Digital Services Architecture

for

Higher Education Sector

Citation

Hage, J. (2021). *Digital Services Architecture for Higher Education*. Digital Transformation Experts. Retrieved from https://dxexperts.pro/Assets/Publications/EN-US/Digital-Services-Architecture-Higher-Education-EN.

Revision 2021.12.24

TABLE OF CONTENTS

THIS PAGE WAS INTENTIONALLY LEFT BLANK

TABLE OF FIGURES

THIS PAGE WAS INTENTIONALLY LEFT BLANK

Acronyms and Abbreviations

Abbreviation	Description
AI	Artificial Intelligence
API	Application Programming Interface
BPMN	Business Process Model and Notation
CMMN	Case Management Model and Notation
EHR	Electronic Health Records
ERP	Enterprise Resource Planning
FERPA	Family Educational Rights and Privacy Act
FIS	Faculty Information System
GDPR	General Data Protection Regulation
GRC	Governance, Risk, and Compliance
HEI	Higher Education Institution
HEMIS	Higher Education Management Information System
IAM	Identity and Access Management
IoT	Internet of Things
IT	Information Technology
LIS	Library Information System
MOOC	Massive Open Online Course Cours en Ligne Ouverts et Massifs
NLP	Natural Language Processing
NRC	National Research Cloud
NREN	National Research and Education Network
P2P	Procure-to-Pay
SCORM	Sharable Content Object Reference Model
SEO	Search Engine Optimization
SIS	Student Information System
SMS	Short Message Service
URL	Uniform Resource Locator
xRM	Extended Relationship Management

THIS PAGE WAS INTENTIONALLY LEFT BLANK

Introduction

In addition to its foundations and pillars, digital transformation requires building blocks of common and shared platforms and services that support university life and address the needs and wants of academic, research, and administrative stakeholders in higher education. **Figure 1** shows a typical enterprise architecture of digital services in higher education. It is important to note that actors in the higher education sector must do everything they can to leverage existing building blocks, components, and platforms available at the national level or through private sector partnerships. The institutions and entities in the sector must conduct an inventory of the deployed digital services and applications everywhere. They will determine how to integrate them and build a scalable, robust architecture to offer all stakeholders a pleasant user experience.

1. Academia

The following are the major digital services focusing on education and pedagogy:

- **Student Information System (SIS)** is the core academic information system that holds student records and is the single source of truth for grades, transcripts, assessments, degree evaluation, registration, and more. The SIS also offers services for faculty members such as class lists, advising pages, daily schedules, and overrides.
- **Faculty Information System (FIS)** manages faculty records, processes, research studies, and portfolios. The FIS is a one-stop shop for faculty members' profiles, including general information, contracts, positions, and education. The FIS is also home to research activities such as journals, manuscripts, grant research, presentations, service and teaching activities, refereed publications, and conference proceedings.
- **Learning Management** is the core academic system for hosting and delivering teaching and learning activities. It contains course shells for all the courses, i.e., face-to-face, hybrid, and online, with all the needed activities within a course, such as digital books, assignments, attendance, digital certificates, files and resources, quizzes, forums, questionnaires, SCORMs, and other media files.
- **Plagiarism Prevention** is usually an Internet-based plagiarism detection system that promotes academic integrity, streamlines grading and feedback, deters plagiarism, and improves student outcomes. This system does so by comparing a specific paper with millions of prior submissions to detect similarities and return reports on the percentage of similarities. This capability is usually integrated within the learning management system to provide a seamless experience for students and teachers.
- **Digital Repository** is a core academic archival system containing all the reusable learning objects used within the courses, programs, or libraries. Such a repository provides the services to store, search, and distribute content securely

in multiple formats. Distribution of the content could happen in different ways, either via the Web or via technology channels that allow integration with other content providers such as learning management systems.

- **Online Timeline** is a vital tool to create and visualize timelines and calendars by showing individual schedules for students, faculty, and researchers and a full schedule for a program or schedules for facilities utilized at the university. These are even more important and useful for advertising online courses and programs.

- **Electronic Portfolios** are personalized collaboration spaces for individuals inside the university. Students and teachers mainly use this capability to create and build up their portfolios during their educational journey inside and outside the university in alignment with the competency framework. ePortfolios are usually integrated with the learning management system so that students can post essential projects directly into their ePortfolio or submit their assignments as an ePortfolio section.

- **Online Surveys and Polls** are usually a set of tools used inside or outside the classroom or learning management systems to survey and poll students, faculty members, or staff to assess, evaluate, or research topics.

