

Virtual Campus as a Core Information Infrastructure of the European University

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Abstract

Many European Universities emerged since the first call in 2019, up to now 44 of them. These alliances have some specific goals but also share basic ideas like boosting student, teacher and researcher mobility and cooperation or creating and implementing joint study programmes. To fulfil these shared goals and keep the related processes running smoothly in the alliance, a virtual campus is often envisioned as an information system that will bind the partner universities' information and fill in the gaps where needed. However, building such a system presents a number of challenges on organisational, informational, and technical levels.

In this paper, the basic functionalities of virtual campuses are identified, and a set of specific principles for building such a distributed information system is stated. The architecture of such a system is presented using the example of a particular virtual campus, along with the lessons learned in creating it. The topic is complemented with information on the current state of the system and the future work on this virtual campus.

1 Introduction

European Universities are transnational alliances of universities based upon a co-envisioned long-term strategy focused on sustainability, excellence and European values. They offer student-centred curricula jointly delivered across inter-university campuses, where diverse student bodies can build their programmes and experience mobility at all levels of study and also focuses on the teacher, researcher and external partner collaborations (European Universities Initiative, 2023). There are currently 44 European Universities funded through Erasmus+, which include more than 340 universities from 31 countries. A typical European University contains up to 10 partner universities from the same number of countries spread across 27 EU member states and four additional countries (Norway, Iceland, Serbia and Turkey); has a specific theme as its backbone; works on specific goals related to it;

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collaborates in the fields of education and research, including setting up of joint study programmes and enhancing student, teacher and researcher mobility.

Depending on the goals set by each European University, specific needs arise related to the information infrastructure of the alliance as a whole. Namely, new information systems are often needed to fulfil the goals and smooth the processes within the alliance. Some alliances have recognised these needs and have proposed the creation of “virtual campuses”, a form of a joint information system designed to keep the processes inside the alliance going. A number of challenges arise regarding the architecture and implementation of such a system in the real world. In this paper, we set up a stage for such a system, address those challenges and show the advance in building the system of a particular alliance – UNIC, the European University of Post-Industrial Cities (UNIC Alliance, 2023).

UNIC is one of the European Universities which emerged during the second Erasmus+ call in 2020. One of the particular goals of UNIC is inclusion and superdiversity, which are obtained through the inclusion of the cities. UNIC was originally the partnership of 8 universities: Koç University, Istanbul, Turkey; University College Cork, Ireland; Erasmus University Rotterdam, The Netherlands; University of Deusto, Bilbao, Spain; University of Liège, Belgium; Ruhr University Bochum, Germany; University of Oulu, Finland and University of Zagreb, Croatia. Two more universities joined this partnership in 2022: the University of Łódź, Poland and Malmö University, Sweden.

The UNIC use case shown in this paper is not unique, as many European Universities share the same goals, challenges and problems. Therefore, this paper is organised as follows. Sections 2 and 3 deal with standard functionalities and fundamentals on which each virtual campus should be built. The distributed architecture of the UNIC Virtual Campus is elaborated on in Section 4, and the current situation of development and implementation of this virtual campus is given in Section 5. Section 6 covers the lessons learned in the process of creating the UNIC Virtual Campus so far. Future work on this system concludes the paper.

2 Core Functionalities of Virtual Campus

Analysing the projects of different European Universities while considering all the specific differentiations, an unsurprising fact emerges – most of them have common goals, which can translate into the following:

- Increase student mobility, physical but primarily virtual, by enabling the students to enrol in a particular course offered by any of the partner universities
- Support student identification by providing a way for them to present themselves as students of the particular alliance (i.e., a form of student card)
- Create and implement joint study programmes
- Promote scientific output, especially related to open science
- Increase teacher and researcher networking.

We argue that these goals represent what a virtual campus of a European University should provide, the means to help all of these processes run as smoothly as possible. In other words, those should be the main functionalities of a successful virtual campus.

3 Main Principles

Developing a system that will cover all listed functionalities could be done in several ways. However, implementing such a system in the real world in ten different universities presents an

organisational undertaking. Therefore, before even starting the development process, some postulates need to be defined and agreed upon.

