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Adaptable Architecture for the Digital Transformation of the Cameroonian University Ecosystem: A FORM/BCS Approach

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Abstract. The university education ecosystem in most developing countries where demographics are evolving exponentially, faces the problem of the massification of education with its corollaries in terms of teacher shortages and deterioration in the quality of training, Cameroon is not left out. Faced with this situation, most stakeholders agree that the digital transformation of the ecosystem makes it possible to tackle this problem. Several solutions are proposed, ranging from the digitization of training materials downloadable by learners to the implementation of hybrid training combining the face-to-face model with distance training in direct streaming, including models "semi-face-to-face single-teacher multi-room synchronous" training courses, thus qualified because it would consist of exploiting ICT to allow the same teacher to be, through dedicated screens, simultaneously followed in several classrooms by learners with the possibility for the latter to communicate in real time with him thanks to judiciously positioned cameras. However, whatever the formula adopted, problems persist such as time which is not always sufficient, the shortage of teachers and insufficient infrastructure. Thus, this article, through the analysis of the proposed solutions and the use of the software product line engineering paradigm, proposes a formula and adaptable reference architecture for a computer system making it possible to deal with the problem of massification of teaching.

Keywords: Adaptable Architecture, Digital Transformation, University Ecosystem, Product Line Engineering, Feature Orientation.

1 Introduction

To improve their level of development, countries implement long-term strategic planning. The National Development Strategy Document 2020-2030 (NDS30) [1] of Cameroon highlighted the axes of the Government's human capital and well-being development policy to support the industrialization of the country, among others (i) education, training and employability and (ii) research for development. If during the period 2010 - 2020, the Education and Vocational Training Strategy [2] provided training based on a **modernized system** and made it possible to make significant progress in terms of education provision, through the construction of several schools and support structures for all education cycles, **the current supply structure in terms of educational infrastructure and teaching staff and trainers is not yet able to satisfy the demand for education and professional training, with regard to international norms and standards**. This insufficiency is accentuated by the phenomenon of the massification of higher education.

Indeed, the number of students over the last twenty years has more than doubled if we take a look at the 2017/8 global monitoring report on education for all (Table 1) from the United Nations Educational, Scientific and Cultural Organization (UNESCO). This situation causes several problems, notably the shortage of teachers with the consequent increase in additional hours. This results in a very high academic debt that university institutions are unable to cope with. Also, this has led to an increase in precarious employment throughout the world, as assistant, substitute, part-time worker, contract worker or non-tenured teacher [3,4,5,6]. Another problem of the massification of higher education is the deterioration of the quality of education which has the corollaries of a loss of the value of the diploma on the market, the failure to keep the promise given to students concerning their future career.

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Table 1: Indicators of Participation in Higher Education

	Schooling (in thousands)		**Gross enrollment rate** (%)	
	2000	**2015**	**2000**	**2015**
World	99 718	212 670	19	36
North Africa and West Asia	6 836	17 054	20	42
Sub-Saharan Africa	2 559	7 428	4	8
Latin America and the Caribbean	11 315	24 894	22	46
East and Southeast Asia	24 213	66 813	15	40
South Asia	12 162	41 895	9	25
Caucasus and Central Asia	1 425	1 895	22	25
Europe and North America	39 940	50 702	56	75
The pacific	1 044	1 750	46	62

Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), Education for All Global Monitoring Report 2017/8.

For a bright future of Higher Education, as part of the E-National Higher Education Network project, the Ministry of Higher Education in Cameroon is following the development of an integrated higher education management software platform called "**IT System for Networked Integrated Management of Higher Education (ITSNIMHE)** " The implementation of this software takes into account that all state universities are autonomous and if it is true that the academic system in force is the BMP system (Bachelor, Master, PhD), it is not implemented in the same way with the same management rules in all universities. We note variabilities.

The Computer System for Networked Integrated Management of Higher Education is in reality a software products line, that is to say "a set of systems sharing a set of common functionalities, satisfying specific needs for a particular field and developed in a controlled manner from a common set of reusable elements" [7].

This work, through the description of the adaptable architecture of this system following the "Feature Oriented Reuse Method with Business Component Semantics (FORM/BCS)" approach, offers possible solutions to the problems of teacher shortage and deterioration of the quality of teaching mentioned above. FROM/BCS is a method for analyzing and designing software product lines set up by Marcel Fouda Ndjodo and Amougou Ngoumou [8].

The document is organized as follows: After this introduction, the second part is devoted to related works to attenuate the academic massification phenomenon throughout the world; the third part is concentrated to the method we adopt and the fourth part before the conclusion of this work focuses on the core of this work, that is the design of the reference architecture for the digital transformation of the Cameroonian university ecosystem following the FORM/BCS approach, then opens a discussion.

