



Distributed Internet based Performance Support Environment for Individualized Learning – improved model, software architecture and integration with remote labs

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Abstract: *Distributed Internet-Based Performance Support Environment for Individualized Learning (DIPSEIL, <http://env.dipseil.net/v3>)- software model and software architecture. This paper describes the model, software architecture and integration with remote labs for building distributed information learning environment from several servers spread all over Europe with educational content, based on performance support systems concept with educational elements. Many of the problems with the design of geographically distributed information systems are not fully solved so the investigation of this field is a question of very present interest. A specially designed distributed conceptual model based on IEEE LTSA P1484.1 specification is presented. Based on conceptual model were developed functional model, IPSS_EE Learning Objects Model, Adaptive System Model, Sequencing and Navigation Model and Learner Activity Flowchart model. The paper also describes the use of remote laboratories in electronics engineering education and their integration with DIPSEIL learning environment.*

Keywords: *Distributed learning management system, performance –centred learning, remote laboratories*

I. Introduction

Distributed Internet-based Performance Support Environment for Individualized Learning (DIPSEIL) is a learning management system (LMS) designed, developed, tested and used in University of Plovdiv Paisii Hilendarski, Plovdiv, Bulgaria. DIPSEIL is a project to define, develop and test a distributed system for individualized learning and the underlying pedagogical procedures to implement, facilitate and promote performance-centered learning experiences in the context of International university engineering education. The main characteristic which distinguishes DIPSEIL LMS from other LMS' is the Performance-Centered learning method [1] and the system geographical distribution.

The use Performance-centered learning method in Higher University education leads to different course design where all educational activities and student learning paths are integrated around of "tasks for performances". This means that all educational content is divided in small tasks which student has to perform for a given time period for example 1 week. The tasks are with practical approach and the student has to perform it and solve many practical problems which are related with the learning outcomes which course design has defined. For each task DIPSEL LMS offers 5 educational virtual instruments: task description; task specific training; reference information; instructions how to perform; expert advises; connection with remote labs. These virtual educational instruments contain the all the information which student needs to perform the task. The task description instrument contains a file which forms the task – it can be any web page, multimedia file, schematics and so on. Task specific training instrument is built by IPSS_EE learning objects designed to supply the theoretical foundations and the necessary minimum of knowledge related to the task. Reference information about the task virtual instrument provides dynamically web-links and external for DIPSEIL content regarding the task – more information, books, bibliography, etc. Instructions how to perform is fundamental virtual education instrument which provides students with specific instructions for dealing with the problem - a sequence of actions, the algorithm to work, concrete steps in implementing - measurements, simulations, etc. Expert advises educational instrument is a tool by means of which the student meets predefined expert advice from experts or automated expert system for performing the task. For performing complicated engineering problems in the field of Electronics, Communications and Information technology, DIPSEIL LMS offers a connection with remote laboratories for performing experiments in real time.

Using Performance-Centered approach [1] we have developed the first Prototype of DIPSEIL [2] with two main characteristics: Distribution and Individualization. Distribution reflects mainly on the functionality and organization of the physical and geographical distribution of educational content. Individualization reflects on the way that the user will use DIPSEIL system – Student Area. DIPSEIL promotes the concept of distributed

learning with an attempt to make a conceptual shift from a support of individual learning, based on information processing, towards a support of learning based on distributed cognition. DIPSEIL provides online access to a vast number of distributed text and multimedia information sources in the field of engineering education in an integrated manner. [2].

Distributed Internet-based Performance Support Environment for Individualized Learning (DISPEIL) is defined as an integrated and Internet accessible collection of performance support systems for educational purposes, that can be used when required, at a particular point of need, by an individual user, or a workgroup. [2]

In DIPSEIL multiple users can interact with distributed educational content in real time, running on several servers, connected by a computer network using client server applications.

The educational content is spread over several DIPSEIL servers across Europe and is structured mainly in the field of Electronics and Information technologies engineering education.