Most often than not, the alliances have limited budgets for IT and administration of “common tasks”, such as student mobility. So, one of the main postulates is that building a virtual campus should have *minimal impact on the existing processes*, i.e. minimal addition of new work.

In practice, universities already have their own information systems. Therefore, *a virtual campus should be an information exchange hub. It should not be the source of truth. The source of truth is always an IT system at the local university (a local student management system).*

Different universities have different levels of technological readiness and different ways of organising things. Hence, *the virtual campus should provide a common way to exchange information between universities without obliging them to synchronise or use the same level of IT integration.* Some universities may manually enter the data in the virtual campus, and some may automatise it as much as possible.

There are also many systems and standards already in place. Many universities already use those systems or standards or are already a part of some organisation, exchanging some data. A virtual campus should not reinvent the wheel; *it should rely on the existing standards and systems wherever possible.* Some good examples of those are identifiers, trust and identity infrastructure etc. The following subchapters will provide a deeper dive into these topics.

3.1 Authentication

User authentication is already a problem solved. Most commonly, an electronic identity is given to a person who can use it to gain access to particular IT resources of the university. A good practice is that the electronic identity is issued by someone who can verify a person’s real identity. However, a set of problems arise when mobility comes to mind. Most students, teachers and other staff already have their identities issued by their home university. If they come as guests to a receiving university, they might get another identity (or, even worse, more of them) in order to be able to access the receiving university’s resources. This has two negative effects:

- A person has to juggle several identities in order to use all of the resources available to them
- After the mobility is over, a receiving university has to take care of all the identities issued to guests and invalidate them (and open the identities again for the same people if they revisit the university).

These issues have already been addressed and solved by establishing eduGAIN (eduGAIN, 2023), a global interederation service that connects identity federations. To be a part of eduGAIN, IdP has to be registered, follow a set of rules and provide a set of attributes for each identity.

However, each resource also has to be able to provide an eduGAIN authentication (on top of their local authentication), which is not a small undertaking. Successfully enablement of eduGAIN authentication throughout the European University would mean enabling this authentication at least to all student management systems and all learning management systems across all the partners and to a virtual campus as well. On the other hand, this provides an important trust and identity layer across the alliance. By establishing the eduGAIN authentication on an alliance level, all end-users use only one electronic identity issued by their home university. Also, neither the partner university IdP nor the resource manager has to worry about allowing access to anyone who does not have the right to access it. The trust is placed on the issuer of the sole original IdP of the home university.

3.2 Identifiers

In general, the unique identification of any entity inside an information system is crucial, but this topic gains a much bigger weight when a distributed or highly interoperable system is in place. That means that all shared entities need to be described with a common identifier, if possible. For identifying students, a common identifier that can be used throughout the virtual campus is the European student identifier (ESI) (European Student Identifier, 2023). That way, each student is identified solely by an identifier issued by their home university. ESI should also be communicated as an obligatory attribute inside the eduGAIN infrastructure.

Since teachers and researchers do not have an ESI, ORCID ID (ORCID, 2023) could be used as an alternative. Relying on the premise that most researchers already have their ORCID profile and that there is considerable overlap between research and teaching staff, ORCID ID could provide a solid starting point for identifying users other than students.

The virtual campus needs to hold information copied from some of the partner universities. Therefore, to make information exchange and pairing on both sides smoother, it would be prudent to hold the other local identifiers (such as course identifiers) in the virtual campus as well. This does not mean that those should be used as unique identifiers (i.e. primary keys in the database) in the virtual campus, too, because that would make the virtual campus too dependent on the other systems.

4 The Architecture of the UNIC Virtual Campus

UNIC Virtual Campus is envisioned as a distributed information system. It consists of a central component named UNIC Central Campus and local components, namely partner universities' information systems, which can be interoperable with the Central Campus. Every partner can choose how tightly their local systems will be integrated with the Central Campus. This means that most functionalities of the Central Campus can be used either manually (by the university employees) or automatically (by the systems' integration). Each partner can choose to automate some of the functions (e.g., copying the courses from their student management system to Central Campus) and leave others to administrators (e.g., entering students' grades). Ideally, all partners should integrate their systems fully, thus achieving maximum interoperability.