2 Related works

Faced with the phenomenon of the massification of higher education, solutions are proposed throughout the world, in particular:

a. Updating programs in partnership with socio-professional circles, with a view to short university training, the professionalization and employability of learners as employees, self-employed or entrepreneur [9, 10].
b. Launching training and other activities income generators with a view to cross-subsidies for training deemed to be non-market [11].
c. Partitioning students in the same class into several groups to mitigate the harm of quality deterioration; this solution leads to programming, in the same class, each course unit in as many times as there are groups [12, 13]. In function of available human capital, the same different teacher or teachers are assigned to the different groups thus created. This bursting of students in the same class in several groups helps to mitigate the deterioration in the quality of teaching, allows teachers to better control their classes, and to be able to improve the quality of supervision of learners.
d. Systematization of digital training supports to be downloading by learners [14].
e. the implementation of "semi-face-to-face, single-teacher, multi-room, synchronous" training models thus qualified because it would consist of exploit ICT to enable the same teacher to be, through

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dedicated screens, simultaneously followed in several classrooms by learners with the possibility for these last to exchange in real time with him at the favor of judiciously positioned cameras [15].

f. Implementing a hybrid training model face-to-face-distance (blended learning) contextualized because consider in terms of E-LAN (Educational Local Area Network) or E-MAN (Educational Metropolitan Area Networks)[16, 17]. Their originalities would then reside in the fact of functioning under form of intranet, with admittedly controlled access, but free, via wifi to learners on campus (E-LAN) or within a radius to be defined (E-MAN).

Strengths and weakness of these solutions are synthesized in the Table 2 below:

Table 2: Strengths and weaknesses of solutions to the problem of massification

Solutions	Strengths	Weakness
Updating programs with a view to short university training.	This solution relieves congestion on campuses because learners do not waste much time in training.	This solution works in the short term but does not hold up in the long term.
Launching training income generators.	Learners able to pay training fees receive quality training.	This solution installs elite training and does not solve the problem of massification.
Partitioning students in the same class into several groups.	This solution makes it possible to temporarily manage the problem of massification.	Universities do not have enough resources to support this solution.
Systematization of digital training supports to be downloading by learners.	Learners have training materials.	Learners do not have a face-to-face explanations to theirs questions.
The implementation of "semi-face-to-face, single-teacher, multi-room, synchronous" training models.	Learners can have a semi-face-to-face explanation to theirs questions.	Semi-face-to-face explanations to learners are not sufficient.
Implementing a hybrid training model face-to-face-distance (blended learning).	Face-to-face explanations to learner'questions are provided.	The essential resources in terms of teachers, time and infrastructure to implement this solution are not always available.

In Table 2 above, we have brought together in a summary, six solutions to mitigate the undesirable effects of the problem of the massification of teaching, ranging from updating programs to implementing the hybrid teaching model. Each solution has strengths and weaknesses. It should be noted that alongside the difficulties mentioned in this table, in developing countries like Cameroon, extra-academic weaknesses present themselves, notably the availability of devices, low bandwidth and the lack of means to motivate teachers to digitize their courses due to the fact that this activity is not a clause of their recruitment contract.

3 Method

To approach an optimal solution, it is necessary to examine how to take advantage of the strengths of certain existing solutions by combining them. This approach is the one that we adopt in this work on digital transformation of the ecosystem of Cameroonian universities.

As shown in Figure 1 below, we have chosen the last three solutions in table 2, namely, the digitizing training materials solution, the semi-face-to-face, single-teacher, multi-room synchronous teaching solution and the face-to-face-remote hybrid solution to offer the model that we call the *3S training model*. Each S designates a teaching solution. Thus, the three models act in synergy on the learner, which makes it possible to mitigate the negative effects of the massification of teaching.

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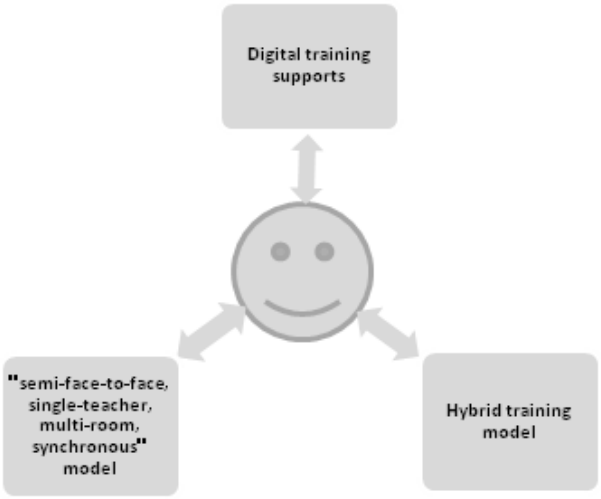

Figure 1. 3S training model.