II. DIPSEIL improved model

The first model prototype of DIPSEIL LMS was described in [4]. It defines the conceptual, functional, structural and technical foundations of the Performance-Centered, distributed, web-based environment. The model is composed of many elements communicating each other. Each element has different specifications and applications designed to meet the requirements of a distributed management environment and the use of IPSS_EE_LOs – DIPSEIL Learning objects, and to create conditions for individualization. General pattern of DIPSEIL model is an aggregation of:

- Conceptual model of DIPSEIL +added information flow between delivery process and remote labs
- Functional model of DIPSEIL+ added remote instrumentation servers and remote lab equipment
- Model of learning objects used by DIPSEIL
- Adaptive system model
- Sequencing and Navigation - S & N Model
- Learner's Activity Flowchart (LAF)

The improved model of DIPSEIL LMS includes connection with real-time remote laboratories for performing engineering experiments and it makes some changes into the following models: Conceptual model of DIPSEIL, Functional model of DIPSEIL, S&N model. The changes include a new flow of data in DELIVERY process (fig.1), in DIPSEIL conceptual model based on IEEE P1484.1/D9, Draft Standard for Learning Technology — Learning Technology Systems Architecture (LTSA).

The aggregation of DIPSEIL Learning Objects with the conceptual and functional models of the DIPSEIL learning environment as well with remote labs servers in functional model also presents the processes associated with the delivery of educational content, and communication between student DIPSEIL environment and standardized model for data transmission to the learner.

