free of charge for users. Privacy is a crucial issue for the developers of the app, so they clearly state that they do not want nor need the data of their users.

The developers of Integreat are envisioning comprehensive service ecosystem for cities, municipalities and (German federal) states to overcome language barriers and create transparency of information. The project receives funding through payments from the municipalities using Integreat as well as some public (German Ministry for Work and Social Affairs) and private funding (winners of Google.org Impact Challenge).

Integreat is a highly recognised and awarded project, having received nine awards related to migration, integration and technology since 2015 (e.g. Integrationspreis 2016 – Regierung Schwaben; google.org Impact Challenge Deutschland 2018). Many <u>cities, regions and municipalities</u> in Southern Germany (Bavaria and Baden-Württemberg) are using Integreat and the users can receive relevant information of organisations, contacts and procedures in many different domains (e.g. education, housing, health) in the location they are residing.



⁶ https://integreat-app.de/ or https://integreat-app.de/en/

2.1.5. phase6 hallo Deutsch Kinder⁷

This is a language-learning app especially for children and young migrants in Germany developed by Phase-6 GmbH company and Mildenberger Verlag. Its focus is on children, which have no German language skills at all. Children will learn a basic set of German words with sound samples and picture exercises. The app works with rewards to motivate the children to work continuously. The aim is to speed up language learning for a better and quicker integration into the German school system.

The users select their native language. Visual and textual information is combined in all screens. However, most of screens contains only information in German. It could be difficult to understand the information provided if the migrant/refugee does not know the basic vocabulary.



The application does not require any information from the user.

Figure 5: Phase6 Hallo Deutsch Kinder

2.1.6. ImMigRant (Immediate Migrants Resources and tools)⁸

The European Centre for Disaster Medicine (CEMEC, San Marino) launched an app to support migrants in accessing health facilities. This app is designed to improve access for migrants to primary care, learn about the social and healthcare resources and take the right actions and decisions in case of emergencies.

⁷ https://www.dazhandbuch.de/empfehlungen-apps/phase6-hallo-deutsch-kinder/

⁸ https://www.migrantaid.eu/

The app allows filtering by typology: accidents, illness and disasters (nuclear or radiological incident, earthquakes, floods or landslides). The user interface combines visual descriptive information with textual information in two languages. The information presented on each screen is structured in steps. The last screen where sequences are represented does not contain textual information being the visual representation similar to storyboards.



Figure 6: ImMigRant

2.1.7. FindHello - Refugee & Immigrant Services⁹

FindHello helps refugees, immigrants and asylum seekers to settle in the United States. It displays maps and reliable services that are available for the users. The main features are: find immigrant and refugee resources with a zoomable map based on the user location (jobs, hospitals, accommodation, etc.), information about citizenship and immigration, ESL (English as a Second Language) classes to learn English, how to obtain legal help, among others.

This app is a partnership with the UN Refugee Agency (UNHCR) to help refugees, immigrants, and those seeking asylum in the USA. It is available in three languages: English, Arabic and Spanish. No login or registration is required and the list of resources are available offline whenever the user need it.

⁹ https://findhello.therefugeecenter.org/



Figure 7: FindHello

2.1.8. Refugees@Business¹⁰

The Refugees@Business application is an easy and open guide to start your own business in Europe for refugees. It enables refugees to understand the challenging way to economic independence due to all rules and regulations. The app is meant for people who want to be independent and self-reliant: people who want to explore the possibility to start as an entrepreneur in Europe. This app could be used as input for your conversation with municipalities, social organizations, consultants / advisers and lenders as well. It is only focused on Netherlands. It was developed by Stichting Immigration Guidance Foundation.

The information provided by the application is scarce. The user must select a topic from a list of frequently asked questions. Once the question has been selected, a brief explanation is provided. All information provided is textual so the user may not understand it if they do not master the language.



¹⁰ https://play.google.com/store/apps/details?id=com.igf.refugeesbusiness



Figure 8: Refugees@Business

2.1.9. Rights4Refugees¹¹

This application was created by Hellenic League for Human Rights with the aim of providing reliable legal and other essential information in order to inform migrants/refugees/asylum seekers who are in Greece on their rights. The information is available in four languages: Greek, English, Arabic and Farsi. The developer was AstroLabs, a digital communications agency.

The initial screens combine visual and textual information to help the user find what they need. However, when a certain option is selected, the information provided has fewer and fewer visual supports, which makes it difficult to understand the information if the language is not mastered.

¹¹ https://play.google.com/store/apps/details?id=gr.ast.rights4refugees



It does not need registration or access to the GPS of the mobile phone.

Figure 9: Rights4Refugees

2.1.10. App4refs¹²

The aim of the app for App4refs is to help refugees to search basic information. The main areas of this app are the provision of simple legal information, useful local resources locations and community interaction between the own refugees. The information of different activities is presented geo-located and it is possible to filter by interest (i.e., green areas, music and entertainment, culture, education and workshops). These activities allow people to organize their own time and create communities with common interests. Additionally, it provides useful links about education, official websites, public and emergency phones and sites.

This app is only focused on the metropolitan area of Athens. It is designed for low-end smartphones and the language used is easy. Its user interface is quite simple and visual. In this case, as there are no keywords accompanying the icons, the user may have problems understanding if they do not recognize the meaning of the icon. The postal address of the activities and points of interest are provided and a link is available for opening the corresponding map application installed on the device.

The app was developed by Fundacio ACSAR, a Spanish NGO.



¹² https://app4refs.org/



Figure 10: App4refs

2.1.11. The Collective (The Collective for Refugees and Immigrants)¹³

This app is a multilingual free social media platform powered by refugees, immigrants and their supporters. Content and languages are community-sourced. The current languages available are Arabic, English, Farsi, Swahili, and Kinyarwanda. It was developed by Derek Smith.

Its main features are to provide a directory to healthcare, immigration services and legal help; to connecting refugee/immigrants to one another and supporting organization through a social media platform that includes posts, messaging and groups; and to give discussion boards.

The app requires registration. The user must provide a username, email address and real name. Optionally you can also provide your nationality and the languages you speak. No GPS access is required. The points of interest are listed but they are not included in a map.

The user interface is simple combining descriptive icons with keywords in order for the user understand the information and they can find what they need.



¹³ https://play.google.com/store/apps/details?id=com.pale.app



Figure 11: The Collective

2.1.12. DICTUM¹⁴

DICTUM is a mobile application that supports migrants during health consultations. In lots of cases, the lack of language skills on both sides aggravates communication between doctors and (migrant) patients. As there are also not enough official translators, often relatives or friends of patients, or if they are not available, (online) translation services are used for assistance.¹⁵

In order to provide a more reliable tool for communication, a consortium led by the University of Göttingen developed an application that guides foreign-language patients through symptom assessment, providing basic information for the treating doctor. The adaptive questionnaire was developed to include cultural factors in symptom identification and description is able to create a reliable medical history in thirteen languages.

First evaluation results have shown that the application was well adopted both by doctors and patients and the developers are currently working on a number of enhancements in order to survey more complex medical issues (also in additional languages) in order to provide a solid and reliable translation service for both doctors and patients.



¹⁴ http://www.dictum.med.uni-goettingen.de/

¹⁵ Müller, Kleinert, Furaijat, Kruse, Simmenroth (2019)

2.1.13. Welkom in Antwerpen¹⁶

In 2017-2018, Atlas developed an app for newcomers in partnership with the City of Antwerp. The 'Welkom in Antwerpen' app centralises information about all possible services/organisations in the city that may be of interest to migrants during their integration process. Information is grouped into categories such as Emergency numbers, Administration, Housing, Dutch, Studying, Working, Health, etc.

Each organisation has a fact-sheet with information on its services, opening hours, address and documents to bring to an appointment. Organisations are displayed on a map, which can be linked to the user's own navigation app. There is also a function that allows users to store personal information to be used as a business card, the contact details of their counsellor at Atlas and general practitioner, etc.

During the design and development process of the app, special attention was paid to the visual design. Icons and visual elements are used to make the navigation easier for migrants with a low literacy level. The app can be downloaded from the AppStore for iOS and Android.

Since its launch in March 2018, the app has been installed on 5238 devices and has won the prize for best practice in the European research project RACCOMBAT.



Figure 12: Welkom in Antwerpen

2.1.14. Conclusion

In summary, most of the applications presented above focus on necessities for both, immigrants and refugees (language, health, education, housing, legal aspects, among



¹⁶ https://www.atlas-antwerpen.be/nl/nieuw-in-antwerpen/app-welkom-in-antwerpen

others). In addition, some of them include the possibility of creating communities and communicating between users with the same characteristics in order to share experiences and to help each other.

The trend in the design of these applications follows a pattern of combining visual and textual information in order to facilitate the understanding of the information presented and navigation between the different options for users. In addition, the textual information provided is basic, using a simple vocabulary.

Some applications include points of interest such as local-authorities, police stations, hospitals, among others. These points of interest are geolocated with the information associated. Most of these apps integrate a map within the application itself.

Very few applications are developed by country authorities or trusted entities such as wellknown NGOs. This causes the information to be unreliable to the immigrant/refugee. In addition, many applications only provide the most basic services.

2.2. User point of view

2.2.1. User Experience

In order to come up with adequate solutions it is essential to identify the concrete needs and demands of MICADO's future users. This will be done mostly during the co-creation workshop sessions (WP2), however a few key points can already be listed as guides for future development.

A central factor in the project's success lies in its adoption rates by the target groups. MICADO's ready application should be able to effectively address potential users and encourage them to employ it in their everyday actions.

A simple user interface is especially important for the migrant application, which should make use of an innovative and easily comprehensible symbol language, and/or voice commands. This makes the application accessible for people lacking the ability to read and write (or only being alphabetised in their native language). Such a feature might also serve as a main attractor of the proposed application; as such solutions are currently not widespread. Many of the applications listed above might serve as an orientation in interface design, as many of them applied intuitive symbols and layout. In this respect, the app "Welkom in Antwerpen" might be regarded as a good-practice example.

Cultural sensitivity also concerns an apprehensive approach in designing user interfaces. Figure 13 is an extract and gives an idea of which associations colours cause in different cultures. The colour for Happiness (38) is yellow in the western, green in Hindu, white in Chinese and red in Asian and eastern European culture. For displaying a sad topic, none of those colours should be used.



Figure 13: Colours in Culture (source: https://informationisbeautiful.net/visualizations/colours-in-cultures/)

The figure also shows that the most relevant regions in the figure only contain little information. This underlines that visualization should be part of the co-creation process (WP2).