4.1 UNIC Central Campus

The main features of UNIC Central Campus (depicted in Figure 1) are:

- Providing the catalogue of joint study programmes, such as (RePIC, 2023), to the public
- Providing the catalogue of all available courses to the public
- Providing the UNIC European Student Card to UNIC students
- Enabling the students to enrol on courses, attend them and get a grade
- Enabling the universities to track and administer incoming and outgoing UNIC students and their grades
- Enabling the universities to administer the lecturers and courses they are offering
- Providing the catalogue of UNIC researchers and their interests to UNIC members
- Providing the catalogue of the research results of UNIC researchers

To enable those features, UNIC Central Campus consists of several components and applications:

- Central database; containing the data about courses, programmes, users, enrolled students, issued student cards, teachers, researchers, publications, etc.
- Public UNIC Campus portal; a web application serving publicly available information about programmes, courses, research activities and results.
- Administrative UNIC Campus portal; a web application for administrative purposes used by university administrators and their units.
- Student's UNIC Campus portal; a web application for students to enrol into a course, issue a student card and see their mobility history within UNIC.
- Researcher's UNIC Campus portal; a web application for researchers to create interest groups and connect to peers.
- Interoperability Application Programming Interfaces (APIs); a set of REST APIs available to partner universities, enabling the automatisisation of most administrative actions.
- OpenAIRE interoperability client; a server application used to fetch the data about research results.
- ORCID interoperability client; a server application used to identify persons and fetch researchers' data.

Additionally, the authentication module serves as an eduGAIN client, enabling the eduGAIN authentication to the Central Campus. UNIC Central Campus uses ESI (European Student Identifier) to uniquely identify students, so each partner university has to provide ESI through their eduGAIN-enabled IdP.

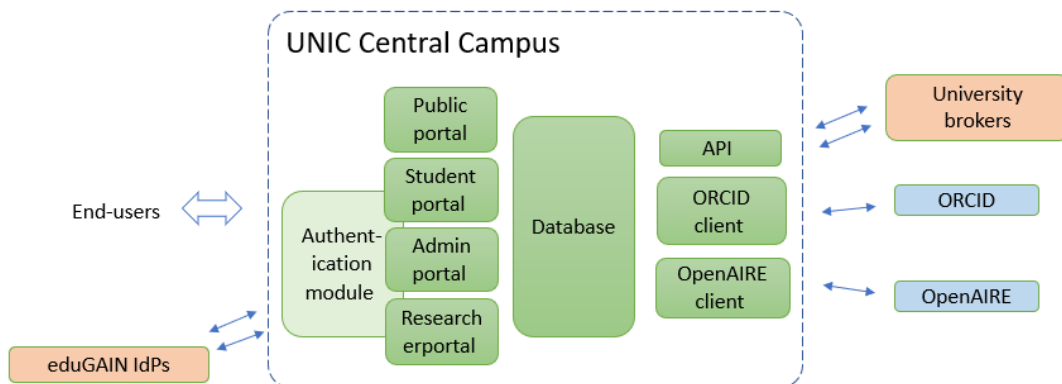


Figure 1: The schema of UNIC Central Campus

4.2 Local Components of the UNIC Virtual Campus

As mentioned before, each university can choose the level of integration of its own information infrastructure into the UNIC Virtual Campus. The minimum that needs to be set up is the integration of

IdPs used by the particular university to identify their students into eduGAIN and the provision of ESI. Also, it would be desirable if researchers and teachers already had their ORCID profiles. Regarding the presentation of UNIC research outcomes, if universities want to share that information, they must have their repository or research information system open to OpenAIRE (OpenAIRE, 2023). Figure 2 presents the local university components of the UNIC Virtual Campus.