- **Classroom Responses** consist of hardware and software to provide probes into lectures inside the classroom or learning management system, giving the instructor the capability to stand on the level of understanding of topics. Classroom responses ensure students are confident about their level of knowledge in a specific topic before moving on to the next one.

- **Massively Open Online Courses (MOOCs)** are courses developed by the university and made available over the Internet either through the university learning management system or through cloud learning management systems without any charge and usually to lots of people. These are typically self-paced, not instructor-led, and might lead to a digital certificate.

- **Digital Pedagogy** is a service with its associated tools that have to do with transforming a learning object, such as a course or a program, to the digital format leading to deliver it with either technology-assisted face-to-face, blended, or entirely online delivery. It includes instructional design tools and processes, multimedia production tools, and quality assurance tools.

- **Registrar** is a set of services and functions to digitize the course catalog creation, student registration, class assignments, degree completion, semester configuration, cohort creation, and general student records.

- **Higher Education Management Information System (HEMIS)** is designed for students, researchers, educators, administrators, planners, and governmental agencies in the higher education sector to plan, manage, and monitor the student life cycle from the completion of the secondary education stage through tertiary education and lifelong learning. The HEMIS may include capabilities complementing other academic and administrative systems.

2. Research

The following are the major digital services focusing on research:

- **Library Information System (LIS)** plays the role of an ERP system for library administrators, a content manager for researchers, and a repository of digital credentials for external database subscriptions at higher education institutions. The LIS tracks the different physical and digital items, provides the needed space for university-generated research or teaching content, and provides the channel to access external research databases and publications.

- **High-Performance Computing** is a set of services, including large-scale computing clusters, to provide necessary computing power that is needed for specific types of research such as genomics, big data analysis, complex simulations, machine learning, and other types of resource-intensive computations.

- **AI-Assisted Research** is a set of services that provide the tools necessary to facilitate artificial intelligence in research. It offers several Artificial Intelligence (AI) engines, such as Natural Language Processing (NLP), that would facilitate literature analysis, data extractions, and significant subjective survey results. or such as image and video processors that would enable the analysis of digital images or other media.

- **National Research and Education Networks (NRENs)** are specialized intra-university services aimed at connecting national universities within a country to support research and education needs. NRENs are usually provided through high-speed backbone connections and higher-level services such as Internet roaming – within universities – and identity federation.

- **Research Cloud** is either a national research cloud (NRC) or an individual research cloud for the institution. It contains the set of tools and services to provide access to high-performance computing resources in the form of either fair access if it is an NRC or dedicated access in the case of an institutional research cloud.

3. Administration

The following are the critical digital services focused on administrative processes in higher education:

- **Financials** enable the university to prepare capital and operating budgets, allocate and track expenses, issue bills, capture payments, generate financial statements, and report cash flows and revenues.

- **Procurement** lets community members acquire material, assets, and services through a Procure-to-Pay (P2P) process, which facilitates order management

and goods and services delivery. Purchase requisitions and purchase orders are equipped with approval workflows through a Workflow Engine to control and meet budget expectations. It is also the repository where approved vendors and catalog items are managed and maintained.

- **Facilities** is a module that handles logistics, maintenance, repair, and operations, such as housing, janitorial services, utilities, buildings, and plant fixtures. This digital service helps maintain a healthy environment and safety standards.

- **Enterprise Assets** is a digital service to track, monitor, and maintain capital assets. Assets might vary from tangible to abstract assets, such as software and licenses. The assets are captured, tagged, linked to specific locations, and possibly assigned to faculty members, staff, or students. This digital service helps engineers obtain assets in their best availability and performance possible throughout preventive and corrective plans. The tool enables the community to report failures and request maintenance services electronically.

- **Scholarship and Financial Aid** handle the financial and scholarship aid applications for students requesting financial assistance to settle their higher education expenses. Potential candidates excel in their academic record and cannot afford the university costs or those who match criteria set by donors and sponsors.

- **Grants** is a digital service that manages financial gifts or grants donated from various sponsoring parties to students, faculty, and researchers. Grants are handled, monitored, and spent based on agreed-upon purposes and restrictions.

- **Contracts** is a digital service used by different stakeholders, such as procurement officers or grant officers, that centralizes the storage and management of the contracts for approved suppliers, funding agencies, or contractors. These contracts are recorded, managed, and audited on a regular basis.