Another quite simple example for thoughtful use of colours is housing in maps. In Western European Countries, housing areas in maps are usually shown in reddish, which makes sense, as roofs are red. In Arab countries most house are white and red is not associated with housing.

Similar challenges can be expected for symbols: The red cross for hospitals is used in Christian countries, in Islamic countries it is the red crescent moon. To use the red crescent moon in an app could mislead people as hospitals in European countries usually use the red cross as a symbol. All these aspects will be taken into account in order to improve the accessibility of the user interface.

As it is hard to find out all the relevant differences in advance, the co-creation process as well as usability try-outs should address this topic. We will obtain requirements from the point of view of the user interfaces from these workshops.

Trust is another inevitable prerequisite of MICADO's success. For migrants this point concerns an attentive dealing with the user's privacy and a safe storage and processing of personal data. For public authorities it is similar, they need to exercise control over the (often) sensitive data they possess.



Therefore, in data processing, MICADO should be able to deal with these concerns, for example by working with an indirect access to information, without the possibility to save datasets on own servers.

User friendliness within the scope of MICADO also includes an easy, modular implementation of the ready application, without lengthy installation and configuration processes.

In a later project phase, the ready solution should also be aware of the vulnerability of its target groups and provide a number of abuse mitigation measures. The application should stay resilient against unethical/immoral or even illegal offers and activities; it should recognise such contents and provide an efficient platform for moderation.

The dashboard will serve as a basis for decision making, so it is crucial that it presents information in a very clear, understandable way. As also the examples show (see Chapter 4.6.3), it is challenging to design a visual interface that is not becoming overly chaotic with an enormous amount of information but presents multiple indicators in a meaningful way.

Though some of the examples can serve as a guideline for certain questions in designing the dashboards, as of today, there are no (publicly available) dashboards that display such a complex topic as migration in a depth MICADO intends to do.

2.2.2. Devices

A number of studies and articles¹⁷ have highlighted the role of smartphones in the activities of refugees and migrants. These devices play a crucial role in communication (with peers, helping organisations, friends and relatives, etc.) and accessing information. Therefore, as it was presented in the previous section, migrant assistance applications are generally developed for smartphone operating systems.

As there is a number of different devices used by migrants, it is essential to offer a reliable solution, regardless of brand or operating system. To better serve this need, the state-of-the-art technology offers a modern approach called PWA (Progressive Web App) that represents a website that is designed to be installed and consumed as a smart phone application.¹⁸

Amongst the various technical solutions adoptable in the project, this will be carefully examined.

Regardless of the concrete structure and architecture of the application, a main feature of it should be a high efficiency in information retrieval and sharing. The ready solutions should



¹⁷ for example Gillespie, Osseiran, Cheesman (2018); Brunwasser (2015); Dekker, Engbersen, Klaver, Vonk (2018)

¹⁸ Biørn-Hansen, Majchrzak, Grønli (2017)

utilise data access flexibly and (ideally) directly from the data provider, using the methods presented in Chapter 3.3.2.

2.3. Guidelines for component selection

The basic technical development guidelines have been set in D8.3, the section below lists a number of further recommendations to consider when choosing and/or applying the software components.

2.3.1. Durability

In order to be able to create a long-lasting solution it is important to use components that are up-to-date and regularly updated, so that they do not become deprecated in a few years.

2.3.2. Level of advancement

As MICADO wants to collect, analyse and visualise data in an extraordinary depth and variety, it is crucial to use frameworks and components that are able to exploit the most modern techniques.

As an example, the data visualisation framework should be capable of dealing with large amounts of data, displayed on a broad range of (spatial) levels, enabling to zoom in to a building, or also get a view of the city as a whole. Although conventional diagrams and charts present information in an understandable and simple way, alternatives (sankey or chord digrams) can be utilised to display networks, flows and other types of content.

The same approach is also to be applied to the other components. The frameworks applied in data preparation and analysis should not just match the standard requirements but also present a wide range of options dealing with the assigned tasks.

Basic information about the efficient handling of Big Data and interactive visualisations are discussed in Chapter 3.1.

2.3.3. Minimization of need for customization

Another important aspect from a developer's perspective is the easy implementation of a solution. An efficient application development is characterised by a simple harmonisation of the single components, minimising the needs for customization.

2.3.4. Open source development

The project team has decided to choose an open source development approach throughout the whole development process (wherever possible), as this provides a number of benefits, not only during the development but also later on. This principle should also be applied at the selection of frameworks and components.

Through using such solutions, expenses for licensing costs can be saved. Furthermore, such components are developed consistently meaning that bugs or (most importantly) security issues are resolved rapidly.



Another significant aspect is the independence from (private) organisations that may not guarantee open standards or require the usage of proprietary data formats, leading to vendor lock-in under certain circumstances.

2.3.5. Community activeness

The efficiency of the application does not only lie in its usability but also in its developer friendliness. In order to create a sustainable application it is crucial to use components that are well documented, so developers can quickly get used to the functions and features of a component. This also helps in case of problems and troubles during the creation phase, where an active community is also integral in providing support and tips.

A reliable indicator of the activeness of a framework's developer group can be accessed via the GitHub repository of the components, namely the number of stars and contributors.

GitHub is a development platform where multiple users can work on a common software project. It is widely used both in private and in open source software projects. As latter are commonly developed through a crowdsourced and collaborative approach, the number of users being involved (contributors¹⁹) in the project serves as a good indicator for its activeness.

Another indicator for project's significance is the number of stars²⁰, which users can give to a project they are interested in and want to follow.

3. Technical Aspects

Two central challenging aspects in the development phase of MICADO's applications lie in the heterogeneous thematic, organisational, and contextual conditions and circumstances for its application. On the one hand, the solution should be applicable in a number of cities that have possibly different administrative standards, schemes, and guidelines for data provision, preparation, storage and visualisation. On the other hand, the application should be able to address very specific issues (in different languages), which consequently also means a large flexibility and adaptability of the product.

Focussing on the application from a functional perspective, some schematic steps can be derived to describe the organisational flow of the ready application. Data has to be collected, mainly from public actors and prepared in a way that requires minimal effort on the part of the Public Administration, to deliver a set of predefined features, such as dedicated visualization and innovative services.

In consequence, following necessary components can be defined:



¹⁹ https://help.github.com/en/articles/viewing-a-projects-contributors

²⁰ https://help.github.com/en/articles/about-stars

- a component that helps the user to transfer its own data and to feed the MICADO system
- a component (or set of components) that is able to analyse and transform the data to derive enriched content and novel decision support knowledge/information
- a component that visualizes the resulting data

As the examples have shown, there is a number of migrant assistance applications that utilise some aspects of modern technologies, however, still in a very basic way. MICADO wants to become a flexible, innovative, "out-of-the-box" solution, covering multiple aspects on the issue of migration, therefore it becomes crucial for the app to utilise the most up-to-date technologies and to make the best of big datasets and the connected technologies and other aspects.

Consequently, gaining solid knowledge about characteristic aspects of Big Data, networked solutions, their potentials, surrounding challenges and the current state-of-the art of these technologies is needed for the successful development of the MICADO tool.

The following chapters describe the state-of-the-art of those components and others needed to implement the overall set of features that MICADO has planned.

3.1. Big Data

In recent years, the phenomenon Big Data has become an important part of both the academic and the public discourse.²¹

Technological advancement resulted in creation of novel methods and tools that promise to give unique insights into a wide range of topics. Social sciences have in recent years also adapted many of these technologies²² and come up with innovative ways to answer complicated questions or assess complex systems such as cities.²³

The most commonly used definition for Big Data consists of the "3Vs", namely Volume, Velocity, and Variety²⁴. They refer to modern technologies that allow generating datasets in an unprecedented:

- size, allowing to perceive phenomena in an exceptional level of depth,
- speed, making the assessment of these phenomena possible in (near) real-time,
- and variety, meaning that although these datasets may contain large amounts of information, they can only be assessed after being pre-processed and distilled.



²¹ Mazzocchi (2015)

²² Venturini, Jacomy, Meunier, Latour (2017)

²³ Batty (2013)

²⁴ De Mauro, Greco, Grimaldi (2016)

The dataset(s) MICADO will build upon will probably match many of the features of Big Data, thus they will need to be handled accordingly in order to utilise their most promising potentials.

Members of the research team of the sciences po médialab in Paris reiterated their experiences with working with novel digital technologies in social research in an article²⁵, which can also serve as an orientation for MICADO's approaches regarding this field.

As they reflect, digital technologies in research dissolute the divide between qualitative and quantitative, allowing novel methodological concepts. They also overcome the gaps between micro (focus on interactions between individuals), meso (between groups) and macro (perspective on the whole society) layers, making a phenomenon accessible on all of these levels. In addition, they allow tracing back the data creation procedures to its sources and assessing knowledge/information generation processes.

This means, it is easier to explain through which transformations and filter mechanism a specific knowledge output was created based on a given dataset. For MICADO, this particular aspect becomes relevant during concept integration and story mapping in WP3.

However (especially resulting from the commonly unstructured and "unclean" nature of Big Data) there are some challenges to be tackled when working with such datasets.

Regarding Big Data preparation and visualisation techniques and tools, Bikakis²⁶ provides a proper overview on these questions and forms a number of recommendations on dealing with large datasets.

More concretely, he describes four aspects modern visualisation and exploration systems should efficiently handle. These are listed as follows²⁷:

- "Real-time interaction"
- "On-the-fly processing"
- "Visual scalability"
- "User assistance and personalisation"

All of these four points are of significant importance for MICADO, as the ready solution should visualise data in real-time, in a flexible way and based on the specific user groups' needs and requirements.

²⁵ Venturini, Jacomy, Meunier, Latour (2017)

²⁶ Bikakis (2019)

²⁷ Bikakis (2019): 336

The following chapter describes the steps related to data ingestion and handling (happening mostly on the backend side), while the subsequent chapter presents the visualisation techniques and concepts, focusing mostly on the user's frontend.

3.2. The role of Urban Data Platforms in MICADO

In order to utilise the large amounts of information stored in databases of public and private entities, efficient solutions for data exchange are of increasing significance. A promising possibility in doing this is presented by Urban Data Platforms - interfaces that help integrating data from various sources.