To specify in the following section the adaptable architecture of the software product line named "IT system for networked integrated management of higher education", we use the feature oriented reuse method with business component semantics (FORM/BCS) [18].

According to [19], adaptable business (or system) architectures, as shown in Table 3 below, has four perspectives or views:

a. The *service view*, which is a set of feature business components (the functional perspectives), provides the solution for the analysis of the service provided by a business organization.
b. The *system view*, which is a set of subsystem business components (the structural perspectives), gives the solution for the decomposition of a business organization.
c. The *process view*, which is a set of process business components (the procedural perspectives), provides the solution for the description of the processes of a business organization.
d. The *logical view*, which is a set of module business components (the logical perspectives), gives the solution for the specification of application modules associated to sub processes or tasks of a business organization.

Table 3. Specification of Adaptable System Architectures

AdaptableArchitecture = = [serviceView: 𝔽 **FunctionalPerspective**;
systemView : 𝔽 **StructuralPerspective**;
processView: 𝔽 **ProceduralPerspective**;
logicalView: 𝔽 **LogicalPerspective** |];
FunctionalPerspective = = FeatureBusinessComponent;
StructuralPerspective = = SubsystemBusinessComponent;
ProceduralPerspective = = ProcessBusinessComponent;
LogicalPerspective = = ModuleBusinessComponen

Detailed specifications of feature business components, subsystem business components, process business components and module business components are gave in [19].

4 Results and Discussion

4.1 The Service View

Universities have the missions of teaching, research and development support. To carry out these missions, higher education in Cameroon offers a set of services ranging from Preregistration Management to Distance Education, including Academic Management, Management of the Interuniversity Digital Library and Follow up of Private Institutions of Higher Education (PIHE). The following functional model describes higher education. In this model, ITSNIMHE stands for IT System for Networked Integrated Management of Higher Education. It is possible to configure this functional model to the specificities of each university. It therefore contains

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adaptation points. This is an adaptable feature business component from which a specification of the selection of system features by university based on user requirements analysis can be derived.

The different modules of the system are detailed respectively in subsections provided for this purpose.

Name : Functional model of the IT System for Integrated Management of Higher Education Resources

Descriptor :

Intention : (Define) $_{ACTION}$ ((Management) $_{ACTION}$ (Higher Education) $_{TARGET}$) $_{TARGET}$

Context :

Domain : (Manage) $_{ACTION}$ (Higher Education) $_{TARGET}$

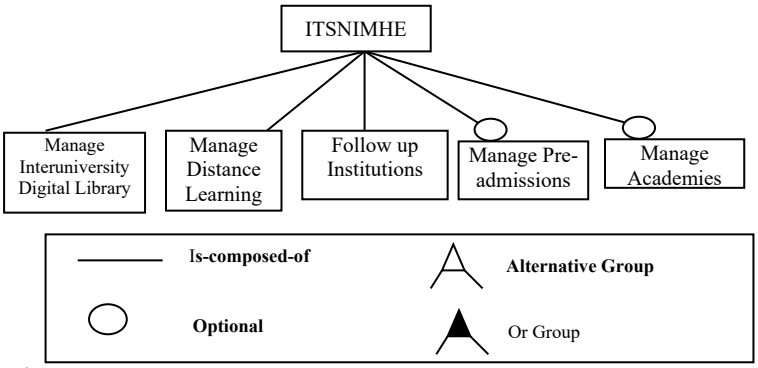
Processes :

F1 = (Manage)$_{ACTION}$ (Interuniversity Digital Library) $_{TARGET}$
F2 = (Manage)$_{ACTION}$ (Distance Learning) $_{TARGET}$
F3 = (Follow up)$_{ACTION}$ (Institutions) $_{TARGET}$
F4 = (Manage)$_{ACTION}$ (Pre-admissions) $_{TARGET}$
F5 = (Manage)$_{ACTION}$ (Academies) $_{TARGET}$

Rules :

Realization :

Solution :



Adaptation points:

{(Manage Higher Education, {{Manage Interuniversity Digital Library, Manage Distance Learning, Follow up Institutions}, {Manage Interuniversity Digital Library, Manage Distance Learning, Follow Institutions, Manage Pre-admissions}, {Manage Interuniversity Digital Library, Manage Distance Learning, Follow up Institutions, Manage Academies}, {Manage Interuniversity Digital Library, Manage Distance Learning, Follow up Institutions, Manage Pre-admissions, Manage Academies}})}

End.

4.1.1 Features of interuniversity digital library management module

The interuniversity digital library management module makes it possible to monitor the process of acquiring documentary resources and their sharing. This involves collecting the needs from the central libraries of the different universities, then consolidating these needs, selecting the documentary databases, acquiring the resources, pooling the resources and finally administering the resources. The specification of the interuniversity digital library management module is given below. In this specification, IDL stands for Interuniversity Digital Library and DDB stands for Documentary Databases.