- **Human Capital** is a digital service to help plan for human resources and define employees, casual workers, and contractors. The scope of this service includes employee contracts, continual appraisal, grading system, and career path. It also serves as a single repository for all workforce information.

- **Talent Management** is used to measure the skills and abilities of employees and students regarding the responsibilities they have, and the mission assigned to them. This will help identify talented individuals across the higher education sector.

- **Payroll** is integrated with the Human Capital digital service to generate pay slips for faculty and staff. The service ensures that everyone is paid on time with the flexibility of payment rules, methods, and currencies.

- **Materials and Inventory** is a module for managing goods, spare parts, and consumables used within the organization. The services allow community users to request items through the Procurement digital service. Standard inventory

procedures are implemented, such as regular inventory counts, slow- and fast-moving items, and ABC analysis to ensure the organization's daily operations are running efficiently.

- **Marketing** enables recruiters to seek opportunities and decide on possible candidates and applicants. Marketing professionals are responsible for the outreach campaigns, nationally and internationally, to present the academic programs and promote the HEI's brand and image. The service must integrate with all social and digital media channels.
- **Bookstore** is a digital service where students access printed or electronic books, materials, and products required for their academic journey.

4. LIFE

The following are the critical digital services related to university life:

- **Healthcare** is a digital service that enables HEIs to manage the health insurance coverage and Electronic Health Records (EHR) of students, faculty, and staff. The EHR is visible only to authorized staff and be integrated via the interoperability platform to other national or private healthcare systems.
- **Mental Health** is a digital service enabling community members to get connected, obtain clinical psychological advice, and take care of their mental health. Licensed psychologists, mental health professionals, life coaches, and domain experts usually guide and monitor these mental health activities.
- **Device Management** is a service to facilitate the management of organizational devices and personal devices. Management includes standardizing software and configuration for organizational devices and standardizing specific configuration and access settings for all – including personal – devices connecting to the HEI networks.
- **Security and Protection** is a digital service that offers the security team more physical control of access to the campus, buildings, and facilities, e.g., restricting access into critical laboratories to only authorized faculty, staff, and students. Digital technologies, such as face recognition and other biometric data, e.g., fingerprints and retina scans, can be deployed for a better and more secure environment.
- **Access Management** is a digital service that closely integrates with identity management to identify persons and grant appropriate access to various platforms and digital services where single sign-on authentication is utilized for a better seamless experience. It would elevate the security standards of the institute by allowing administrators to automate numerous user account related tasks, managing identities, authentication tasks, and authorization task.

- **Food and Beverage** is a digital service that acts as an e-commerce platform, integrated with the digital payment services, for the community to book meals, shop for food, and request delivery services. This digital service would also include capabilities for managing food preparation and recipes, quality, and safety based on the ISO 22000 standard.

- **Placement and Careers** is a digital service offering a one-stop shop for senior students and alumni to seek post-graduation employment opportunities in various markets and industries. It usually provides a moderated gateway for employers to post jobs and manage the hiring process of graduating students and alumni. This vital service impacts university rankings positively, especially in the employability category.

5. Common Services

The following are the primary digital services that are common among academia, administration, and research in higher education institutions:

- **Content Management** is an enterprise application that manages any type of content in the organization and provides the required tools to digitize content, set the appropriate access rights, and make the content available on the Web, either portals or websites, or to other applications, via SEO-friendly URLs.

- **Document Management** is a vertical service built on top of Content Management services to provide the requisite features to manage documents. It provides the mechanism to define different document libraries, types, and approvals. For the academic stakeholders, it typically provides a storage folder for each student holding his or her admission records, transcripts, petitions, and other documents. Document management provides the needed components for the research community to search, extract, edit, and view documents. Finally, for the administrative staff, it gives storage folders for advancement, procurement, human capital, and all other administrative departments.

- **Correspondence Management** is a vertical service, built on top of the Document Management services, to provide the features required for managing internal and external correspondences. It gives the needed profile for a correspondence (metadata) and the hierarchy of storage for correspondences, plus the labeling and retrieval of correspondences.

- **Knowledge Management** is a service providing collaboration spaces aimed to retain knowledge generated in different areas of the institution. It provides a customizable store for general documentation, experiments, findings, inventions, standard operating procedures, and Wikis.

- **Project Management** is a standard service for managing projects and leading teams with specific skills and knowledge, working on tasks to achieve the preset goals and desired outcomes. This digital service crosses all domains of higher education and may be used anywhere.