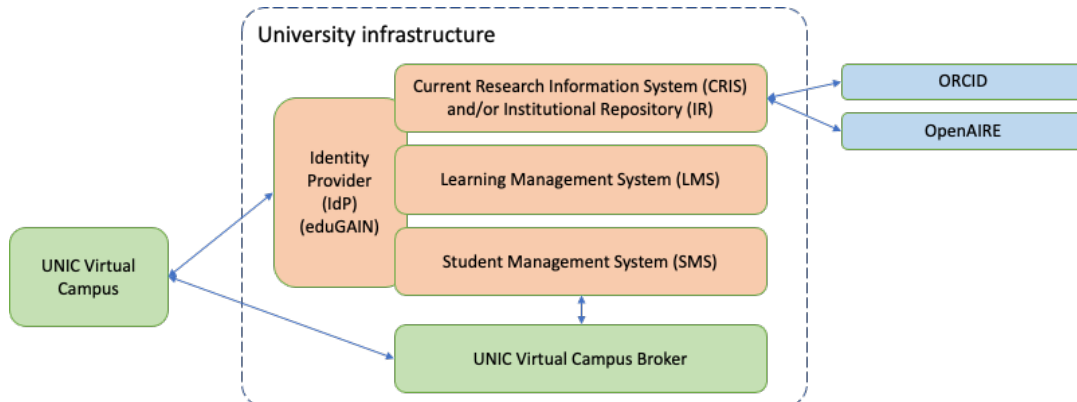


Figure 2: Local components of UNIC Virtual Campus

As stated earlier, the critical local component of each university is the Identity provider (IdP). To ensure the authentication and authorisation of users, the trust to a user, and also the uniqueness of users, one of the main goals of UNIC Virtual Campus is that all local systems of all universities use IdPs that are part of eduGAIN infrastructure. That way, all users can use only one electronic identity across the UNIC information space, which is convenient for users and administrators alike and raises the security of the whole system. Namely, there is only one IdP that all systems should trust – the one that has issued the original identity to the user. When that one is revoked, there is no fear that the user could continue to use any of UNIC Virtual Campus services.

A student management system (SMS) is an information system that contains data about a university's students, courses, programmes, grades, diplomas and everything else regarding the study process of a university. A learning management system (LMS) is an e-learning system that contains learning materials for courses, online exams and other related applications. While SMS is more administrative in its nature, LMS provides a day-to-day activity for the enrolled students. In order to make the Virtual Campus a living IT system, these systems need to communicate with each other and the central component.

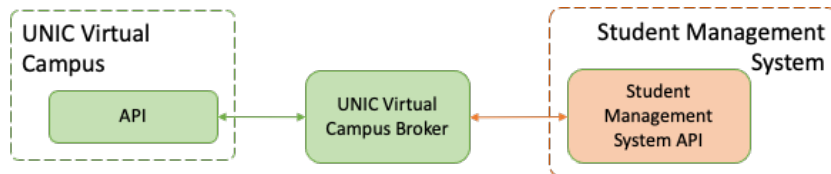


Figure 3: A broker module as a bridge between the university and UNIC

As UNIC Central Campus covers functionalities similar to SMSs, the basis of the Virtual Campus is the live communication between the Central Campus and local SMSs. For example, when a guest student enrolls on a course, once all the necessary data is provided from the Central Campus to local SMS, the basic information should be further communicated between local SMS and local LMS to

facilitate the e-learning platform to the enrolled student. This live connection between a local SMS and Central Campus is ensured via a local application called the broker (Figure 3). The broker should be developed by a local team familiar with the specifics of the local system and how it should communicate with it. On the other part of the broker is the Central Campus API, used to get and serve the data from the Central Campus database.

Finally, UNIC Virtual Campus serves as a public catalogue of researchers and research results. In order to keep data flow as simple as possible, UNIC Central Campus uses two well-known open-access platforms to collect the data – ORCID and OpenAIRE. However, those systems also need some data sources as well, and more specifically, those are mainly local CRIS (Current Research Information System) or IR (Institutional Repository) or both. Therefore, it is vital to ensure that every partner university has its CRISs or IRs open to both ORCID and OpenAIRE. The important notion here: by relying on these two significant platforms, UNIC Virtual Campus promotes open science, making sure that all partners provide as much data as possible into these platforms, which gives them more visibility.