Name: Functional model of the management of the Interuniversity Digital Library

Descriptor :

Intention : (Manage) $_{ACTION}$ (Interuniversity Digital Library) $_{TARGET}$

Context :

Domain : (Manage) $_{ACTION}$ (Higher Education) $_{TARGET}$

Processes :

F1 = (Collect)$_{ACTION}$ (Needs)$_{TARGET}$
F2 = (Consolidate)$_{ACTION}$ (Needs)$_{TARGET}$
F3 = (Select)$_{ACTION}$ (Documentary Databases)$_{TARGET}$
F4 = (Acquire)$_{ACTION}$ (Documentary Ressources)$_{TARGET}$
F5 = (Mutualise)$_{ACTION}$ (Documentary Ressources)$_{TARGET}$

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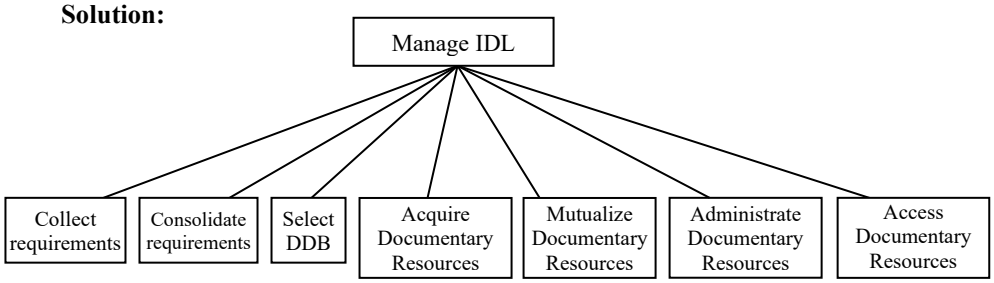
F6 = (Administer)$_{ACTION}$ (Documentary Ressources)$_{TARGET}$
F7 = (Access)$_{ACTION}$ (Documentary Ressources)$_{TARGET}$

Rules:

Realization:

Solution:



Adaptation points:

End.

4.1.2 Features of the distance learning management module

The distance learning management module offers a digital space allowing teachers to provide their courses in digital version (in PDF, audio and video support) to learners. This module also offers to learners the possibility of following live streaming lessons remotely. The specification of this module is given below.

Name : Functional model of the management of Distance Learning

Descriptor :

Intention : (Manage)$_{ACTION}$ (Distance Learning) $_{TARGET}$

Context :

Domain : (Manage) $_{ACTION}$ (Distance Learning) $_{TARGET}$

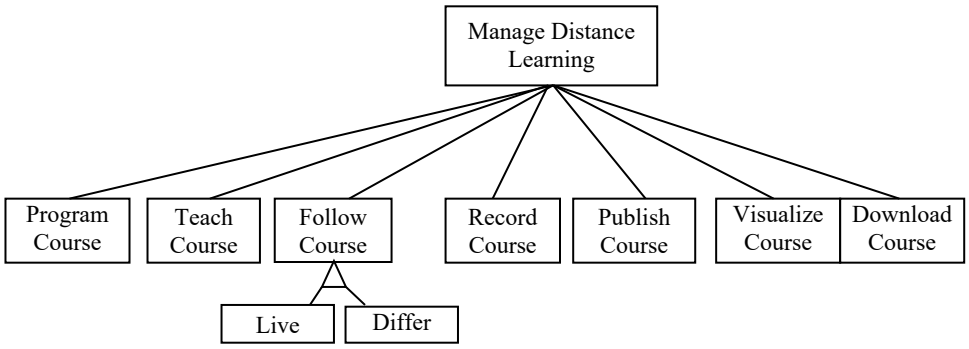
Processes :

F1 = (Program)$_{ACTION}$ (Course)$_{TARGET}$
F2 = (Teach)$_{ACTION}$ (Course)$_{TARGET}$
F3 = (Follow)$_{ACTION}$ (Course)$_{TARGET}$
F4 = (Record)$_{ACTION}$ (Course)$_{TARGET}$
F5 = (Publish)$_{ACTION}$ (Course)$_{TARGET}$
F6 = (Visualize)$_{ACTION}$ (Course)$_{TARGET}$
F7 = (Download)$_{ACTION}$ (Course)$_{TARGET}$

Rules :

Realization :

Solution :



Adaptation points:

{(Follow Course, {{Live}, {Differ}})}

End.

