

# Instructional Design in the Vocational Training on “Computer Networking”

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**Abstract:** The educational approach is a three-step process implying a cognitive, a self-tooling and a customization phase which are based on the investigation of the community's educational needs. The paper details on the advantages of new techniques of e-Learning driven by BPMN (Business Process Modeling Notation) services. The implementation is oriented on training needs analysis and instructional design for vocational training of computer networks technicians and engineers. The BPEL approach is done on two platforms – VCP (Virtual Community Platform) and BizAgi (Business Agile programming), with emphasize on portability of the accomplished (educational) service logic based on XPDL (XML for Process Definition Language).

## I. INTRODUCTION

Nowadays the education process is considered to be more challenging, addressing towards industrial / economic / commercial sectors and communities, implying constraints imposed by the rapid change in technologies. The technical staff is required to adapt fast in the dynamic companies' working environment, to meet the qualification demands and to have business and communicational skills. The new life style of people - trying to expand their time resources - conducted to explosive development of e-Learning methods, which allow asynchronous learning, remote and even mobile. There were important e-Learning facilities (content and instruments) but less evaluation of the efficiency of learning in e-Frames.

That is why a group of institutions proposed to implement an innovative complete e-Learning evaluation methodology in the frame of the program Leonardo da Vinci - Transfer of Innovation, approved for financing under the name “Management and Assessment of Electronic Services for Technicians and Retailing Operations” with the acronym MAESTRO. The project is mainly addressed to enterprises connected to product marketing and support activities related to services and products. The coordinator of the project is the National Technical University of Athens, Greece, and among partners that have sustained the activities are the consultancy company for enterprise development Noema - Finland, the Swedish TelePedagogic Knowledge Center, “Transilvania” University from Brasov - Romania and the Institute for Parallel Processing of the Bulgarian Academy of Sciences.

The MAESTRO project aims to support new educational-Web 2.0 collaborative environments with online services dedicated to VET (Vocational Education and Training) and Product Management (mainly training services for new products and their support).

The online environment provides special interaction between trainers and trainees (in comparison with face-to-face training there are also some advantages of asynchronous, traceable and reconfigurable learning scenarios).

Multimedia content is used in order to increase the effectiveness of Computer/Web-Based Training (CBT/WBT). Online assessment modules are oriented towards various selling and support processes regarding new products and services (including computer networking – the object of the case-study). The learning platform includes the Learning Management System – LMS and the Learning Resource Center – LRC, with shared access to products / services in a controlled, role-based way. This allows users to undertake VET training on “individual learning paths” (guided or instructed by a computer) or as a part of a virtual VET class that should meet either synchronously or asynchronously (methods of Web 2.0 like Wiki and Blog should be used). A collaborative toolbox (VET-Wiki) supports the communication of trainers and trainees using Unified Communications and Collaboration Portals (Enterprise Product and Support Portals - EPSP).

The main objectives of the MAESTRO programme consist in:

- the identification of various models of learning-working of trainees-employees with a pertinent analysis of required skills and training needs;
- definition of characteristics of a virtual learning community by means of digital training services;
- validation of the self-learning methodology and evaluation of digital training services applied on several pilot projects.

The main activities are included in eight work-packages:

- WP 0 - Project management;
- WP I - State of the art analysis/ Self-learning Methodology/Training qualifications in IT and Support Services;
- WP II - User Requirements and Training Needs/ Creating Sales and Support profiles based on qualifications/Create employers' profiles involved in the selling sector;
- WP III - Development of Self Learning Methodology/ Development of a dynamic learning content generation environment/ Development of a learning support system;
- WP IV - System Design and Development/Design of the whole system/Development of all prototype modules and interfaces/Technical design and development of the multimedia and content tools software applications;

- WP V - Pilot Implementation/Apply system and methodologies to SMEs and Banks;
- WP VI - Evaluation/Assess the results and measure effectiveness/Evaluation of specific standards;
- WP VII - Dissemination, exploitation plan and demonstration.

The expected impact will be:

- Encouraging progress towards common European infrastructures and platforms for e-Learning;
- Assisting the ways to improve the competitiveness of Sales and Support services in European countries;
- Encouraging synergies within the SMEs actor groups as well as between the Commercial sector and educational foundations.