- **Issue Tracking** is a common service for tracking issues, incidents, and problems. Multiple parties could use it, such as the IT Help Desk to track technical issues and support tickets, facilities to track physical plant requests, or academic departments to track student issues and requests.

- **Web Conferencing** provides virtual spaces for meetings and webinars. This service usually provides advanced features for modern meetings and conferences such as spotlight, breakout sessions, and personalized presence.

- **Presence** is a set of features to provide information about the virtual presence for individuals. This service is typically integrated with an IoT platform and other collaboration and Web conferencing tools and email and calendar tools to provide the accurate presence status of an individual.

- **Electronic Mail** facilitates the communication among community members. Capabilities of this digital service also include calendar, tasks, to-do items, notes, among others.

- **Collaboration Workspaces** are tools that facilitate the collaboration environment among community members. Capabilities of this digital service include workgroup channels, shared tasks, virtual meetings, audio calls and messages, document sharing, among others.

- **Digital Assessments** are administered on digital devices and are designed to assess students and judge their achievement, knowledge, and skills at a given moment. Micro-assessments use dynamic and innovative XR and AI technologies to provide frequent engaging assessments that take only a few minutes to complete. Such services may be hosts to centralized national exams, self-service evaluation of curricula, and other purposes.

- **Licensures and Certifications** are often required for some professions in the health, engineering, legal, and accounting fields. Licensures consist of an assessment process based on preset criteria necessary to obtain a permit to practice a profession in a specific field and sometimes in a geographic area. On the other hand, certifications are more focused on continuing education of professionals.

- **Governance, Risk, and Compliance (GRC)** is a system for directing and controlling the performance of institutions and entities in the higher education sector. These capabilities enable the sectoral actors to mitigate risks reliably, resolve uncertainties, achieve objectives, and safeguard institutional integrity. Implementing the GRC processes and technology across organizations should reduce costs, eliminate duplicate activities, improve information quality, and increase the efficiency to consistently perform functions and procedures.

- **Extended Relationship Management (xRM)** is a set of digital services that aim to foster a relationship between the HEI and its leading stakeholder groups, e.g., prospects, students, alumni, donors, sponsors, and employers. It is mainly used to capture, manage, and nurture leads until they become students and

throughout their journey after graduating and becoming alumni. Moreover, it helps streamline advancement for alumni and development offices.

6. Shared Components

The following are the shared components that are used by the common services as well as the academic, administrative, and research applications in the sector:

- **Roles and Privileges** is a shared repository for defining different roles in the organization along with the privileges assigned to each role so that they are enforced across the entire digital services architecture. This repository acts as a central source of truth for the roles and their associated privileges along with the individuals assigned these roles and privileges.
- **Workflow Engine** is a tool to automate procedures and business processes. This engine enables authors to define the schema of a specific process, set approval levels, set task owners, conceive approval forms, specify workflow actions, and create scheduling and automation.
- **Publishing Engine** is a digital repository for document generation and management and is responsible for availing public documents, such as policies, procedures, announcements, and more in a user-friendly format. It also enables tracking and confirming the receipt, reading, and acceptance of these documents. For example, the HEI might want to guarantee that all staff has read and accepted the code of conduct in compliance with the GDPR and FERPA.
- **Notifications Engine** is a central engine to send different types of notifications to end-users, such as emails, SMS, push notifications, and more. This engine supports a guaranteed delivery by having queues and retries, thus enabling administrators to define templates for the notification with placeholders so that other platforms can conveniently generate and send a readable and informative message.
- **Rules Engine** is a central component for defining rules to be used by other platforms, applied during a workflow process, or performed conditional actions and computations. This engine must be highly integrate-able with other systems through a set of flexible APIs, web services, and support for standards like Business Process Model and Notation (BPMN) and Case Management Model and Notation (CMMN).
- **Digital Signature** is a trusted system serving as a signature authority enabling community members to digitally sign their emails, documents, correspondences, and workflows.
- **Digital Payment** is a service integrated with a very flexible and mature payment processing gateway for collecting application and admission fees, tuition fees, and other types of fees, such as event seats, university artifacts, and others. Digital Payment may also be used in settling supplier invoices and reimbursing

researchers, faculty, and staff for approved expenses. This service benefits HEIs by reducing the collections cycle time combined with Digital Signature.

- **IoT Platform** is a critical component for achieving the goals of a smart campus. An Internet of Things (IoT) connectivity platform is designed to streamline the use of campus resources, e.g., buildings, energy, rooms, spaces, libraries, equipment, and even individuals. This platform could be used for improved control of sustainable energy, air quality control, space availability control, and attendance and presence of individuals.