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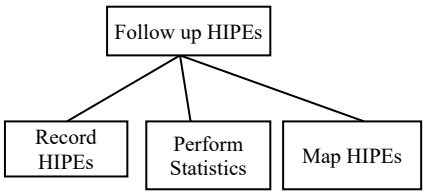
4.1.3 Features of Private Institutions of Higher Education follow up module

The Private Institutions of Higher Education (PIHE) follow up module makes it possible to list PIHEs, to have statistics, to know at any time HIPEs which are in good standing (those which have creation and opening orders) and to carry out mapping. The specification of this module is given below.

Name: Functional model of the follow up of Private Institutions of Higher Education
Descriptor:
Intention: (Follow up)$_{ACTION}$ (Private Institutions of Higher Education) $_{TARGET}$
Context:
Domain: (Manage) $_{ACTION}$ (Higher Education) $_{TARGET}$
Processes:
F1 = (Record)$_{ACTION}$ (Private Institutions of Higher Education)$_{TARGET}$
F2 = (Perform)$_{ACTION}$ (Statistics)$_{TARGET}$
F3 = (Map)$_{ACTION}$ (Private Institutions of Higher Education)$_{TARGET}$
Rules:
Realization:
Solution:



Adaptation points:
End.

4.1.4 Features of the distance learning management module

Pre-admissions management module presents two alternatives depending on whether you are at the university or the ministry. At the university, this involves carrying out pre-admissions; this process takes place through a certain number of activities, in particular the recording of information on candidates such as civil status, choice of fields and the basic diploma. This information allows the university to analyze the candidate's educational background in order to direct them to one of their three choices. At the level of the ministry of higher education, this involves producing national statistics on the choice of mentions and the distribution of students by specialty. The functional model of this module is as follows:

Name: Functional model of Pre-admissions management
Descripteur :
Intention : (Manage) $_{ACTION}$ (Pre-admissions) $_{TARGET}$
Context :
Domain : (Manage) $_{ACTION}$ (Higher Education) $_{TARGET}$
Processes :
F1 = (Carry out)$_{ACTION}$ (Pre-admissions)$_{TARGET}$
F11 = (Realize)$_{ACTION}$ (Bachelor's pre-admissions)$_{TARGET}$
F12 = (Do)$_{ACTION}$ (Master's pre-admissions)$_{TARGET}$
F13 = (Accomplish)$_{ACTION}$ (Doctorat's pre-admissions)$_{TARGET}$
F14 = (Perform)$_{ACTION}$ (Payment)$_{TARGET}$
F2 = (Produce)$_{ACTION}$ (National Statistics)$_{TARGET}$
Rules :
Realization :
Solution :

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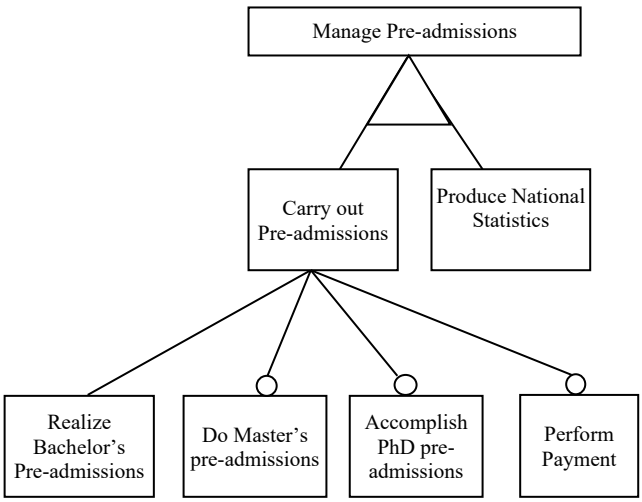

Adaptation points:

{(Manage-Pre-admissions, {{Carry out Pre-admission}, {Produce National Statistics}}), (Carry out Pre-admissions, ({Realize Bachelor's pre-admission}, {Realize Bachelor's pre-admission, Do Master's pre-admissions}, {Realize Bachelor's pre-admission, Do Master's pre-admissions, Accomplish PhD pre-admissions}, {Realize Bachelor's pre-admission, Perform Payment}, {Realize Bachelor's pre-admission, Do Master's pre-admissions, Perform Payment}, { Realize Bachelor's pre-admission, Do Master's pre-admissions, Accomplish PhD pre-admissions, Perform Payment})}

End.

4.1.5 Features of the distance learning management module

Academic management makes it possible to monitor the teaching process in its pre-active, active and post-active phases. In the pre-active phase, this involves recording the academic years, semesters, fields, specialties, teaching units, courses (or constituent elements), types of teaching (lecture courses, Directed Work, Practical Work) and periods. This information is used to carry out administrative and academic registrations for students and to generate timetables. The active phase consists of following the progress of the lessons in such a way that at any time, we can know the rate of progression of the semester hourly volume. The active phase also allows continuous evaluations to be carried out. The post-active phase is devoted to exams, from their programming to the publication of the marks. It thus makes it possible to calculate the level of each learner.