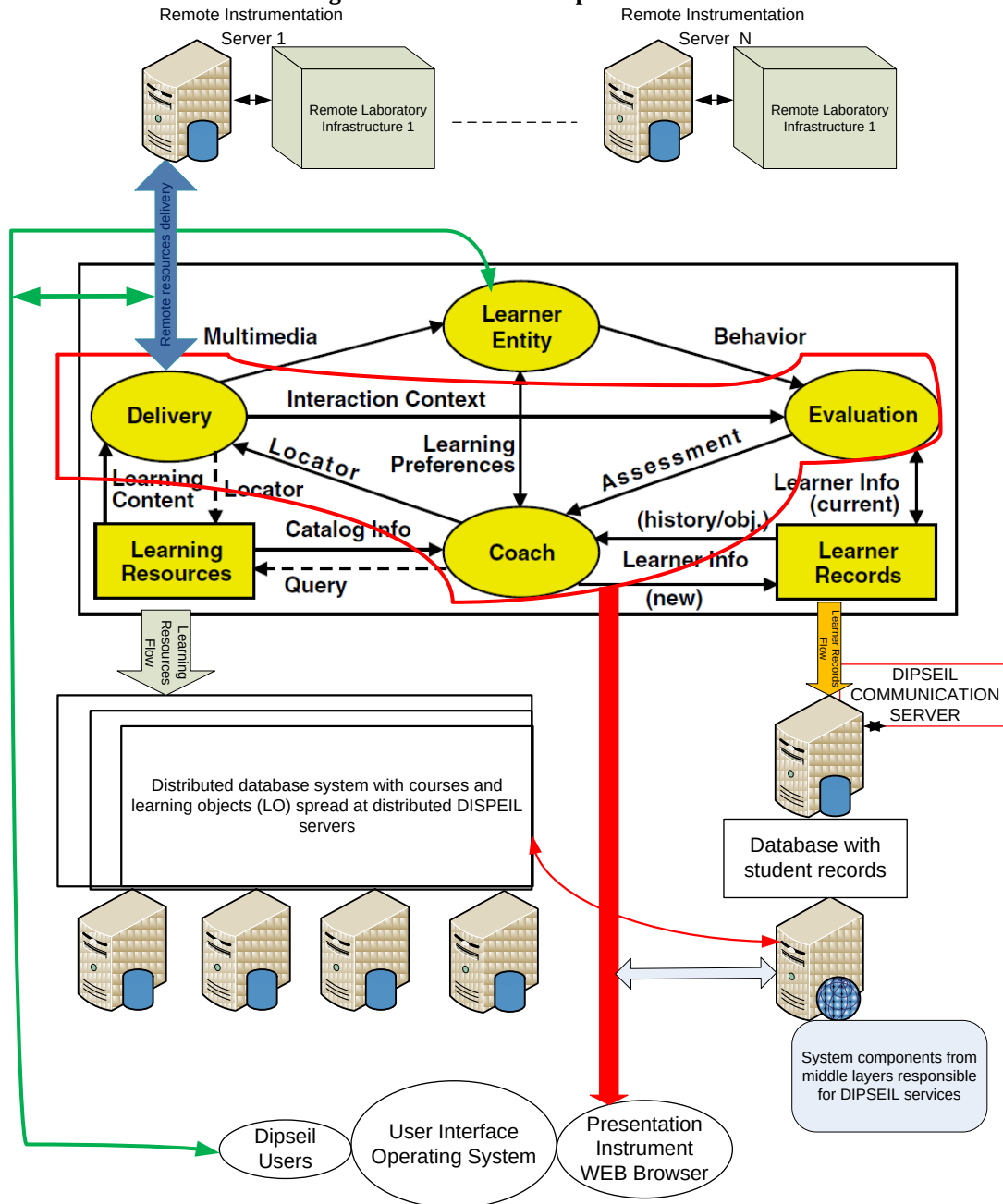
III. DIPSEIL Conceptual model

DIPSEIL conceptual model (fig.1) is based on IEEE P1484.1/D9, Draft Standard for Learning Technology — Learning Technology Systems Architecture (LTSA).

According to [3] DIPSEIL conceptual model describes four processes: learner entity, evaluation, coach, and delivery process; two stores: learner records and learning resources; and thirteen information flows among these components: behavioural observations, assessment information, learner information (three times), query, catalogue info, locator (twice), learning content, multimedia, interaction context, and learning preferences.

Briefly, the overall operation has the following form: (1) the learning styles, strategies, methods, etc., are negotiated among the learner and other stakeholders and are communicated as learning preferences;(2) the learner is observed and evaluated in the context of multimedia interactions;(3) the evaluation produces assessments and/or learner information;(4) the learner information is stored in the learner history database;(5) the coach reviews the learner's assessment and learner information, such as preferences, past performance history, and, possibly, future learning objectives;(6) the coach searches the learning resources, via query and catalogue info, for appropriate learning content;(7) the coach extracts the locators from the available catalogue info and passes the locators to the delivery process, e.g., a lesson plan; and (8) the delivery process extracts the learning content from the learning resources, based on locators, and transforms the learning content to an interactive multimedia presentation to the learner. (9) The delivery process interacts with remote instrumentation servers 1,2...N and controls all the information flow between student and remote lab – authentication process, time slots management, network access between remote desktop software, DIPSEIL communication and remote servers. Considering the distributed nature of the learning environment (fig.1), and the fact that the curriculum is geographically distributed in multiple servers the DIPSEIL conceptual model makes a major change some of the key information flows for educational content delivery and student records information flow.