- **Artificial Intelligence** plays a vital role in multiple areas of teaching and research, and other non-academic aspects like security breach detection or face recognition. In teaching, AI has significant application in detecting students struggling in academic and social issues, thus helping in advising and early interventions to avoid dropouts and failures. Also, in the teaching process itself, AI supports adaptive learning by replacing the one-size-fits-all approach with the delivery of a customized learning experience that meets students' individual needs. This is achieved by using just-in-time feedback and pathways. In research, the application of AI is enormous, depending on the type of research being conducted.

- **Chatbots** may be used across various digital services and platforms. They may be used in marketing pages to help prospective students in their application process. Chatbots usually help students and staff get answers to their questions by being directed to the appropriate solution, thus reducing the load on IT helpdesks and call centers. AI-powered chatbots may also be used for the academic tutoring of students.

- **Blockchain** provides an immutable trusted general ledger, which is best used to store official documents, such as degrees, diplomas, certificates, or transcripts of records. The Blockchain could be the next generation trust system to prevent fraud of official university credentials. In research, the Blockchain could be used to store significant research findings and authorship, copyright, and intellectual property ownership information.

- **Experiential Reality** may be applied in different aspects of teaching depending on the discipline. The immersive experience provided by such tools is revolutionizing industries, and higher education is not an exception. It could either be used to provide better remote virtual learning or to offer the in-classroom students with multisensory experiences, such as simulating a hospital's operating theater, an archeological exploration, aerospace, and astronomy studies, or even navigating through digital signals.

- **Geo Tracking** is used for tracking campus security vehicles, shuttles, and other vehicles. Fleet management solutions heavily use this technology to streamline the tracking of movables. Moreover, this can be used for attendance tracking by having an application local to the university where students in the classroom confirm their attendance using this application that detects their location.

- **Multimedia Authoring** is a set of media authoring tools availed with proper support and capacity-building training. These are used for research advertisement and dissemination, university communications and marketing, and, very importantly, to develop reusable learning objects offered in online or hybrid courses.
- **Social Media** usage in a university should be streamlined to direct traffic to its appropriate destination. In addition to raising awareness, advertising university achievements, and showcasing research and projects, social media could also be used in conjunction with AI-powered Chatbots for recruitment and fundraising.

7. Portals

Portals are a set of web gateways that provide personalized services to the university communities. Portals host electronic services, calendars, task lists, discussion forums, information pages, document libraries, and more. They provide on-demand access to information with fine-grained security that ensures data is delivered only to authorized and privileged users.

The Student Portal is among the essential portals, which provides a one-stop-shop for students and alumni to view relevant information, apply for specific services, and collaborate with other students/Alumni. This portal stays with the student from the time s/he is a prospect to their Alumni life. Services in such portal typically include (depending on the logged in person status) classes schedule, calendar, and events, announcements and news, application statuses, requests statuses, tasks, support sections, relevant resources, profile editors, in addition to links to the LMS, library systems, specific applications, storage folders, email, and more.

8. Identity Platform

To enable innovation and transformation in university operations, i.e., teaching, learning, and research, a robust Identity and Access Management (IAM) platform must be implemented to allow secure and authorized access to information. The Identity Platform categorizes users – into students, alumni, staff, faculty – using a federated identification to enable collaboration with other universities, single sign-on features, appropriate provisioning of identities, among other authentication features. This Identity Platform is usually linked through the national identification systems to various systems managing services, such as healthcare, social security, and financials.

9. Interoperability Platform

The Interoperability Platform is a highly available platform that provides the required tools and services to enable different applications to communicate. It provides the

management for interoperability, e.g., traffic controllers, service bus, API services, adapters, and message queues, to guarantee that a message is received, queued, transformed, and delivered in the correct format from one application to another.

10. Data Platform

Data platforms are vital for ensuring scalable and interoperable technologies to provide the necessary data needs of the HEIs and the various actors in the higher education sector. Data platforms will cover data classification, data warehousing, trend analysis, and extraction/transformation/loading tools.

11. Performance Platform

- **Data Warehouse** is a multi-dimensional space for storing analytical data ready for reporting. Transactional data are usually used in day-to-day operations. In contrast, analytical data are considered time-stamped snapshots of transactional data that are immediately ready for fast access and reporting.
- **Business Intelligence** is a set of tools that provides interactive means to visualize data, which come either from databases, data warehouses, or external services.
- **Educational Indicators** are statistical analyses that compute and describe important aspects of higher education, including assessing quality, interpreting performance, and identifying problematic situations.
- **Reports** vital outputs that all actors in the higher education sector request and demand. These reports are typically easily customized, without the need for programmer intervention, to the users' requirements.