It should be noted that most of the IT components of local partner universities already exist. The only component which is genuinely new is the Virtual Campus broker. All other changes on the side of the local teams, if even necessary, are general in nature, aimed towards better integration (like eduGAINization of local resources), data quality (like using ORCID IDs) or visibility (like connecting to OpenAIRE).

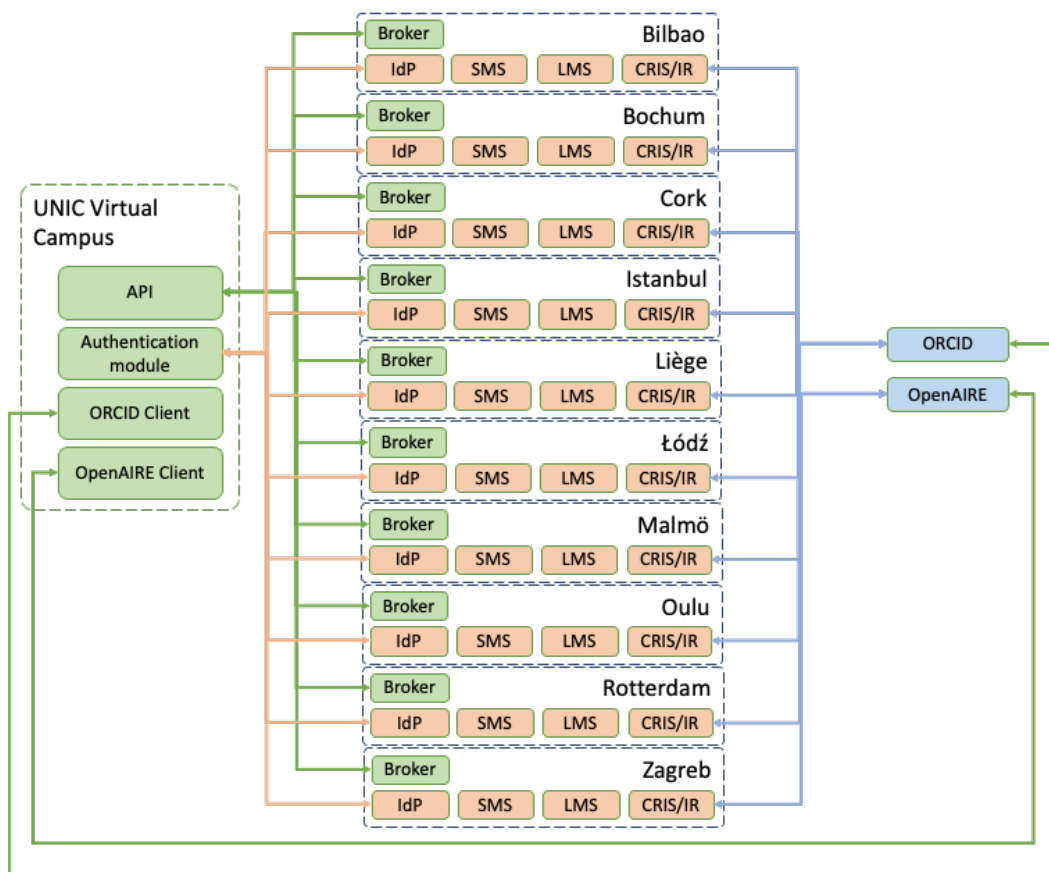


Figure 4: Overview of the UNIC Virtual Campus interoperability

4.3 Interoperability at-a-glance

Finally, the outcome of this joint venture will produce a complex information system. However, it should be noted that this system only consists of a limited number of tables in the database and several relatively simple applications and is not the source of truth but serves as an information exchange hub and the presentation layer. The schema of campus interoperability is shown in Figure 4.

5 Current Status of UNIC Virtual Campus

The UNIC Virtual Campus is in its initial production phase. Most functionalities are already built, but campus implementation in the universities is in the beginning, so there are no indicators of the success of the implementation yet.