Figure 1 DIPSEIL Conceptual Model



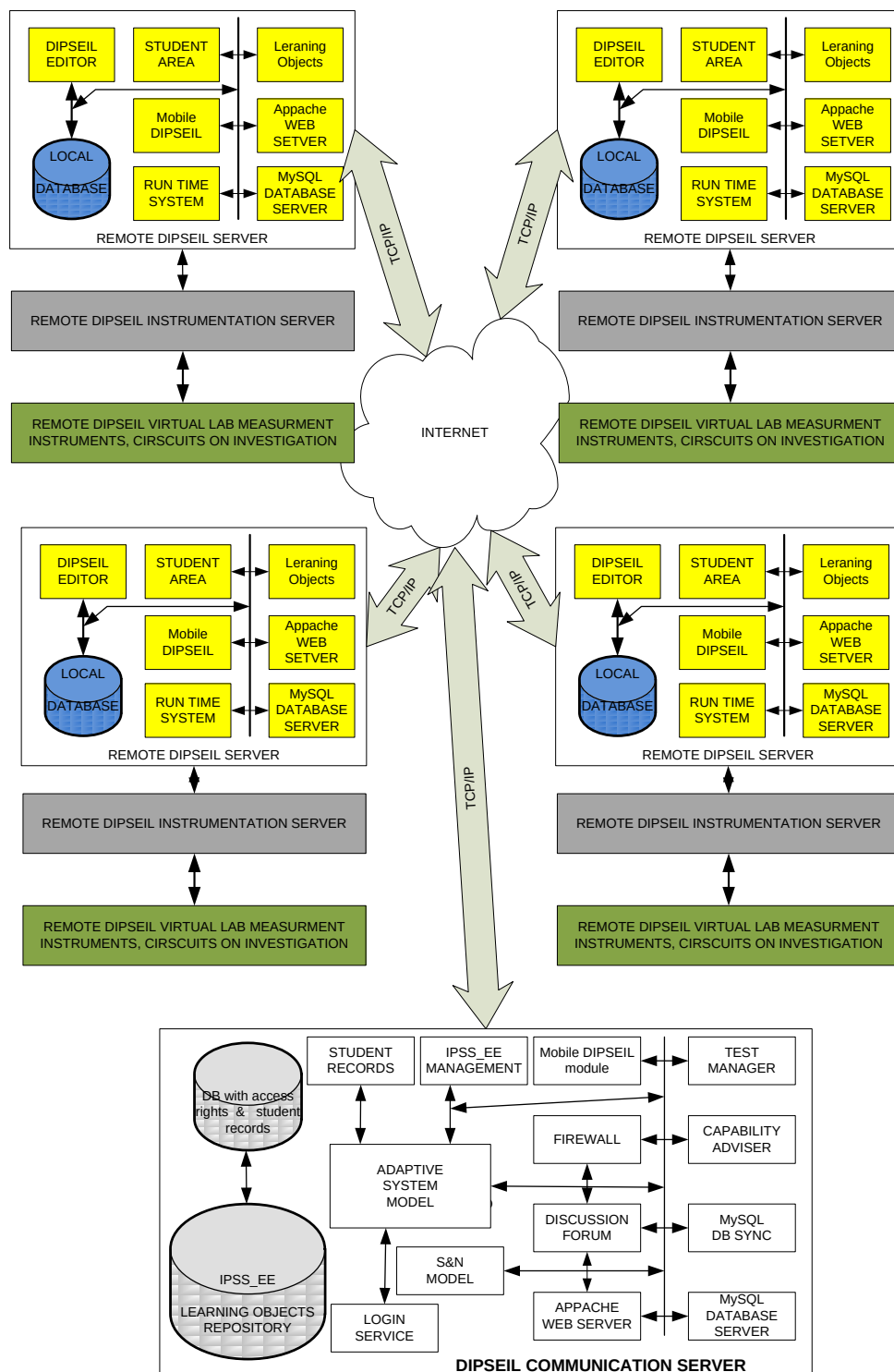
Key contributions from DIPSEIL conceptual model are:

- Need of two repositories - for educational content which is distributed and for student records (student portfolio) on DIPSEIL communication server
- Need for "system communication" process for delivery and distribution of educational content.
- Need for a specialized information flow between DIPSEIL Users (students, course designers, administrators) and remote labs infrastructure and instrumentation servers.