The European Innovation Partnership on Smart Cities and Communities (EIP SCC) developed the concept of Urban Data Platforms. The importance of such platforms is underlined by the partnership's goal, that by 2025 "300 million European citizens are served by cities with competent urban data platforms".²⁸

An Urban Data Platform is the implemented realization of a logical architecture. This platform integrates data flows within and across City Systems and exploits modern technologies (e.g., sensors, cloud services, mobile devices, analytics, social media etc.). The concept of building blocks enables cities a shift from fragmented operation to a better-connected and integrated approach.

This leads to the facilitation of utilising innovative (for example predictive effective) operations, as well as to new ways in engaging and serving city stakeholders. Consequently, it allows for a clear, tangible and measurable evaluation and assessment of activities and outcomes at a local level (for example increased energy efficiency, reduction of traffic congestion and emissions, etc.). As many of such datasets are available via standardised APIs (Application Programming Interfaces), they can be integrated easily into external applications.

In simple terms, an API can be defined as a "set of commands, functions, protocols, and objects that programmers can use to create software or interact with an external system".²⁹

The current Urban Data Platform³⁰ of the City of Hamburg serves as a good example for a data-storing unit containing open and non-open data of different authorities, third parties and few sensor data. It holds geospatial information in several categories, e.g.: education, culture, urban development and planning, environment, traffic which are distributed via standardized web services (OGC – see Chapter 4.7.3) for viewing, downloading and processing of data. Each dataset is connected to a metadata catalogue web service

²⁸ https://eu-smartcities.eu/initiatives/68/description

²⁹ Christensson (2016)

³⁰ http://www.urbandataplatform.hamburg/

interface, which is based on a city metadata catalogue (Hamburger Metadatenkatalog - HMDK) for government information.

The city datasets are further linked with each other across each other to extract additional insights. E-Government applications and services use the standardized web interfaces for domain specific solutions via intranet and internet. A number of additional services/data are already planned to be deployed i.e. supervision of streetlights, charging station management, traffic light and many more.

The open Urban Platform Hamburg shown in Figure 14 follows the common architectural framework developed in the EU Project Espresso³¹ and a System of Systems approach.

Heterogeneous systems or platforms can easily be connected and incorporated upon demand. The core of the data management of the Hamburg Urban Data Platform is divided in five modules: Data Web Services, Metadata Web Services, Processing Web Services, Data Analytics and Sensor Web Services.



Hamburg Urban Data Platform Architecture

Figure 14: System Architecture of the Urban Data Platform Hamburg (Source: http://www.urbandataplatform.hamburg/contentblob/11813892/90f33690cfeb20630bcf195c34a7a a5d/data/d-schnittstellen.pdf)

While the former four are fully deployed (and extended regularly), the latter is under development. The five modules are substantiated by the Data Warehouse where all data is

³¹ http://espresso.espresso-project.eu/

stored and extracted for the different services. The data from neighbouring systems are integrated using ETL (Extract-Transform-Load – see Chapter 3.3.2) techniques with different adaptors. The Urban Data Platform is under continuous development, which follows an iterative approach.

3.3. System Architecture

In order to come up with a solid and persistent solution that is able to deal with the challenges and utilise the potentials lying in Big Data, it is crucial to have a reliable system architecture. Though the architecture of the project will be defined in WP4, this report already sketches a basic architecture, in order to find and list needed components and assess how they could work together.

From a developer's perspective, it is also beneficial to draft a vision of the potential architecture early, in order to intercept critical elements.

MICADO will be an integrated "out-of-the-box" system, which provides digital tools for managing the integration of migrants in cities across the EU. It will be built applying a "one-fits-all"-approach, meaning that the system will address core requirements coming up in each of the piloting cities, which are thought to be representative.

The main user groups will be public authorities, migrants and organisations working in the context of migration. Each user group will have an own MICADO solution implemented according to the identified needs and requirements during co-creation. The different frontend components will be browser based and a smartphone application could be developed. The decision on the latter will be done after requirement analysis.

The approach the team proposes is to prepare a predefined and empty shell where data schema is ready to be filled with the information coming from the piloting site.

The data layer will represent the centre of the system that will be elaborated and consumed by the other components of the system.

As it is shown in Figure 15, there are a set of components that will be briefly described in the following chapters.

The aim of the activity that will take place in task T4.1 will be to identify (in the open source ecosystem) frameworks that empower development without having to build a custom MICADO solution. This is why a set of best of breed solutions are presented in this document - to list the most promising candidates that the architectural definition will take into consideration.





Figure 15: Sketch of the system architecture, which could be used. This includes the possible components and ways of communication between those. The purpose of this figure is to mainly list components and get an overview of the system. (Source: own work)

The components shown serve as exemplary for more complex software products that the consortium will have to integrate. They describe specific functions the specific components need to address in order to come up with a solid and reliable solution. The main functions of these parts are described below, more specific details and tasks will be described later in more depth.

Data lake	This component represents the data storage of the MICADO solution. A database will keep all the data organized. As previously stated, MICADO, in its <i>universal</i> version, will ship with a pre-defined data schema that can be extended in the pilot site. The data lake will be composed by a set of technologies that will enable proper data management accordingly to the requirements of tasks such as Big Data analysis or geospatial representation.
Data ingestion	This component will manage the process of transferring the data from the various sources into the MICADO environment
Chatbot component	The project defined to have a chatbot feature to interact with migrants; this component also depends on the data stored in the data lake to offer information to users.
Dashboard component	Dashboards represent the core technology of MICADO: data have to be managed and analysed to be given back to the user for decision support and better knowledge
Integration frontend	All the backend components need to be integrated at frontend level and placed in a user-friendly interface as stated in the previous chapters.



3.3.1. Data lake

Important statistical data, combined with personal information will be stored in MICADO's data lake together with the information coming from other sources of the Public Administration or publicly available. Data lake is the term used in MICADO to represent a set of storage technologies that go from usual relational databases to storage methods more oriented to Big Data analysis.

External services, such as for example Map Services (WMS) hosted by public authorities can usually be included directly into the MICADO frontend components if access to the source is given.

Concrete decisions will be done accordingly to the estimated potential amount of data and the needed features. Widely known and adopted solutions in the open source ecosystem are:

Link	http://postgresql.org/
Price/ License	PostgreSQL License
Advantages	 High performance, scalable Widely used Extensible High standard-compliance The PostGIS-extension facilitates spatial data representation
Disadvantages	Can be hard to manage/configure

PostgreSQL

MariaDB

Link	http://www.mariadb.com
Price/ License	GPL 2
Advantages	Supports different storage engines
Disadvantages	Not always standard compliant

SQLite

Link	https://www.sqlite.org/
Price/ License	Public Domain
Advantages	Low footprint
Disadvantages	No client/server, more for embedded use



To be considered only for development purposes or as an internal component of existing frameworks

MongoDB

Link	http://www.mongodb.com
Price/ License	GNU AGPL 3.0
Advantages	High performance, scalableWidely usedNon-relational
Disadvantages	Can be hard to manage/configure

3.3.2. Data Ingestion

The data sources used by the MICADO solution may vary between the different partner cities, even within the same country. Public Authorities and other organizations might use different DBMS (Database Management System) and file formats for storing data. In addition, differences in local legislation can lead to different data being collected by PAs. This leads to a relatively high effort in customizing data ingestion and storage on a local level. The solutions used should therefore be easy to customize.

Minimum three potential types of data sources were identified:

- Information accessible via Websites (e.g. office hours for public authorities, doctors, etc.)
- Database (public authorities and NGOs, including open data)
- Online Services (public authorities and other)

Extracting data and information from these three types leads to different ways of doing so.

Also accessing publicly available data or services via Websites can be done; for example, the Places Library as part of the Google Maps JavaScript API can supply information on opening hours.

Extract-Transform-Load (ETL)

Collecting all this information is typically done through the usage of ETL tools that could offer various approaches. These tools have advantages like automation, better connectivity to source systems and improved scalability than using traditional programming languages. In addition, using these tools usually greatly improves development time. An ETL-tool usually consists of a reader, which extracts the specified data and a writer, which writes the extracted and transformed data into a specified database. Since for this to work, read access permissions to the source data, specifications on the format and of course origin (server address, Port, DBMS) are needed to implement a proper reader a careful evaluation will be done as a general approach to propose a solution that will be acceptable by data owners. Since the target database will be the local MICADO database if necessary, the data can be transformed and adjusted based on the requirements of the MICADO tools.



For a more detailed description of the ETL process, please refer to the project glossary: https://github.com/micado-eu/MICADO/wiki/Glossary

Tools

ΤοοΙ	Pentaho Data Integration (Kettle) https://community.hitachivantara.com/community/products- and-solutions/pentaho
License	Apache 2.0
Kind	Metadata execution engine
Relational	JDBC
Non-relational	MongoDB
File	Delimited, XML, JSON, ORC, Parquet, Avro
Webservice	REST, SOAP
Messaging	Kafka, JMS, MQTT, AMQP
Remarks	1

ΤοοΙ	Talend Open Studio https://www.talend.com/products/talend-open-studio/
License	Apache 2.0
Kind	Code generator
Relational	JDBC
Non-relational	1
File	Delimited, XML, JSON
Webservice	REST, SOAP
Messaging	Kafka, JMS, Amazon, Google
Remarks	/

ΤοοΙ	Apache Nifi https://nifi.apache.org/
License	Apache 2.0
Kind	Metadata execution engine



Relational	JDBC
Non-relational	MongoDB
File	CSV, XML, ORC, Avro
Webservice	REST
Messaging	Kafka, JMS, AMQP, MQTT
Remarks	Streaming oriented

ΤοοΙ	Kafka Connect https://docs.confluent.io/current/connect/index.html
License	Apache 2.0
Kind	Framework/ Java API
Relational	JDBC, PostgreSQL
Non-relational	MongoDB
File	CSV, XML, Avro
Webservice	Generic HTTP
Messaging	Kafka, JMS, MQTT
Remarks	Streaming oriented Connectors need to be installed or developed separately

Data virtualization

Another option for the MICADO solution could also be the application of data virtualization techniques. The used data is not loaded physically into the system but stays within the source system and is requested directly in real-time. This approach reduces data duplication, batch time and leads to lower maintenance costs of data transformation.