REMAINDER OF PAGE WAS INTENTIONALLY LEFT BLANK

THIS PAGE WAS INTENTIONALLY LEFT BLANK

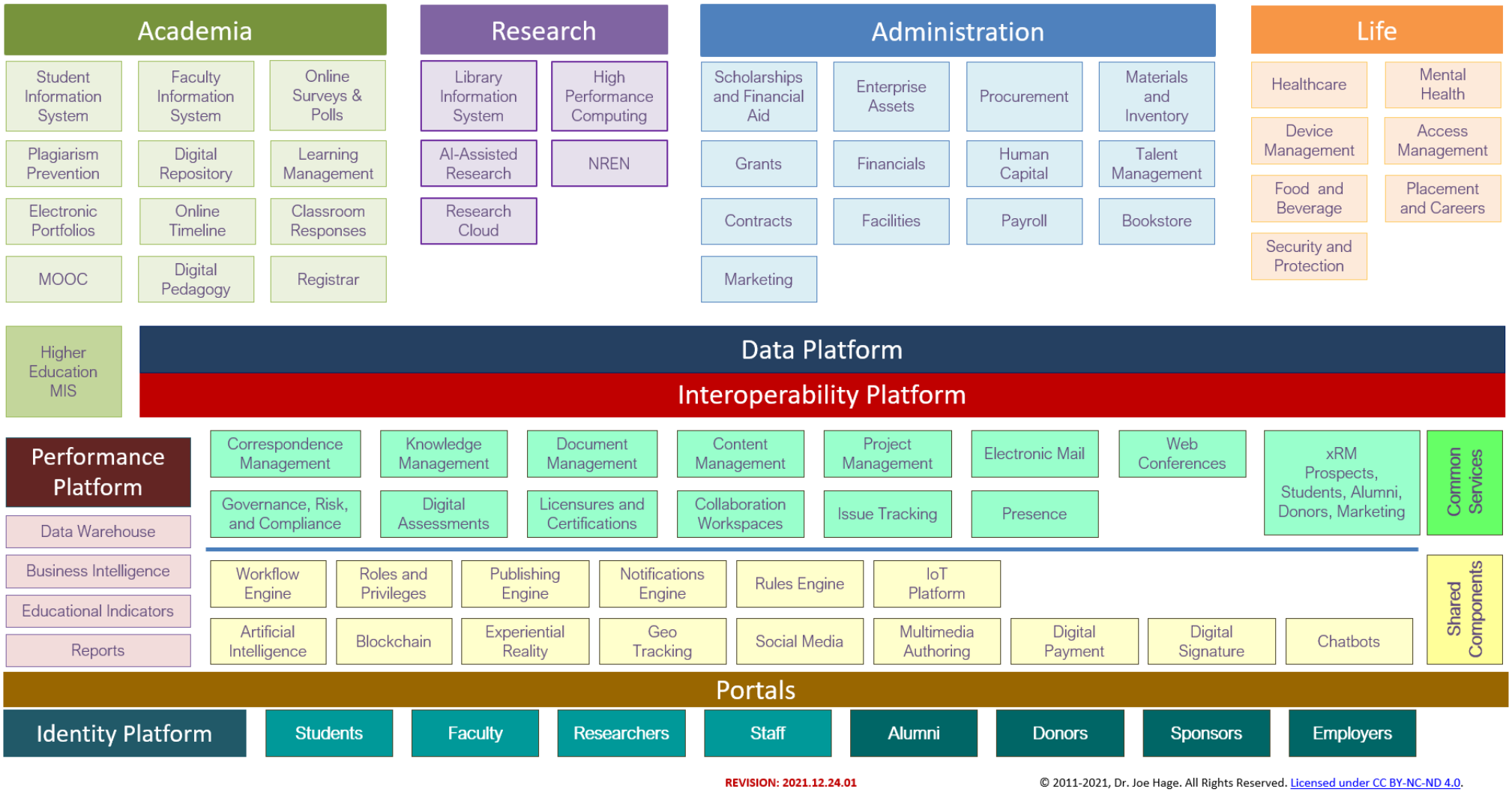

Figure 1. Digital Services Architecture for Higher Education

THIS PAGE WAS INTENTIONALLY LEFT BLANK