Specifically, the UNIC Central Campus is operational in production regarding all modules except the Research portal, ORCID and OpenAIRE clients, i.e. the functionalities regarding student mobility and student cards are in production. The data about courses is imported from the previous sources, so the system is populated with some basic data.

Each university is appointing one or several people who will take the role of Virtual Campus University Administrator – the ones who will organise (or do) the work related to Central Campus. University administrators can enter the organisational structure of their university into the Central Campus and then appoint organisational unit administrators to distribute further the work related to Virtual Campus.

Partner universities are also using the testing system through web applications or APIs to learn about the system and its requirements. At the same time, programming work is being done in the area of researchers and research outputs. That specific part of the system is planned for production at the end of 2023.

UNIC Central Campus infrastructure is set up in three environments: development, testing and production. The development of the system is done by the University Computing Centre of the University of Zagreb – SRCE, which provides daily support for the UNIC Central Campus end-users and the adaptive, preventive, perfective maintenance and adjustments of UNIC Central Campus software and hardware. SRCE also provides consulting and support to all partners regarding programming and implementation of connection brokers, adjusting other local components, and implementing security and automated testing.

The Virtual Campus-related work is being coordinated through the UNIC ICT Subgroup.

6 Lessons Learned

General lessons learned from working on the Virtual Campus are more or less the same as working on any distributed system with multiple partners: the importance of continuous communication between partners and having the right people in the right meetings. Although the latter sound obvious, most often than not, IT experts do not seem to be included in creating visions or policies, which in turn sets the stage for unrealistic expectations. That, combined with inadequate budgeting, can create a low efficient environment that can be cured only with significant willpower and a vision of its own to drive the projects forward. Therefore, IT needs more visibility in the university alliances. It needs more inclusion in planning and funding as well.

Another crucial lesson learned is that not all partners are in the same place (and that should be considered). By that, we mean that the level of digitalisation of information and processes regarding

virtual campus functionalities differs between partners. For example, some may have one SMS; some may have multiple. Some may not issue an ESI; others may not be into eduGAIN or not connected to OpenAIRE. The virtual campus should be flexible enough to allow different work organisation and distribution in the early stages of its implementation. The most pressing needs among all the partners should be identified, and if possible, a joint effort should be undertaken to solve those before moving on to others. E.g., the first step in UNIC Virtual Campus would be to ensure all partner IdPs are in eduGAIN and that they return the ESI attribute during the authentication process. After that, the next level would be the work on encouraging all partner researchers to join ORCID, and so on.

7 Future Work

Future work on UNIC Virtual Campus is threefold. First, this includes finishing the basic envisioned functionalities in the Central Campus, primarily focusing on open science, research portal and research outputs. Second, several analytical dashboards must be built to enable data-driven decision-making. And lastly, the focus is shifting towards all partner universities to build strong support for interoperability, thus making the informational part of the Virtual Campus run as automatised as possible. These must rely on the close cooperation of the IT layer throughout the alliance, which will ensure the long-term stability of the alliance and enable future UNIC endeavours as well as daily operations.

After these prerequisites are met, further work may be undertaken to build the next generation of the virtual campus on solid ground. These include blending in various artificial intelligence, augmented reality or metaverse features like the ones presented in (González-Yebra, 2021), (Bakhmut, 2021) or (Alam, 2022) in the interuniversity space.

8 References / Citations

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9 Author Biographies



Ognjen Orel is currently the CIO of SRCE. He has over 20 years of experience modelling, building, implementing and maintaining national information systems mainly related to higher education and research. He holds a PhD in Computer science and teaches advanced databases and business intelligence at the University of Zagreb. His research interests are focused on data models, analyses and algorithms, information systems architecture and security. Ognjen is a member and representative in EUNIS and euroCRIS.



Alen Novosel holds a master's degree in informational sciences and has more than five years of experience developing, maintaining and providing support to users of national systems within higher education. He works as a development lead at SRCE, where his primary responsibility is building and implementing the UNIC Virtual Campus with his team. Alen also works as a data analyst and performs many complex tasks related to data warehouses in the field of higher education and research in Croatia.