Data Virtualization allows to integrate various data sources and represent them differently, without the consuming application having to know any technical details about the source systems. Unlike ETL, data is not physically moved between systems. Rather, the data virtualization system queries the source systems in real time. This of course has some advantages:

- Data can be read and written back to the source system
- Data is not moved, so storage requirements are lower
- Data can be accessed in real time, there is no need for any batch processes to run to update the data
- It reduces the risk of errors, lost data, or moving around data that is never used


However, this approach can have several disadvantages as well:

- The load on the source systems increases
- Performance of the consuming application might be hindered by slow source systems
- The amount of transformations and calculations that can be executed on the data is limited

ΤοοΙ	Teiid http://teiid.io
License	Apache 2.0
Kind	Metadata execution engine
Relational	JDBC
Non-relational	MongoDB
File	Delimited, XML, JSON
Webservice	REST, SOAP
Messaging	/
Remarks	

Tools

3.4. Chatbots

Chatbots offer an interactive experience to users, aiming to simulate human interaction. Thanks to the advances of AI (artificial intelligence) technology and NLP (Natural Language Processing) solutions, this type of software has grown in capacity in recent years and the open source ecosystem is thriving with frameworks.

The adoption of chatbot-based tools by the wider public is rising as voice assistants (Siri, Google assistant, Alexa) are displaying increased figures in sales.³² This indicates a technological level of advancement that allows an efficient interaction with such solutions.

To function, the chatbot has to understand the input it receives from the user through a channel. This channel can be spoken language recorded through a microphone or plain textual input in a chat application. The first method obviously requires an additional complex step to transform the speech to text.



³² Kinsella 2019

Given the text, the bot can use different approaches to extract the meaning and also some parameters that configure the resulting action(s). As an example, it could understand that the user asked to book a restaurant with the parameters being the time for the reservation or the type or name of the restaurant.

Meaning extraction is not a "certain" operation, but a set of possibilities. This probabilistic approach means that the chatbot selects the highest matching meaning based on results of a training process. In the simplest solution, this means that the chatbot selects an answer to the question of a predefined list. For example if the user provides the input "Where can I find a flat to rent?" the topic identification algorithm classifies it to the topic of accommodation it can simply provide a predefined answer with a link to the responsible housing authority. More sophisticated approaches that create more complex and elaborated outputs are summarised under the term NLG (Natural Language Generation).

Existing frameworks distinguish themselves by the software algorithms used to understand the text, identify the parameters and ways to interface with input or output channels.

Some framework leverage cloud services since processing different languages could be a high processing task that demanding high computational requirements. In this state-of-theart, evaluation only on premise framework will be taken into consideration since integrating with external NLP system is out of the actual vision of the integration plan.

In general, the open source frameworks require a training moment where the algorithms of the bot are tuned to the context of the tasks managed by the application. This training is usually done by human intervention where real users interact with the robot and validate the answers (supervised machine learning).

In the meaning extraction task there are algorithms that are language independent since are based more on pattern recognition and other that are more language dependent and relay on vocabulary. The first approach has the advantage of removing the complexity of analysing the semantics of the sentence, having a proper dictionary in the target language, but allows only simple patterns of recognition and could limit diversity of interaction. The second facilitates a richer interaction but requires a specialized bot for different languages.

3.4.1. Technologies

Chatterbot

Link	https://github.com/gunthercox/ChatterBot	
Price/ License	BSD 3-Clause	
Advantages	 Fairly language independent Logic adapters can be created Django integration 	
Disadvantages	 Can be hard to manage/configure requires hard training/programming 	



Link	https://rasa.com/
Price/ License	Apache License, Version 2.0
Advantages	 Good community Has NLU33 engine Can use tensorflow library Deployed on premise Has API for interacting with it
Disadvantages	Can be hard to manage/configure

Microsoft bot framework

Link	https://dev.botframework.com/	
Price/ License	The MIT License (MIT)	
Advantages	Strong vendorMany channels and adapters	
Disadvantages	 Highly dependant on MS environment Complex code Uses LUIS.ai that is offered as a service 	

BotPress

Link	https://botpress.io/	
Price/ License	GNU Affero General Public License v3.0	
Advantages	 An administration dashboard A visual flow editor A chat emulator/debugger Support for multiple messaging channels 	
Disadvantages	Coding skills are requiredMore developers oriented	

As an additional reference a comparison of external AI services is presented below in Figure 16:

³³ Natural Language Understanding

Comparison of Most Prominent Al Services				
	wit.ai	api.ai	LUIS.ai	IBM Watson
Free of charge	\odot	Sut has paid enterprise version	it is in beta and has transaction limits	30 days trial then priced for enterprise use
Text and Speech processing	\odot	\odot	⊘ with use of Cortana	${}^{\oslash}$
Machine Learning Modeling	\odot	\otimes	\odot	\odot
Support for Intents, Entities, Actions	⊘ Intents used as trait entities, actions are combined operations	Intents is the main prediction mechanism. Domains of entities, intents and actions	${ \oslash }$	${\otimes}$
Pre-build entities for easy parsing of numbers, temperature, date, etc.	${}^{\oslash}$	\odot	\odot	\otimes
Integration to messaging platforms	(S) web service API	⊘ also has facility for deploying to heroku. Paid environment	⊘ integrated to Azure	⊘ possible via API
Support of SDKs	includes SDKs for Python, Node.js, Rust, C, Ruby, iOS, Android, Windows Phone	⊘ C#, Xamarin, Python, Node.js, iOS, Android, Windows Phone	© enables building with Web Service API, Microsoft Bot Framework integration	Proprietary language "AlchemyLanguage"
Created by ActiveWizards				

Figure 16: Comparison of AI Services (source: https://activewizards.com/blog/a-comparativeanalysis-of-chatbots-apis/)

As can be seen, only wit.ai and api.ai provide free of charge services, but the model is deployed and runs in the service environment outside the perimeter of MICADO.

The main evaluation checks that will be done are:

- capability of managing multiple languages
- being able to interact with APIs

3.5. Application Layer

The application layer organizes incoming requests from the client applications and runs the needed components. Main tasks of the application layer are to identify the communicating components in the network, to determine resources and to organize communication between components, databases and the clients.

An Application Layer Gateway (ALG) can be used to send all requests defined by the users to a single point of contact via http-requests. This component then forwards the requests to the behind components. An advantage is that not all specified ports for each component need to be open on the application server, making it harder for attackers to get into the



system. In addition, dynamic opening of ports is possible which means that only the ports addressed are being opened.

Static and dynamic content shown on a website has to be delivered by web servers. These applications are hosting a description of the content delivered via *HTML*, but also CSS, and JavaScript-Code and images such as jpeg/png. The content is requested via protocols as HTTP/HTTPS. These tools are also used to load balance requests and hide the overall back end complexity to the front-end layer.

The following list enumerates the most frequently used tools in the open source ecosystem to solve this task, since these are widely known and do represent the actual infrastructure of the web there is no need to provide detailed description, but is provided for sake of completeness; the technical motivation for the adoption of chosen one will be described in task 4.1.

- Apache HTTP Server: https://httpd.apache.org/
- nginx: http://nginx.org/

4. MICADO Client Applications

4.1. Overview

The client applications will be built on top of the database, data extraction and application layer. The main task is to present the information gathered and produced in an organised and user-friendly way. This is done by browser based platform solutions and can be done by web-based mobile applications both coded in *HTML5*, *CSS* and *JavaScript*.

The following figures are examples on how the different client applications could look like:





Figure 18: Mockup of the public authority interface



Figure 19: Mockup of the helping organisation interface

Migrations issues and challenges will be handled by providing migrants, public authorities and local communities with tailored cockpits and dashboards.³⁴

The Migrant Cockpit will generate important data on migrants, which can be analysed to derive tailor-made integration measures. Migrants' personal data from cockpit interfaces is matched or combined with existing data from public authorities or other resources. The Migrant Cockpit needs to address migrants and refugees as early as possible, and guide

³⁴ Regarding the difference between cockpits and dashboards, see below section 4.2.1

them effectively into regular social systems (health, education, labour, housing). Ideally, it becomes a "one-stop shop" thanks to all the essential information being easily accessible. In any case, the Migrant Cockpit will feature language interfaces, as language is a central challenge in migrant integration. This includes text- and audio-based chatbot functionality, as well as automatic translation will add considerable value in particular to the migrants' cockpits. This facilitates easy, direct, and trustful communication with helpers and authorities and make integration services substantially more accessible.

For Public Authorities and administrations, dashboard functionalities can offer comprehensive, multi-level overview of activities, measures, and programs in the respective competences a) horizontally across the different domains of integration (labour, housing, education etc.), as well as b) vertically across impact levels (person, neighbourhood, district, and city). Basic services may include cartographic overviews on current activities and actors in their respective area (incl. civil society activities). Further, Key Performance Indicators (KPI) for measuring integration success can be monitored and benchmarked, thus forming the basis for the impact-oriented design of new programs and measures. Monitoring functions and statistical analysis can be purposefully combined with automatic generation of reports on the current state of affairs.

Going beyond the capacity of dashboards, authority cockpits may provide interactive functions for special purposes of data access and transfer. Helping to streamline information and communication flows between public authorities, migrants, and other stakeholders, functions such as "Request for information" can improve quality in the processes of communication or document transmission between stakeholders, and also reduce information losses through interfaces.

The Local Communities cockpit can support Helping Organisations, civil society, NGOs, etc. effectively in organising and coordinating bottom-up help activities. Cockpits that communicate well with the systems of the Public Authorities will reduce mismanagement of activities, and contributes to avoid frustration about ineffective help. Here, mentor matching appears to be an especially attractive service, as in practice one-to-one mentoring has proved to be one of the most effective means for successfully guiding migrants into jobs and communities – a task that necessarily involves civil society.

4.2. Strategic Visualisation

Within the MICADO project, dashboards and cockpits are understood as visualisation and communication tools aimed at depicting key issues and indicators related to migration and integration. By doing that they facilitate evidence-based and comprehensive decision making processes.

Within this project, it becomes important to understand the concept behind strategic visualisation in decision making processes, the underlying rationale behind (scientific)



illustrations in order to guide technical development and the compilation of the project's end products.

As Forster discusses, the aim of scientific illustrations is "an exact understanding of an analysed subject (object, creature, issue) and the wish of sharing what has been understood."³⁵ Within the context of MICADO, dashboards should provide insights into the current state of the subject migration, focussing on the 4 main domains of labour, education, health and housing and facilitate decision-making in an effective way.