IV. DIPSEIL functional model

The functional model of DIPSEIL fig.2 describes the main software components needed for the realization of a distributed learning management system. Here we can describe 2 core elements – distributed DIPSEIL servers and DIPSEIL communication server. Distributed DIPSEIL servers main software elements are: DIPSEIL Editor – software component for course and learning objects creation; Student Area – distributed software component with parts both on distributed servers and in communication server – its main functionality is to make the learning environment working interface;

Figure 2 Functional Architecture of DIPSEIL



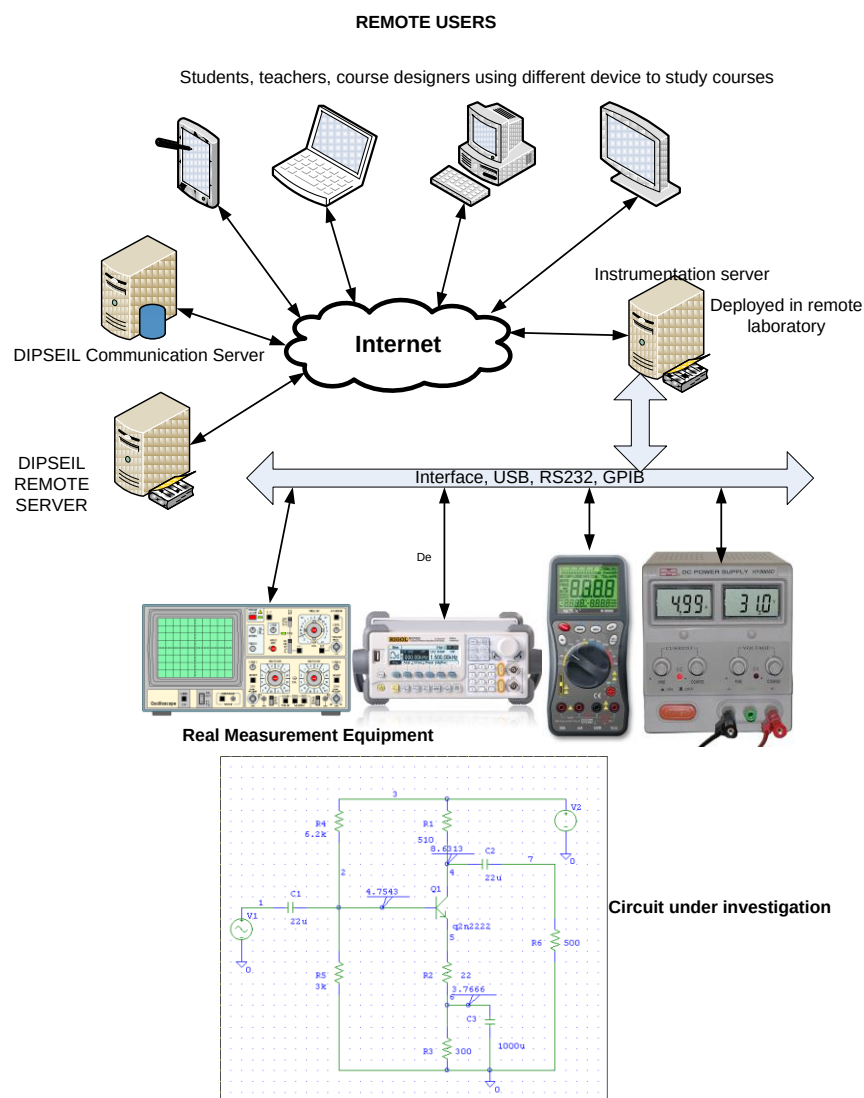
Database with learning objects – where the LO's actual files are stored; Apache web server and MySQL database servers are key software components for DIPSEIL software environment; mDIPSEIL is a software component for interaction of the remote content with mobile devices for mobile-learning purposes. In the DIPSEIL communication server we can see the following software components: IPSS_EE Learning objects repository – database component which stores catalog information for actual learning objects files locations on distributed DIPSEIL servers; Database with student records and DIPSEIL user's rights in the system; Course IPSS_EE management is a software component responsible for DIPSEIL courses management and information flow to

distributed servers; ASM-adaptive system model software component which main function is to add some level of individualization of the student's learning process; S&N - software component which function is the sequencing and navigation of learning content from the distributed servers to the learner according conceptual model processes and adaptive system model current condition; Login service - software component which deals with DIPSEIL users authorization in a distributed environment; Mobile Dipseil module – software component which interacts with the distributed component in the distributed servers and adds Mobile Learning functionalities.