## II. RELATED WORK

The problem of designing and evaluating a customizable e-Learning system adapted to the needs of the trainee and to the requirements of the business process that it serves, has been addressed in different manners by the research community.

The authors of [1] use the concept of ontologies in order to define personalized learning web-based learning systems. In their opinion ontologies can be served as a structured knowledge representation scheme, which can assist the construction of personalized learning paths. Paper [2] analyses the impact of the e-learners' learning path and their learning style on their learning performance. The authors conclude that path-controlled learning methods perform significantly better than random ones and that sequential and iterative learning processes are better than free ones. Another approach focused on learning paths is presented in paper [3]. The authors have implemented an agent called Learning Assistant which is responsible for defining individual learning paths for pupils in e-learning environment. The Assistant is able to infer using metadata described pupils and didactic materials; this inference is a basis for building the individual learning path for each pupil.

The authors of paper [4] present an innovative technique for predicting in an early stage of the e-Learning process the achievements of the students involved in this process. Such a prediction technique allows the teachers to improve the efficiency of their courses by addressing specific needs of their students at an early stage.

In paper [5] the author has addressed the need of inserting learning objects into business processes. This integration has been performed using BPMN, by attaching metadata to learning objects and to business process tasks in an ontology-oriented manner. A similar approach is presented in paper [6] which describes a method for using ontologies in order to create collaborative business networks with the purpose of improving the efficiency and the competitiveness of the business process.

Another aspect which needs to be taken into account when performing a state of the art analysis in the field of e-

Learning systems is the one related to virtual communities and platforms that can be adapted to this domain.

The authors of [7] present a networked virtual community which uses a digital repository in order to distribute multimedia content among teachers and students. The authors of [8] present two platforms implemented in Germany and Switzerland, which are supporting virtual student communities.

## III. TRAINING NEEDS ANALYSIS FOR VET IN "COMPUTER NETWORKING"

The authors have analyzed and modeled the online training process for a network support technician / engineer. The first phase of the analysis consisted in a Training Needs Analysis (TNA) for people working in the field of Network Maintenance and Support. This was done by surveying the job offers in computer networking, as posted on the Internet by companies based in Romania and in other EU countries. As a result of the TNA, three levels of job profiles were identified, corresponding to three different levels of competencies and training. These 3 levels of job profiles are the following:

- Network technician: Medium level training (Level 1 - High School Diploma, level 5 from EQF – the European Qualifications Framework [9]);
- Network Engineer (Level 2- Bachelor's degree, level 6 from EQF);
- Senior Network Engineer / IT Integrator (Level 3 - Master degree, level 7 from EQF).

A summary of the technical skills required for each of these job profiles is presented in Table 1.

Once the TNA for a network technician / engineer has been concluded, the authors have moved to the next phase of their analysis of the training process for a network support employee. This second phase consisted in analyzing and modeling the process of network support.

Network level problems and faults should be reported by *customers* by means of *fault reports* or *helpdesk tickets*. In order to resolve the reported fault the system supplier needs to perform analyses and provide the adequate solution to the problem (within an agreed time).

The solution will be represented through a ticket response which should contain the corrective measures. In the future, one could easily extrapolate the systematic support (granted to the "customer") to collaborative volunteer support (granted to the "beneficiary") in *bi-directional vocational education*.

In order to differentiate the fault reports, one needs to assign a *priority* level to each report, according to a prioritization tree. Priorities are defined in agreement with the customer and specify the maximum processing time for a specific problem. Depending of the severity of the fault the technical priority (1-4) has to be assigned to all faults. The assignment of the technical priority has to be according to the following criteria:

- Priority 1: Major impairment of system availability;

- Priority 2: Faulty operation of system functions;
- Priority 3: Impaired use of system functions;
- Priority 4: Minor impairment and few disturbances.

The objective of the network troubleshooting process is to provide the customer with a ticket response (with or without correction). Depending of the status of the error report the validity of the ticket response is preliminary or final. As soon as the customer has tested the provided solution, it needs to insert its response as a customer ticket response (in the error report tool).