Strategic visualisations therefore go beyond simply depicting the analysed subject and are able to stir the imagination in order to elaborate problem solving strategies, serve as a communication tool for assessing these and help us to classify, summarise elements of our life in order to elaborate their similarities and differences.³⁶

Graphical representations of complex phenomena present a long history that looks back to prehistoric times. The infographic, as we know today, dates back to the 18th century Scottish economist and mathematician William Playfair. Since then, abstract visualisations of different matters have become an important tool of communication and have in some cases even reached iconic status, such as Harry Beck's 1933 tube map, which is still followed in multiple cities around the world.³⁷

Beck's tube map is a good example of a successful simplification of complex matters in graphical representations by focussing (in this example) on the topological structure of London's tube system, regardless of geographical distances or shapes. Cartography addresses this activity by the process of generalisation, by finding the balance between accuracy and understandability.

A major benefit of technological advancement is the increased interactivity in data preparation and visualisation. As described in Chapter 3.1, this flexibility is one of the most important potentials MICADO needs to harvest.

4.3. Visualisation and Simulation

In contrast to visualisation, which focusses on the abstraction and simplification of complex phenomena, simulation aims for a reproduction of a phenomena, in general with the largest level of detail and accuracy possible. Simulation of societal questions is often a complicated task, on the one hand because of its inherent complexity but also because of the sensitivity of such topics, especially within the context in migrant integration.



³⁵ Forster (2016: 77)

³⁶ Forster (2016: 77)

³⁷ Ashton Smith (2011)

MICADO keeps the focus on visualising migrant information, instead of simulating the behaviour of its target groups, as the ethical (but also computational) issues emerging from such an activity could exceed the limits of the project.

4.4. Narrative Visualisations

Especially the European influx of refugees in summer 2015 sparked a major interest in mainstream media for migrant integration and immigration. In many reports, journalists and migration experts adapted interactive web-based visualisation techniques, going beyond traditional reports. As Risam ³⁸ reasons, such visualisations can be attributed to the narrative genre, as they focus on storytelling with an interpretation of the presented data.

This means, these data visualisations are more than collections of different charts, graphs and indicators, in contrast to dashboards (see also Chapter 0). This, however, does not mean that MICADO's visualisations should not orient on such approaches. Their popularity encouraged a critical review in the scientific community, with results that are applicable within the context of this project.

A main challenge in the topic of visualising migrant data and information is the perception of migrants as the problem instead of focussing on solving problems of migrants. In her article, Risam explores two examples in the "interplay of written-linguistic, visual, and spatial modes of communication"³⁹ based on two interactive websites addressing migration to European countries. In the first⁴⁰, developed by the data visualisation tool developer organisation Lucify, the issue of perceiving migrants as problems is visible in multiple aspects⁴¹.

The usage of a specific, negative terminology, such as "crisis", contribute to this impression. Additionally, the website also suggests incorrectly, that refugee data (which is provided by UNHCR in this case) includes all forced migrants. The overall visual language of the infographic also contributes to the image, with the dark colour schemes and only national borders providing geographic orientation for the viewer (omitting topographic features). The migrant flows are themselves represented as arrows travelling from one country to the another in linear distance. This misrepresents the facts that one the one hand, migration routes are overly complex and on the other hand, migrants often travel and arrive in waves.⁴²

In contrast, the website "Crossing the Mediterranean Sea by Boat" focusses on the migrants' perspective, being developed in a collaborative approach with migrants themselves. By

³⁸ Risam (2019)

³⁹ Risam (2019: 2)

⁴⁰ https://www.lucify.com/the-flow-towards-europe/

⁴¹ Risam (2019: 6)

⁴² Risam (2019: 7-8)

telling their stories, their "humanizing representations" help to articulate both reasons for migration and challenges they encounter along the way. This approach, complemented by a more sophisticated visual language, helps to acquire a more in-depth view of migration, with focussing on the problems migrants encounter instead of perceiving migrants as being the problem.⁴³

4.5. MICADO Visualisation Guidelines

Based on the review of available references in migrant data visualisation applications, Table 1 below summarises key issues to consider when developing the applications features for data visualisation:

Issue	Description	Visualisation recommendation
Clear	MICADO's main target groups are not a	Highlighting clearly which data in the
terminology	heterogeneous entity, therefore	charts are displayed, assignment of
	denominations cannot be used	different colours/hues to be used
	interchangeably. Refugees, migrants, people	consistently for a specific group. The
	with migration background are not	definition of the specific terms is
	necessarily congruent.	found additionally in the project
		Wiki ⁴⁴ and in the Glossary feature of
		the application.
Traceability	As discussed in Chapter 3.1, a main asset in	Provide access to raw data, including
	modern visualisation techniques is the	metadata (see below)
	possibility of providing ways to understand	
	how the displayed information was	
	generated	
Flexibility	In contrast to (focussed) narrative migrant	Provision of a robust data ingestion
	data visualisations, MICADO should be able	feature, usage of standard
	to display a large variety of datasets, coming	visualisation options and diagrams
	from different sources and formats	
Provision of	Data displayed in dashboard are not always	For each item in the dashboard,
metadata	self-explanatory and need to be set into the	provide information about the data
and	right context	source (e.g. via an information button)
explanations		
Focussing	As stated above, many visualisations suggest	Following a co-creative approach
on problems	that migrants themselves are the problems.	during the project's lifetime,
of migrants	Though MICADO's dashboard does not	distinguish between aggregated and
not	follow a narrative approach, the application	personal information (different
migrants as	still needs to find ways of humanising the	features for these two categories) and
a problem	displayed information in order to reach the	use a decent, clear and not suggestive
	project's overall goal of helping migrants	(visual) language throughout the
	upon arriving in their new cities.	application(s)

⁴³ Risam (2019: 9-10)

⁴⁴ https://github.com/micado-eu/MICADO/wiki/Glossary

Table 1: MICADO visualisation guidelines

4.6. Dashboards & Cockpits

4.6.1. Main topics & questions

Originating from the area of business intelligence⁴⁵, dashboards often provide at-a-glance views of key performance indicators (KPIs) relevant to a particular objective or business process. In general, the term dashboard is often used as a synonym for "progress report" or "report".

Dashboards are visual information displays that can present relevant in achieving one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance.⁴⁶ Dashboards are generally characterised by easy-to-comprehend diagrammatic and/or cartographic manners in displaying information, focusing on the key aspects of the addressed phenomenon.⁴⁷ Easy comprehension of content (visualisations, maps) and language support (thanks to the automatic translation) will empower better decision-making using converged and correlated information in the migrant domain.

Cockpits and dashboards are often used synonymously in discussions and literature. In our understanding, **Cockpits** are applications that imply procedural steps and user interaction, leading to specific results and outcomes. Applicable to all user groups too, they go beyond mere dashboards due to higher levels of interactivity. Well-guided procedures of use in this case are key: the user will not only consume information but also provide data to the system. Most importantly, users (migrants especially) shall provide valuable personal data such as biography, education, or professional skills in exchange when registering or using the cockpit. This valuable data input will allow much more profiled integration measures and management.

A key benefit for public authorities is the availability of rich and personal migrant data from the Migrant Cockpit, which expand the base of evidence for policy- and strategy-making. Public services can be provided more effectively: contacts can be established faster, individual offers promoted, and resources better allocated. Public Authorities will gain easy overview of developments and activities going on in their focus area. This applies especially to non-governmental bottom-up activities that do not necessarily appear on "authority screen".

Officers in public authorities can easily analyse, visualise, and monitor key parameters of migrant integration. They receive feedback on the impact and efficacy of integration measures, e.g. on average processing time per case. The system can quickly generate



⁴⁵ Mattern (2015)

⁴⁶ Few (2006)

⁴⁷ Tidwell (2006): 45

statistical reports and status documents on events and processes. No lengthy preparations or data collections are necessary.

Beyond mere dashboard visualisation, MICADO's data analytics will build up intelligence about relevant trends. Scenario analysis on socio-economic developments and migration forecasts (e.g. people flow mapping) may be created in support of planning human resource allocation and overall institutional strategies.

Cockpits will enable Public Authorities to engage directly with migrants, citizens, or communities. They establish a link for communication and cooperation, eventually raising trust and shared responsibility among all types of integration workers.

By using Cockpits, migrants can receive guidance and advice in a notably more direct and effective manner. Migrants can receive more accessible and attractive help, e.g. personalised offers for jobs, education, accommodation, or healthcare. Visual navigation and mapping features, among others, will help migrants to orientate easily themselves in their new context. Cockpits will provide one-to-one guidance, which would not be manageable through other means at such a high level.

4.6.2. Challenges

Gray, O'Brien and Hügel⁴⁸ list five key questions that are relevant when designing an urban dashboard as follows:

- Are the Data Open?
 - This is the most basic requirement for a functioning dashboard. If the data are not available or accessible, there is nothing to display. This argument sounds very basic and evident and serves as an imperative to all project partners to make sure on time that the relevant public authorities provide APIs for data querying.
- Are the Data Updated Frequently?
 - Linked closely to the accessibility is also the aspect of the frequency of updates. Broken or static data sources devalue dashboards, especially if the users cannot recognise whether the displayed information depicts the current state or is just an older snapshot of a specific phenomenon.
- Are Citizens Interested in the Data?
 - This aspect might be translated into MICADO, whether the specific target groups are interested in the data. Displaying too much information leads to confusion and a dashboard that only includes the most basic (or already known) aspects of one phenomenon is unlikely to be adopted by its users on a long-term basis.



⁴⁸ Gray, O'Brien and Hügel (2016)

- Is the Data Source Available for Multiple Cities?
 - Though MICADO develops specific solutions to specific circumstances in different cities, comparability between the different geographical regions is also a crucial aspect. The applications do not only offer the possibility to assess the performance of different integration measures and activities but also contribute to knowledge exchange and presentation of best-practice examples how to make datasets available efficiently. on This aspect was also taken up in the development of the Dublin Dashboard⁴⁹. where one city authority set an example to others by providing their data in JSON files.⁵⁰
- Is the Data Morally and Ethically Collected?
 - As MICADO deals with an extremely vulnerable target group, an ethical approach in data collection and preparation is evident. MICADO has set very high standards regarding data management policy and ethics. These standards and rules are defined in the IPR and Ethics guideline (D7.4) and in the Data Management Plan (D7.5). Furthermore, ethical questions do not only cover data collection, but also data visualisation. Possible critical questions might include the (unwanted) traceability of a single person from the displayed data. However, from a broader perspective, dashboards also tell a story which needs to be correct, not misleading and most importantly not provide a base for malpractice.

4.6.3. Dashboard Examples

The following section presents and reviews a number of publicly available (urban) dashboard examples. The description refers to the state of the applications in June 2019, the time when this report was created.