Name : Functional model of academic management
Descriptor :
Intention : F = (Manage)$_{ACTION}$ (Academies) $_{TARGET}$
Context :
Domain : (Manage) $_{ACTION}$ (Higher Education) $_{TARGET}$
Processes :
F1 = (Record)$_{ACTION}$ (Years, Semesters, Fields, Specialties, Teaching Units, Courses)$_{TARGET}$
F2 = (Record)$_{ACTION}$ (Teaching types, Periods)$_{TARGET}$
F3 = (Realize)$_{ACTION}$ (Administrative registrations, Academic registrations)$_{TARGET}$
F4 = (Generate)$_{ACTION}$ (Time table)$_{TARGET}$
F5 = (Count)$_{ACTION}$ (Teachings)$_{TARGET}$
F6 = (Manage)$_{ACTION}$ (Learners Evaluation)$_{TARGET}$
F7 = (Publish)$_{ACTION}$ (Grades)$_{TARGET}$
F8 = (Publish)$_{ACTION}$ (Marks)$_{TARGET}$
Rules :
Realization :
Solution :

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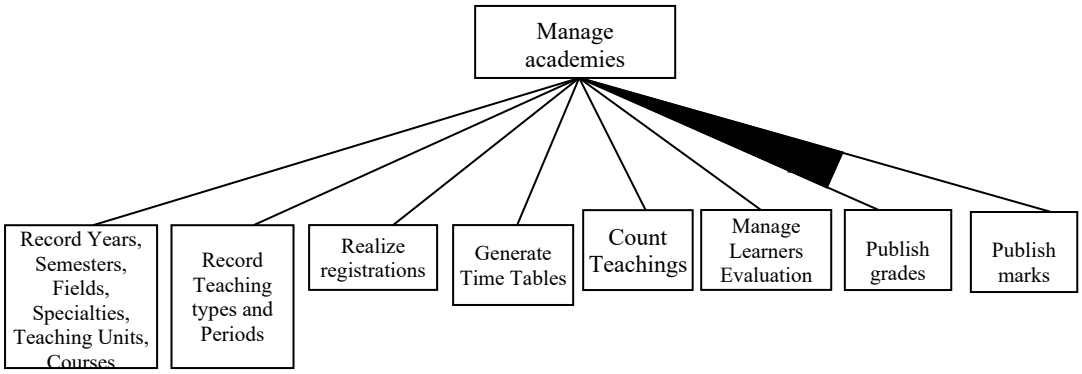

Adaptation points:

{(F, {{F1, F2, F3, F4, F5, F6, F7, F8}, {F1, F2, F3, F4, F5, F6, F7}, {F1, F2, F3, F4, F5, F6, F8}})}

End.

4.2 The System View

The system view of the adaptable architecture for the digital transformation of the Cameroonian university ecosystem is a reference architecture that has adaptation points since each university institution is autonomous and can choose features he want and left other features. This sub-section details the system view.
The different subsystems of the system view are detailed by giving features taked into account by each sub-system.

Name: Structural model of the IT System for Networked Integrated Management of Higher Education
Descriptor:
Intention: (Define) ACTION ((Management) ACTION (Higher Education) TARGET) TARGET
Context:
Domain: (Manage) ACTION (Higher Education) TARGET
Processes:
F1= (Manage)ACTION (Interuniversity Digital Library) TARGET
F2 = (Manage)ACTION (Distance Learning) TARGET
F3 = (Follow up)ACTION (Institutions) TARGET
F4 = (Manage)ACTION (Pre-admissions) TARGET
F41 = (Carry out)ACTION (Pre-admissions)TARGET
F42 = (Produce)ACTION (National Statistics)TARGET
F5 = (Manage)ACTION (Academies) TARGET
F51 = (Record)ACTION (Years, Semesters, Fields, Specialties, Teaching Units, Courses)TARGET
F52 = (Record)ACTION (Teaching types, Periods)TARGET
F53 = (Realize)ACTION (Administrative registrations, Academic registrations)TARGET
F54 = (Generate)ACTION (Time table)TARGET
F55 = (Count)ACTION (Teachings)TARGET
F56 = (Manage)ACTION (Learners Evaluation)TARGET
F57 = (Publish)ACTION (Grades)TARGET
F58 = (Publish)ACTION (Marks)TARGET
Rules:
Realization:
Solution:
Sub-systems: *{SS1 = {F1}, SS2 = {F2}, SS3 = {F3}, SS4 = {F4}, SS5 = {F5}}*
Links : *{SS1 ↔ SS3, SS4 ↔ SS5}*

Adaptation points:
{
(SS4, {{F41}, {F42}}), (SS5, {{F51, F52, F53, F54, F55, F56, F57, F58}, {F51, F52, F53, F54,

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F55, F56, F57}, {F51, F52, F53, F54, F55, F56, F58}})
}

End.