V. DIPSEIL integration with remote laboratories

Practical experimental work in laboratory is an important component of engineering education. In a case of distance learning it is not possible to give opportunity to students to perform complex lab experiments without using a “remote laboratory”. Distance education in the field of engineering is still under research primarily because of difficulty in delivery of practical based instructions and valuable laboratory experience. One possible solution addressing the lack of practical work in distance education in the field of electronics is to use remote real lab experiments[5].

Fig.3 DIPSEIL integration with remote lab



The integration of DIPSEIL LMS with remote laboratory in analog electronics is show on fig.3. Remote LAB users use DIPSEIL Server for studying courses in analog electronics, and after studying the material and they do the tasks for the simulation of the analog circuits they are transferred to instrumental server that is connected to the test circuit to continue with the real investigation of the scheme using the measurement instruments remotely. Access to the instrumentation server is granted using time slots. These specify when the laboratory experiment is

free for use and how many users can use it at a time. For our case only one user can use the lab experiment at a time. When student want to perform an experiment they first must check for a free time slot in their DIPSEIL calendar and register for one of them. Authorization of users of remote lab and remote access are carried out after the student is authorized in the DIPSEIL learning environment. After that he/she must read the task description to perform a computer simulation of the circuit (using PSPICE) and then to be transferred to the real laboratory in which to perform a real experiments with the tested circuit. After the measurements of real circuit are performed, students should summarize data and compare them with data from simulations and send a solution for the current task uploading it in DIPSEIL server. Authentication process between the student, DIPSEIL learning environment and the instrumentation server is performed in several phases. Forwarding student from DIPSEIL learning environment to the instrumentation server that allows remote access is done by the teacher who has prepared a server connection link to the instrumentation server. To prevent the free use of the server by simple clicking on that link was developed authentication mechanism which proceeds as follows: The student follows the link that takes him to a web page provided by apache web server working on instrumentation server, which is located in the internal network infrastructure in University of Plovdiv called DMZ. When student follows the link, first it is verified whether the student has registered for the free time slot of the laboratory schedule and whether this period coincides with the actual time. If both conditions are met, the student is redirected to a remote laboratory, as the access to it is granted by remote desktop sharing using VNC. The information for the user e.g. user name, user id, task id, server number and the time slot, time to work in a remote laboratory is appropriately encrypted and returned to DIPSEIL environment as this the information is used appropriately. Once the student has gained access to the desktop of instrumentation server, he is able to control instrumentation and laboratory equipment that are connected through an appropriate interface to the instrument server. The instrumentation server user interfaces are provided by installed measurement equipment control software. Each connected instrument has its own software for controlling the device and to collect measurement data. This remote laboratory setup which is deployed in University of Plovdiv provides access to five major laboratories in the field of analog electronics, which are crucial for the education of future engineers in electronics and communications.

VI. CONCLUSION

The described in this paper DIPSEIL model and novel network architecture have been successfully implemented in a real Distributed Internet Based Support Environment for Individualized Learning – LMS which can be found at: <http://env.dipseil.net/v3>

The main novel features of the described distributed architecture are: very high level of system integrity; network transparency; replication transparency; improved performance; no data replication in real time;

The current deployment of DIPSEIL LMS system (March 2013) includes communication and remote servers installed in Plovdiv Bulgaria – Plovdiv University. Another 5 remote DIPSEIL servers are installed in Europe with educational content and courses in UNED, Madrid Spain, TU-Graz, Austria, Grenoble, France, Cork Institute of Technology, Cork Ireland and TU-Sofia, Bulgaria.

DIPSEIL system was used for students training in the field of International Master Course in “Information and Communication Systems” which has been created using the educational content from five European Universities. At this moment in the system are loaded more than 35 educational courses in the field of Electronics Engineering, Informatics and Communication systems on 5 different languages.

VII. References

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