⁴⁹ https://www.dublindashboard.ie/

⁵⁰ Kitchin, Maalsen and McArdle (2016): 99



Figure 20: Paris city government dashboard

The city government Dashboard of Paris⁵¹ was created by the public authorities and presents administrative activities and their respective KPIs. These indicators are compared to a number of target measures (which have been set by the administration). By clicking on an indicator, the dashboard leads to detailed information and description of the selected topic.

The dashboard serves as a good example of a clear overview about a wide range of topics, however at the same time, it is very static, displaying outdated information and does not utilise more interactive data visualisation options.



⁵¹ https://dashboard.paris/pages/home/



Figure 21: GeoHub

The GeoHub⁵² of the Canadian city of Brampton applies a similar approach; it also displays a list of urban Key Performance Indicators that illustrate the performance of the city's authorities in various topics. The indicators are in this case not presented on a single page, but categorised, leading to a better overview. The four-colour indicator scale also helps to identify the state of the indicators immediately, however with the danger of providing a very reductionist⁵³ picture of the city.

⁵² http://geohub.brampton.ca/

⁵³ Kitchin (2014): 9



Figure 22: London Dashboard

The London Dashboard⁵⁴ focuses mostly on traffic information, but displays also social media trends and topics, as well as some basic data about air quality. It presents the displayed information in an interactive way, the indicator boxes can be moved around freely (however, it is not possible to add or delete charts).

However, a number of indicators is not available (as of June 2019), resulting in an error message (such as in the case of electricity usage), or also in displaying incorrect information. For instance the happiness indicators display that the inhabitants of the city are currently 100% unhappier, compared both to the country and to the long-term happiness level of the city.

This dashboard serves as an example why continuous connection to data sources is important. In addition, if the sources are not available, it is crucial that the system does not display any incorrect or misleading information instead of an error message.



⁵⁴ http://citydashboard.org/london/



Figure 23: Technical University of Madrid dashboard

The dashboard of the Technical University of Madrid⁵⁵ has a very focused approach. It displays indicators about building occupation, based on the number of connected devices to the routers (see also Chapter 4.7.5). This solution utilises a number of different data visualisation options and provides a neat and clear overview of the current situation at the university campus.



⁵⁵ https://ceiboard.dit.upm.es/dashboard/



Figure 24: Paris traffic dashboard

The other Dashboard from the city of Paris⁵⁶ exercises a similarly focused approach, addressing information related to private transport. The design of the dashboard is high-toned; it contains a 3D-view of the city and shows the data in a very interactive way. The dashboard is also very location-based; every indicator is placed directly on the map.

Although this dashboard is definitely visually highly appealing, its system requirements might exceed the computing capacities of MICADO's end user's devices.



⁵⁶ http://serveur.arcorama.fr/CityDashboard



Figure 25: Mackay Disaster Dashboard

The Mackay Disaster Dashboard⁵⁷ focuses on the topic of weather, supplemented with news and traffic information. This dashboard has a very simple layout, and a plain design principle, providing a straightforward overview of the situation but lacking more detailed analytic features and content.

⁵⁷ http://cyclonedashboard.com/mackay.php



Figure 26: Dashboard of the City Goldcoast

The Dashboard of the City Goldcoast⁵⁸ focuses on the same topics; however, it displays the information on a more detailed level and is visually more appealing.



Figure 27: Snap4City sample dashboard

This Dashboard⁵⁹ is an example created with the wizard developed in the project Snap4City⁶⁰. It displays a lot of information, especially focusing on the topics traffic, weather

⁵⁸ http://dashboard.cityofgoldcoast.com.au/

and emergencies. However, the large number of indicators, their lack of coherence and the visual design makes the dashboard overly chaotic. In this "information overload", many different things are displayed but there is a lack of understanding the purpose of the solution.

It should be noted that this dashboard (along with the others in the dashboard example gallery of Snap4City) serves in the first place presentation purposes. Being an example for information overload, it can be regarded for MICADO as a negative example on how not to design the dashboard solution nonetheless.



Figure 28: Dublin dashboard

Among the dashboards presented in this section, the Dublin Dashboard⁶¹ covers the widest range of topics and themes. It has a clear categorisation of the different charts and displays and incorporates a lot of information from external services (such as Flightradar about the flights around Dublin) by embedding these. Therefore, it is not just a simple dashboard but more an exhaustive collection of publicly available datasets and visualizations about the city that – in many cases – display past information.

The implementation of external services makes the development process much easier, at the same time leading to a strong dependency on these (resulting in a less persistent



⁵⁹ https://dashboard.km4city.org/dashboardSmartCity/view/index.php?iddasboard=MTYz

⁶⁰ http://www.snap4city.org/

⁶¹ http://www.dublindashboard.ie/

application). Persistence results also from using up-to-date components and not incorporating deprecated technologies, such as Flash.

Still, the development and application process of the Dublin Dashboard is very well documented, the published papers⁶² promise to be highly useful in the development phase of MICADO's dashboard solution.



Figure 29: Glasgow Tourism Dashboard

The Glasgow Tourism Dashboard⁶³ provides a simple overview about the addressed topic and related indicators. Though it carries the label dashboard it is more a collection of (past) statistical measures (mostly coming from the year 2017), in a non-dynamic way.

⁶² A list of papers is available on the dashboard's webpage: http://www.dublindashboard.ie/pages/ContactUs



⁶³ http://glasgowtourismandvisitorplan.com/insights-and-tools/dashboard/



Figure 30: Open Migration Dashboard

For MICADO the Dashboard⁶⁴ of the Organisation "Open Migration" is of significant relevance. The website displays up-to-date information about migrants arriving in Europe. It provides a clear and precise overview of the situation and shows a wide range of indicators (origin, destination, date of arrival, etc.) in an easily understandable and interactive way. MICADO's dashboard solution can definitely refer to this web-application regarding the layout and the ways of presenting the information.

4.6.4. Existing frameworks and technologies

Freeboard

Freeboard is a simple to use, easily implementable dashboard solution that focusses mostly on data visualisation in relation to Internet of Things (IOT). The dashboard runs as a client-



⁶⁴ https://openmigration.org/en/dashboard/

side application in the web-browser and has a graphical interface to add/edit charts and other components making up the dashboard. Although both implementation and operation of this solution promise to be very intuitive, many (especially for MICADO) important features (such as private dashboards) are only available through a premium plan.

Link	https://freeboard.io/	
Github	Stars: 5637 Contributors: 19	
Price/license	МІТ	
Pros	Easy to use.No coding required.Drag and drop widgets	
Cons	IoT centered.Limited extensibility.	
Examples	https://github.com/Freeboard/freeboard/tree/master/examples	

Plot.ly / Dash

Plot.ly is a framework that offers easy-to build charts, maps and other interactive data visualisation options. Plot.ly provides libraries for Python, Matlab, R and JavaScript, as well as an online tool (Chart-Studio), which offers basic chart creation without the need for coding. However, the different libraries are in different development phases.

In combination with Dash, it is possible to integrate different charts into one dashboard, with the options of cross filtering and callbacks between the elements (outside the dashboard too). A dash application is written entirely in Python, and through web a framework (such as Django, Flask or web2py), it is possible to develop interactive online applications.

Link	https://plot.ly	
Price/Licensing	MIT (with commercial add-ons, such as Chart-Sudio, Dash Design Kit)	
Github	Stars: 10221 Contributors: 114	
Pros	Well documentedEasy to implement/useActive development community	
Cons	 Web-mapping only very basic Restricted (complicated) customisation of charts Only basic callbacks (no circular references) Relatively slow in comparison with other frameworks 	
Examples	London tweets (www.londontweets.eu) New York Oil and Gas – Production Overview (https://dash- gallery.plotly.host/dash-oil-and-gas/)	



Apache Superset

Superset is a "modern, enterprise-ready business intelligence web application".⁶⁵ It's an open source dashboarding application that integrates with a number of RDBMS or Druid.io for streaming use cases. It also offers a flexible security model and integration with many authentication providers.

Link	https://superset.incubator.apache.org/	
Price/license	Apache 2.0	
Github	Stars: 24426 Contributors: 368	
Pros	 Provides many functionalities out of the box. Provides a semantic layer so the dashboard builder needs less technical knowledge. Integrates with a variety of backends 	
Cons	 Still in its infancy Not always user friendly Less freedom than a charting library 	
Examples	https://superset.incubator.apache.org/gallery.html	

D3.js

D3 is a JavaScript based library for dynamic data visualisation and analysis. "D3 helps you bring data to life using HTML, SVG, and CSS. D3's emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework, combining powerful visualization components and a data-driven approach to DOM manipulation"⁶⁶

Link	https://d3js.org/
License	BSD 3
Github	Stars: 4085 Contributors: 122
Pros	 Mature. Visualisation functionality is basically limitless. Many examples available Plugin infrastructure

⁶⁵ https://github.com/apache/incubator-superset

66 https://d3js.org/



	Using HTML and SVGAll browsers supported
Cons	 Only visualisation, connecting to the data needs another solution Can become somewhat complicated Problems in version consistency and version control
Examples	https://github.com/d3/d3/wiki/Gallery

Mozaïk

Mozaïk is a tool based on nodejs / react / d3 / stylus to easily craft beautiful dashboards.

Link	http://mozaik.rocks/
Github	Stars: 3152 Contributors: 21
Price/license	МІТ
Pros	Easily extensibleOptimized backend communication
Cons	Can become somewhat complicated
Examples	https://react.rocks/example/mozaik

PatternFly

PatternFly is a design library aiming at developing User Interfaces based on HTML/CSS and jquery.

Link	https://www.patternfly.org/
Github	Stars: 1129 Contributors: 71
Price/license	CC BY 4.0
Pros	 Prepared design elements could save resources Standardized interaction patterns and controls can improve operability.
Cons	 current PatternFly3 is based on Bootstrap 3 but next Version (PatternFly4) will not be based on Bootstrap any more – major changes within the library could affect stability (will support latest 2 versions of Edge, Safari, Firefox and Chrome) customization might be tricky
Examples	https://www.patternfly.org/pattern-library/ https://www.patternfly.org/pattern- library/dashboard/dashboard-layout/



Teradata Covalent

Design library for User Interface Elements (collection of design pattern elements). Unlike PatternFly this library is based on typescript and Angular⁶⁷ components, which are the core of Covalent.