The provided code outlines the structural components of the IT System for Integrated Management of Higher Education Resources. It is organized into several key sections: **Intention:** The intention of the system mentions the goal the system which is to manage higher education resources. This sets the broader context for the system. **Context Processes**: Five context processes, F1, F2, F3, F4 and F5 are specified. F1 is dedicated to the feature for the management for interuniversity digital library; F2 is dedicated to the feature for the management of distance learning, F3 is dedicated to the feature for the management of institutions, F4 is dedicated to the feature for the management of pre-admission and F5 is dedicated to the feature for the management of academies. These features are in the first level of the system. **Solution sub-systems**: Five sub-systems, SS1, SS2, SS3, SS4 and SS5 are outlined. Applying the construction rule of sub-systems, features of each sub-system are given. **Solution links**: Two links, SS1 ↔ SS2 and SS4 ↔ SS5 are indicated. Links denote that a sub-system call services of another sub-system. **Realization adaptation points**: Two realization adaptation points are specified. The first adaptation point, (SS4, {{F41}, {F42}}), is for the management of pre-admissions and has two variants: F41 and F42. F41 is the carrying out of pre-admissions and F42 is the production of national statistics. The second adaptation point (SS5, {{F51, F52, F53, F54, F55, F56, F57, F58}, {F51, F52, F53, F54, F55, F56, F57}, {F51, F52, F53, F54, F55, F56, F58}}) is for the management of academies and has three variants: {F51, F52, F53, F54, F55, F56, F57, F58}, {F51, F52, F53, F54, F55, F56, F57} and {F51, F52, F53, F54, F55, F56, F58}.

In summary, this specification serves mainly as a comprehensive blueprint for the structural model of the IT System for Integrated Management of Higher Education Resources.

4.3 The Process View

The process view of the adaptable architecture for the digital transformation of the Cameroonian university ecosystem is a reference architecture that has adaptation points since each university institution is autonomous and, given a feature action in a sub-system, can choose activities he want to perform for this action and left other activities. For a better understanding, the reference process architecture, which is a process business component, for each first level feature in a sub-system must be specified. This sub-section details the reference process architecture for the management of pre-admissions.

Name: Procedural model for the management of pre-admissions
Descriptor:
Intention: (Manage) $_{\text{ACTION}}$ (Pre-admissions) $_{\text{TARGET}}$
Context:
Domain: (Manage) $_{\text{ACTION}}$ (Higher Education) $_{\text{TARGET}}$
Processes:
F1= (Carry out)$_{\text{ACTION}}$ (Pre-admissions)$_{\text{TARGET}}$
F11= (Realize)$_{\text{ACTION}}$ (Bachelor's pre-admissions)$_{\text{TARGET}}$
- (Record)$_{\text{ACTION}}$ (Civil status)$_{\text{TARGET}}$
- (Input)$_{\text{ACTION}}$ (Fields) $_{\text{TARGET}}$
- (Choose)$_{\text{ACTION}}$ (Specialties) $_{\text{TARGET}}$
- (Indicate)$_{\text{ACTION}}$ (Basic diploma) $_{\text{TARGET}}$
- (Orient)$_{\text{ACTION}}$ (Candidate) $_{\text{TARGET}}$

F12 = (Do)$_{\text{ACTION}}$ (Master's pre-admissions)$_{\text{TARGET}}$
- (Record)$_{\text{ACTION}}$ (Civil status)$_{\text{TARGET}}$
- (Input)$_{\text{ACTION}}$ (Fields) $_{\text{TARGET}}$
- (Choose)$_{\text{ACTION}}$ (Specialties) $_{\text{TARGET}}$
- (Indicate)$_{\text{ACTION}}$ (Basic diploma) $_{\text{TARGET}}$
- (Orient)$_{\text{ACTION}}$ (Candidate) $_{\text{TARGET}}$

F13 = (Accomplish)$_{\text{ACTION}}$ (Doctorate's pre-admissions)$_{\text{TARGET}}$
- (Record)$_{\text{ACTION}}$ (Civil status)$_{\text{TARGET}}$
- (Input)$_{\text{ACTION}}$ (Fields) $_{\text{TARGET}}$
- (Choose)$_{\text{ACTION}}$ (Specialties) $_{\text{TARGET}}$
- (Indicate)$_{\text{ACTION}}$ (Basic diploma) $_{\text{TARGET}}$
- (Orient)$_{\text{ACTION}}$ (Candidate) $_{\text{TARGET}}$

F14 = (Perform)$_{\text{ACTION}}$ (Payment)$_{\text{TARGET}}$

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F2 = (Produce)$_{ACTION}$ (National Statistics)$_{TARGET}$