Link	https://teradata.github.io/covalent/ https://github.com/Teradata/covalent/stargazers
Github	Stars: 1977 Contributors: 300
Price/license	МІТ
Pros	 Prepared design elements could save resources Good documentation (step-by-step node.js installation and deployment guide (>node 6.11.1))
Cons	 UI elements need compilation Customization of templates and creation of new UI- elements might be tricky
Examples	https://teradata.github.io/covalent/#/templates

ECharts

Design library for Charts. Based on Javascript, depends on ZRender Library.

Link	https://teradata.github.io/covalent/ https://github.com/apache/incubator-echarts
Github	Stars: 34855 Contributors: 10404
Price/license	Apache 2.0
Pros	 Vivant community lots of examples and inspirations multiple extension packs for 3D, web maps and other languages (python) can use data streaming (for visualisation)
Cons	Customized modules might need compilation

Metabase

Metabase is "obpen source business intelligence tool"⁶⁸ that includes a simple-to use dashboarding component do be used without in-depth coding knowledge.

⁶⁷ <u>https://angular.io/</u>

Link	https://www.metabase.com/ https://github.com/metabase/metabase
Github	Stars: 21194 Contributors: 222
Price/license	GNU Affero General Public License
Pros	Simple usageRobustness in operationExtensive documentation
Cons	Difficult customisationCan only handle simple data structures

⁶⁸ https://www.metabase.com/docs/latest/users-guide/01-what-is-metabase.html



4.7. Geodata & Web-Mapping

4.7.1. Spatial Data Representation

Representation of spatial data has engaged both computer sciences and geography for many decades. GIS applications are nowadays widely used both in public and private enterprises; however, the widespread implementation of more flexible and/or online geographic data solutions is today still in an early phase.

In MICADO, spatial data representation is relevant for two reasons. On the one hand, the application should provide basic (physical) orientation for newcomers in their new (and probably unknown) city. On the other hand, the localisation of issues and challenges becomes important as it facilitates the development and implementation of activities at a specific and concrete location. This latter aspect, however, proposes a challenge for MICADO, as many of the addressed themes and topics tend to be very abstract and/or invisible.

The following section serves as a basic guideline on using spatial data, defines the most common formats and basic terms to be used in MICADO's development phase.

In traditional GIS, there are two basic approaches on information abstraction, namely raster and vector representation. Raster representation is principally a georeferenced image file with each raster cell (i.e., pixel) containing one value.⁶⁹ A typical example of raster representation is a so-called "heatmap" displaying information about continuous phenomena such as the current temperature across the city.

Discrete phenomena are displayed in general as vector formats. These consist of definite geographical objects (called features) with an exact definition of their shapes, sizes, and positions.⁷⁰ In general, features can consist of points (for example a coordinate pair of a location of a public authority), (multi-)lines (streets) or (multi-)polygons (cities).

Though most public authorities (but also other partners) use GIS-applications frequently, web-mapping generally requires different approaches, conventions and file formats. These relevant points are described in the sections below.



⁶⁹ Dempsey (2017)

⁷⁰ Dempsey (2017)

4.7.2. File formats

ESRI Shapefile

In traditional GIS, a commonly used vector format⁷¹ is the shapefile, developed by ESRI in the 1990s. Although a shapefile in general presents one phenomenon (consisting of multiple features – such as the different boroughs making up a city), it consists of at least three distinct files⁷².

The first file, the shape (.shp), defines the form and the position of the features. The second (.dbf) is an attribute table that lists the features and their respective properties (for example the name, the population, or any additional data related to each borough of a city). The third (.shx) is the positional index of the features⁷³.

Although the ESRI shapefile constitutes a reliable format for storing and processing spatial data, when dealing with larger datasets or with topics requiring greater flexibility, it is quickly stretched to its limits.

GeoJSON

A lightweight alternative (commonly used in web mapping) is GeoJSON, which (as the name suggests) makes use of the Javascript Object Notation format (JSON)⁷⁴.

JSON allows a tree-like categorisation of information (an attribute field can contain multiple subcategories) and a flexible definition of attributes for each feature. Latter aspect is especially relevant if the data set is highly unstructured (or coarse) and the entities contain different categories of information.

Compared to shapefiles, GeoJSON has the advantage of the capability to store all required information (position, shape, attributes, style) in one single file.

GeoJSONs can also contain three basic types (point, line, and polygon); however, it is also possible to save a feature collection of different types into one single file (for example the administrative boundaries as multi-polygons, the streets as multi-lines and the location of authority offices as points).

This flexibility, however, also results in some disadvantages in working with JSON files. The list of attributes is defined for each object separately, leading to disproportionate increase in



⁷¹ Dempsey (2015)

⁷² Environmental Systems Research Institute (1998): 2

⁷³ Environmental Systems Research Institute (1998): 2

⁷⁴ Internet Engineering Task Force (2016)

file sizes if a large number of entities is listed. Indexing of data is also difficult which decelerates data preparation procedures.

On the positive side, the structural simplicity and flexibility of the format makes it widely adopted in many applications, most importantly those dealing with web mapping.

GeoTIFF

Formats used in raster data representation usually match the typical file formats known from image processing (JPG, GIF, etc.). However, the most common format used is GeoTIFF (Tagged Image File Format), which allows uncompressed raster data representation.⁷⁵

GML

The Geography Markup Language (GML) is an XML-based representation of geographical features.⁷⁶

As XML, GML is a relatively easily readable, tree-structured schema of information representation. Geographic information provided in the GML format is easily readable both for machines and humans and contains information about the position and shape of the features, the used coordinate reference system, attributes, and a number of further possible categories.

4.7.3. OGC-Standards

The simple applicability of the finished MICADO solution relies on the application of widely adopted and used standards in geographic data preparation, processing and distribution.

The international non-profit organisation Open Geospatial Consortium (OGC) defines open standards and protocols for dealing with geographic data and information⁷⁷. Through a close orientation on OGC standards, MICADO does not only facilitate the coordination and adaption of the application's components but also makes it easier to complement the solution upon completing the project. Although most standards might be relevant for MICADO, it would be beyond the scope of this document to list them all. The complete list of standards can be accessed via the following link:

https://www.opengeospatial.org/standards

As MICADO is sketched as a lightweight solution with a decentralised data storage system, it should utilise geographic information from different sources. The OGC defines a number of



⁷⁵ EARTHDATA (2019)

⁷⁶ Lake (2001)

⁷⁷ Open Geospatial Consortium (no date)

standards allowing data provision and retrieval. The three most important standards regarding spatial data provision and exchange are presented briefly in the following section.

WFS

The Web Feature Service (WFS) standard allows platform-independent access of vectorformat geographic information. WFS runs in a similar manner as the data extraction services described in Chapter 3.3.2 and passes data to the client server in GML.⁷⁸

Possible application in MICADO:

- Location of certain services/offices
- Definition of administrative units

WCS

The Web Coverage Service (WCS) is raster-based counterpart of WFS. It can provide data in various formats, such as GeoTIFF, NITF, HDF, JPEG, JPEG2000 and PNG. Another important feature of WCS is the capability of providing data related to a specific point in time, making the visualisation and analysis of processes possible.⁷⁹

Possible application in MICADO:

• Population grid

WMTS

Both of the services above provide data efficiently, however, in many cases only basic information (or the visualisation of the information) is required, for example for basemaps.

They are needed only to provide a basic orientation when using the application, the attribute information of streets, buildings and other features are not necessary. To ensure quick response times, it is possible to use a WMTS (Web Map Tile Service), which provides multiple raster image (most commonly PNG) tiles, which in consequence are displayed as a whole entity.⁸⁰

Possible application in MICADO:

• Basemap



⁷⁸ Open Geospatial Consortium (2014)

⁷⁹ Open Geospatial Consortium (2018)

⁸⁰ Open Geospatial Consortium (2010)

4.7.4. Projections

Choosing the right projection/coordinate reference system (CRS) is a bustling discussion in cartography and geography. In web-mapping⁸¹ in almost all cases WGS84 – EPSG:4326 (a pseudo-mercator) projection is used.

4.7.5. Georeferencing

Though MICADO does not plan to profile its users based on their exact locations, for providing orientation, the migrant interface should enable to display where the user is located. The following section lists a number of possibilities for georeferencing, which is defined as:

"specifying the geographic location of an object, entity, phenomenon, image, concept, data, or information with universal parameters (direct georeferencing), code, or place (indirect georeferencing)."⁸²

Nowadays, the most commonly used method for location finding is using a GPS-receiver, which has become a standard equipment of smartphones in recent years. The accuracy of this method lies in about 2-5 meters; however, its exactness might be decreased in built environments, and to a much larger grade, inside buildings.⁸³

Furthermore, the GPS-receiver is on many devices disabled per default, requiring the user to switch it on before using it. In addition to a higher battery usage with enabled GPS-receiver, privacy concerns might avert users from using this option for sharing their position with the application.

Another reliable option (accuracy ~50 metres⁸⁴) for localising devices can be done by calculating the distance to cell-phone-towers⁸⁵. A number of databases with location data of cell towers exist, such as OpenCellID⁸⁶, which is one of the most prominent free solution.

A further possibility is to infer the user's location is to use the method of Wi-Fi positioning. In this case, the position of the devices is done by collecting the MAC-address, the SSID and the signal strength of nearby WLAN hotspots and comparing the information to (publicly



⁸¹ WGS84 is also the only format coordinates in GeoJSON files can be provided.

⁸² Beyan (2016): 3

⁸³ National Coordination Office for Space-Based Positioning (2017)

⁸⁴ Kuusniemi, Chen, Chen (2012): 102

⁸⁵ Wang, Wong, and Kong (2012)

⁸⁶ https://opencellid.org/

available) datasets.⁸⁷ Wi-Fi-based positioning promises a higher accuracy (of about 2 - 2.5 m⁸⁸). At the same time, it is constrained by the availability of WLAN hotspots and the access to Wi-Fi location databases (many of them are proprietary).

Without using technological devices for georeferencing, a common approach is to use geotagging and geocoding. This means that the user can type in the name of a place (geotagging), which is matched by the entries of a list containing pre-defined coordinates (geocoding).⁸⁹ The most commonly used list are Foursquare's places API⁹⁰, Google's Geocoding API⁹¹ (both of them proprietary) and Nominatim⁹², building upon OpenStreetMap data and providing free service.

Some cities also provide their own gazetteering solutions, matching addresses with geographic coordinates, such as in Hamburg's "Zentraler AdressService"⁹³. The approach of geocoding can also be used for localising data not available in a spatially related format yet by trying to match any given geotag in the dataset with available and standardised location information.