Rules:

Realization:

Solution:

Tasks: {Carry out, Realize, Do, Accomplish, Perform, Produce}

datas : {Pre-admissions, Bachelor_Candidate, Master_Candidate, PhD_Candidate, Payment, National_Statistics}

dataaccess : {(Carry out, Pre-admissions), (Realize, Bachelor_Candidate), (Do, Master_Candidate), (Accomplish, PhD_Candidate), (Perform, Payment), (Produce, National_Statistics)}

messages : {(Do, Realize), (Accomplish, Realize) }

Adaptation points:

{
(Do, {{Record, Input, Choose, Indicate, Orient}, {Record, Choose, Indicate, Orient}}), (Accomplish, {{Record, Input, Choose, Indicate, Orient}, {Record, Choose, Indicate, Orient}, {Record, Indicate, Orient}})
}

End.

4.4 The Logical View

The logical view of the adaptable architecture for the digital transformation of the Cameroonian university ecosystem is a reference architecture that has adaptation points since each university institution is autonomous and, given a task action in a process, can choose operations he wishes to carry out for this action, and leave other operations. For a better understanding, the reference logical architecture, which is a module business component, for each task in process architecture must be specified. This sub-section details the reference logical architecture for the realization of bachelor's pre-admissions.

Name: Logical model for the realization of bachelor's pre-admissions

Descriptor:

Intention: (Specify)$_{ACTION}$((Realize = [{}, { preadmit by commission , preadmit by competitive examination }, {}]) $_{ACTION}$ (candidates, applications, competitive examinations, decisions) $_{TARGET}$)$_{TARGET}$

Context:

Domain: (Manage) $_{ACTION}$ (Higher Education) $_{TARGET}$

Processes:

F1 = (Realize = [{}, {preadmit by commission , preadmit by competitive examination}, {}]) $_{ACTION}$ (candidates, applications, competitive examinations, decisions) $_{TARGET}$

/ sub-processes of the process F1 */*

- (preadmit by commission)$_{ACTION}$ (decision, candidates, applications)$_{TARGET}$
- (preadmit by competitive examination)$_{ACTION}$ (decision, candidates, competitive examinations) $_{TARGET}$

Rules:

Realization:

Solution:

pseudonym: realize;

parameters: { candidates, applications, competitive examinations, decisions};

task : < {}, {preadmit by commission = [{apply, submit, decide, display}, {send}, {}] , preadmit by competitive examination }, {} >

include: 𝔽 **Module**

external: 𝔽 **Module**

specification: **PseudoCode**

Adaptation points:

{

*(preadmit by commission, {{*apply, submit, decide, display*}, {*apply, submit, decide,

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display, send*}})*
}

End.

4.5 Discussion

The adaptable reference architecture propose in this section for the digital transformation of the Cameroonian university ecosystem to deal with the problem of massification of teachings poses no problem at the functional level as long as developers understand management rules of the academic organization. This functional success is the consequence of the adoption of a software product line approach which takes into account all the variability encountered in the different universities of the ecosystem. The implementation of this adaptable architecture is still going on and does not encounter any particular problem. Finalization of the eligible version is underway. Problems encountered in the field concern non-functional aspects such as:

a. *Unavailability of electrical current*: Developing countries have a serious problem of unavailability of electricity which makes testing of computer systems cannot be done properly and creates delays in projects. To solve this problem it is important to have several sources of electrical energy such as the national electricity company, generators and solar energy. These different sources will alternate according to need.
b. *Insufficient Internet bandwidth*: Internet bandwidth is also insufficient in developing countries, which does not allow the interconnection of different systems that need to communicate. The solution to this lies in the pooling of resources for group acquisition of sufficient bandwidth.
c. *Unavailability of qualified human resources*: This problem is due to the fact that the university ecosystem is unable to retain the computer engineers essential to ensure the operation and subsequently the evolution of software platforms. Engineers always leave where they are offered attractive salaries.

These aspects are very important and have to be solved.

5 Conclusion

The adaptable architecture of the Computer System for Networked Integrated Management of Higher Education following the "Feature Oriented Reuse Method with Business Component Semantics (FORM/BCS)" approach described in this work offers possible solutions to the problems of teacher shortage and deterioration of the quality of teaching. However, like any IT system, its success depends on its acceptance and appropriation by the stakeholders on the beneficiary side. In addition to the unavailability of electricity and internet bandwidth, the developed system must be accepted by the university community. Teachers must agree to adapt to the new fact by digitizing courses and making them downloadable. The problem is not only on the technological side of software engineering but also on the management side. We must manage change sensitively if we want to succeed. Managing change in the implementation of a digital management platform in Cameroonian universities is an area in which we intend to continue our investigation.

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