It needs to be emphasised that MICADO's ready application probably will not use just one of the approaches defined above, but rather a combination of approaches that suits the given circumstances, the specific task the best being simultaneously in line with the users' preferences and privacy concerns.

In addition, it is important to note that the technical solutions described above will not necessarily be implemented by MICADO's application directly. The HTML geolocation API⁹⁴ also provides access to the user's location based on the available positional information provided by their device.

4.7.6. Spatial data handling

With integration currently being an important topic in European countries and cities, many public authorities have access to dedicated migrant data collections, as it is the case with the



⁸⁷ He, Chan (2016)

⁸⁸ Jekabsons, Kairish, Zuravlyov (2011): 131

⁸⁹ Beyan (2016): 4

⁹⁰ https://developer.foursquare.com/places-api

⁹¹ https://developers.google.com/maps/documentation/geocoding/intro

⁹² https://nominatim.org/

⁹³ https://metaver.de/trefferanzeige?cmd=doShowDocument&docuuid=73017BFD-0A5C-4C97-91E4-FB78F9698C72&plugid=/ingrid-group:dsc-HH

⁹⁴ https://www.w3schools.com/html/html5_geolocation.asp

"Lagebild Flüchtlinge"⁹⁵ (Situation Report Refugees). This monthly report is published by the city of Hamburg and focusses on different topics in migrant integration on three spatial levels (European, National, Local).

Though the logical structure of the document serves as a valuable basis for decision making and evaluation, the tabular presentation of numbers does not utilise its potential in decision-making processes. In the pilot city Hamburg, the MICADO PA-application will build up on the datasets provided in these reports, which are accessed via an API in order to receive up-to-date information in a format (XML) that is ready to be used by the dashboarding component.



Figure 31: Proposed spatial data workflow

Figure 31 above displays a schematic approach in accessing and preparing spatial data. MICADO's applications will build upon existing datasets stored in various external (urban, national and European) databases (such as the datasets included in the Hamburg Situation

⁹⁵ https://www.hamburg.de/sfa-lagebild/

Report). Additionally, PA users themselves can provide their datasets in conventional formats (e.g. CSV, JSON) that will be stored in MICADO's own databases.

Most data will arrive in a tabular form, while spatial data can generally be structured into three categories, which are: raster, vector and basemap information (as described in Chapter 4.7.1). Accessing these datasets happens based on specific OGC-standards (see Chapter 4.7.3), that downloads the datasets from the geoservers provided by respective PAs and other organisations.

These approaches enable accessing these datasets in a standardised form, with visualisation happening decentrally on the end-users' devices. MICADO's applications will use a dashboarding component from the collection in Chapter 4.6.4, extended with a mapping library, as presented in the following section 4.7.7.

4.7.7. Existing solutions and technologies for maps and cartographic visualisations

CesiumJS

CesiumJS is a community based, open-source (with support from the Cesium Consortium, founded by Analytical Graphics, Inc., Bentley Systems, and Rafael) JavaScript library for the creation of interactive 3D globes and maps. It allows visualizing static and time-dynamic contents, is easy to use for developers and provides a broad and extensive platform support. The library allows to visualize 2D and 3D based contents based on GeoJSON and 3D Tile formats.

Link	https://cesiumjs.org/index.html
Price/Licensing	open source
Github	https://github.com/AnalyticalGraphicsInc/cesium
Pros	 easy to use open community development step by step tutorials GIS Support export of different file formats possible dynamic data visualisation base map support (3D terrain layer, open street maps,)
Cons	 size of 92 mb difficulties in loading and positioning 3D objects no support for the 3D-object formats fbx or collada (dae) partly not sufficient documentation
Examples	https://cesiumjs.org/demos http://urbem.tuwien.ac.at


Leaflet

Leaflet is an open-source JavaScript library for interactive 2D maps. Works on all major desktop and mobile platforms, can be extended with plug-ins and has a well-documented API.

Link	https://leafletjs.com/
Price/Licensing	open source (2-clause BSD License) https://opensource.org/licenses/BSD-2-Clause
Github	https://github.com/Leaflet/Leaflet/blob/master/CONTRIBUTING .md
Pros	 size of just 38 kb plugin infrastructure good documentation strong community mobile-friendly easy to use (easier to use than open layers) tiled layers (with mapbox.js)
Cons	lack of advanced functionalityonly 2D and 2.5D support, only for maps
Examples	https://sfbay.craigslist.org/search/apa?query=&srchType=A&u seMap=1&minAsk=&maxAsk=&bedrooms= https://enlyft.com/tech/products/leaflet https://leafletjs.com/examples.html
Extensions	https://leafletjs.com/plugins.html

Mapbox GL

Mapbox is a provider of custom online maps for websites. Not to be confused with mapbox.js, which is a plug-in on top of leaflet, which renders raster tiles, but was initially created and developed by a MapBox developer.

Link	www.mapbox.com
Price/Licensing	Maps SDKs for Mobile free up to 25,000 monthly active users Map Loads for Web free up to 50,000 monthly loads https://www.mapbox.com/pricing/
Github	https://github.com/mapbox/mapbox-gl-js
Pros	 Attractive default map styling Interactive Graphical interface for styling map Highly customizable Great for large data sets



	Lower-priced than CartoDB (see below)
Cons	 Proprietary (pricing based mostly on traffic) Need to learn a simple language to style maps May require complementary GIS software + skills (i.e. QGIS, ArcGIS) to connect your data to geographic data
Examples	Foursquare (https://enterprise.foursquare.com/intersections/article/foursqu are-and-mapbox-partner-to-improve-location/) Pinterest (https://www.pinterest.at/ericgundersen/mapbox/) New York Times (https://blog.mapbox.com/new-york-times-live-mapping- virginia-election-15bfdda54180) Uber (https://eng.uber.com/uber-visualization-mapbox/) https://enlyft.com/tech/products/mapbox
Extensions	https://docs.mapbox.com/mapbox-gl-js/plugins/

OpenLayers

An open source javascript library to load, display and render maps from multiple sources on web pages.

Link	https://openlayers.org/
Price/Licensing	open source (2-clause BSD License) https://opensource.org/licenses/BSD-2-Clause
Github	https://github.com/openlayers/openlayers
Pros	 open source tiled layers OGC mapping very customizable and flexible (more flexible than leaflet)
Cons	 complicated API syntax version consistency (API changing with every release) documentation is designed for developers
Examples	FlightAware (https://de.flightaware.com/live/) https://enlyft.com/tech/products/openlayers
Extensions	https://openlayers.org/3rd-party/

Three.js

Three.js is an open source JavaScript library for the creation of 3D web viewers. It supports gITF, fbx and collada (dae) data formats and allows interactive 3D visualisation. The library is an open source project.



Link	https://threejs.org/
Price/Licensing	open source (MIT license)
Github	https://github.com/mrdoob/three.js/
Pros	 easy to use good option for building/exploring 3D objects good option for creating VR experiences
Cons	 lack of geospatial reference !!! no object manipulation enabled
Examples	https://threejs.org/examples/#webgl_animation_cloth

Masterportal

The Masterportal is a toolbox for Webmapping Application with Dashboard functionalities. The Open Source Application developed since 2014 in Hamburg based on OpenLayers and backboneJS has been implemented in several other German cities.

Link	https://www.hamburg.de/geowerkstatt/8856396/masterportal/
Github	https://bitbucket.org/lgv-g12/lgv
Price/license	МІТ
Pros	 Easy to configure Developer and user community> Exploitation
Cons	German front end (translation of components within MICADO?).
Examples	https://geoportal-hamburg.de/Geoportal/geo-online/ https://www.hamburg.de/schulinfosystem/

4.8. Skills management

This component represents the "out of the box thinking" approach of the MICADO project. As such, it was not yet included in the draft architecture, but represents the project's approach to find, in the open source ecosystem, tools that could be integrated as backend components to enhance the overall experience.

Labour and education are two of the four domains addressed by MICADO; therefore, "skills management" is a step in the process of qualifying an individual as adequate to a work offer. Based on the existing frameworks and components (see below), the MICADO development team will implement a feature in the project's applications that helps to monitor and assess the integration process of the application's users.

In addition, the act of badge collecting by migrants can also support the gamification approach of MICADO and facilitate the administration and verification of claims and entitlements (e.g. to a subsidy).



4.8.1. Existing frameworks and components

As in previous components the evaluation aspect of the components will be:

- the availability of API to interact with the component
- multi language support

Badgr

Link	https://badgr.com/
Price/ License	AGPL v3.0
Advantages	Build on an open specification
Disadvantages	Can be hard to manage/configure

CASS

Link	https://www.cassproject.org/
Price/ License	Apache License, Version 2.0
Advantages	Build a complete system that evaluate competences, levels, relations and assertions
Disadvantages	Can be quite hard to manage/configure Describing competences could be a project on its own

5. Conclusion

It is a central ambition of the MICADO's consortium to create novel, innovative and highly beneficial results. The project goes well beyond being just a simple linkage of available components. It intends to create a solid, reliable, harmonic and valuable application and combination of up-to-date technologies and frameworks.

This document has provided a basic and concise overview about possible adaptation options of ICT-based solutions. During development phase, however, many more questions about possible components and their applicability within the scope of MICADO's ready application will arise.

Although technical development takes place in WP4, many of these questions exceed the scope of technical design and software development. Certain aspects, such as cultural sensitivity in information visualisation (for example using a correct symbology and/or colour scales), need to be taken up during the co-creation workshop sessions. Many tasks of "translation" of user requirements into technical terms will take place in WP3, where also a number of points addressed by this document will be further discussed.

Therefore, this document does not address only the technical development partners but the whole MICADO consortium and intends to provide a basis for a solid discourse during the complete development phase, and later on, when the project is applied in the participating cities.



Consequently, the report employed a strategic approach, going beyond being a simple list of components and frameworks, has also drawn up common potentials, and challenges in utilising novel technologies.

Regarding the technical possibilities and available technologies and methods, lots of welladvanced and easily implementable solutions and frameworks are available and can be included in the system architecture. However, a major challenge lies in the proper application of these solutions and approaches.

Though there are no solutions available that address in the same depth and variety what MICADO intends to do, existing applications can serve as a solid guideline and orientation for development. Many partners in the project consortium already have been involved in the development of these solutions, for example as in case of the "Welkom in Antwerpen" application, or in the implementation of the Hamburg Urban Data platform, meaning that these experiences can easily be adapted into the context of MICADO.

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