Requests can be managed and processed in a *layered* manner. The available *levels* of support could be classified in:

- **TAL1** (Technical Assistance Level 1): from a volunteer / from the proximity of the beneficiary;
- **TAL2**: from a team of volunteers / only with some connection costs but without significant travel costs;
- **TAL3**: from a consultant / with reasonable travel / connection costs;
- **TAL4**: from a dedicated team of professionals in consultancy / with important costs for connection-travel-expertise.

TABLE 1. JOB PROFILES FOR THE DOMAIN OF NETWORK MAINTENANCE AND SUPPORT

Network technician: Medium level training (Level 1 - High School Diploma - EQF level 5)	Network Engineer (Level 2- Bachelor's degree - EQF level 6)	Senior Network Engineer / IT Integrator (Level 3 - Master degree - EQF level 7)
<p>Technical skills and knowledge:</p> <ul style="list-style-type: none"> <li>- Capabilities and limitations of various computer systems, including local area networks (LAN) and wide area networks (WAN)</li> <li>- Ability to engineer raceways / cabling in an unobstructive, esthetic manner, for fiber optic and copper transports used in WANs and LANs</li> <li>- Ability to operate network certification/test equipment</li> <li>- Ability to operate a variety of standard office equipment including personal computers, printers, copiers, etc</li> <li>- Theory and practice of LAN/WAN administration</li> <li>- Basic understanding of LAN/WAN protocols</li> <li>- Basic knowledge regarding the principles of information systems design, especially related to multi-protocol, multi-platform client/server environments</li> <li>- Mastery of desktop operating systems (Microsoft Windows) and various software applications (Microsoft Office)</li> </ul>	<p>Technical skills and knowledge:</p> <ul style="list-style-type: none"> <li>- Demonstrated ability in configuring, troubleshooting, and repairing all networks including Microsoft (MS) networks and TCP/IP networking components such as Cisco routers and switches</li> <li>- Advanced understanding of LAN/WAN protocols: IEEE 802.3, Token Ring, IEEE 802.11, GPRS, xDSL, ATM, VPN, etc</li> <li>- Demonstrated experience in installing and service cable, optical and T1 networks as well as strong understanding of Ethernet, 802.11q how it functions and related equipment as well as wireless networking designed around 802.11a-b-g and securing these networks.</li> <li>- Advanced knowledge in LAN/WAN/ server administration</li> <li>- Comprehensive knowledge the OSI Model, Internet, HTTP, SMTP, POP, IMAP and related protocols.</li> <li>- Ability to operate network certification/test equipment</li> <li>- Advanced knowledge regarding the principles of information systems design, especially related to multi-protocol, multi-platform client/server environments</li> <li>- Familiarity with Linux</li> <li>- Comprehensive knowledge of TCP/IP including Firewall configuration and maintenance.</li> <li>- Mastery of desktop operating systems (Microsoft Windows), server operating systems and various software applications (Microsoft Office)</li> </ul>	<p>Technical skills and knowledge:</p> <ul style="list-style-type: none"> <li>- Excellent Cisco Switch, Router, VPN, firewall, and Load Balancing Equipment knowledge</li> <li>- Excellent understanding of LAN/WAN protocols: IEEE 802.3, Token Ring, IEEE 802.11, GPRS, xDSL, ATM, VPN, VoIP etc</li> <li>- Comprehensive knowledge the OSI Model, Internet, TCP/IP, HTTP, SMTP, POP, IMAP and related protocols</li> <li>- Advanced UNIX/Linux server experience</li> <li>- Advanced knowledge in project management</li> <li>- Advanced programming skills: C++, Java, Perl, PHP, .NET, etc.</li> <li>- Ability to develop and maintain software to aid in the testing of the network systems</li> <li>- In-depth routing protocols experience – BGP, OSPF, HSRP, VRRP, MPLS</li> <li>- Mastery of desktop operating systems (Microsoft Windows), server operating systems and various software applications (Microsoft Office)</li> <li>- Excellent data and network security knowledge and experience</li> <li>- Knowledge of IP-backbone architectures</li> <li>- General Know How of Mobile Networks (basic elements)</li> </ul>

#### IV. INSTRUCTIONAL DESIGN OF VET “NETWORKING” COURSES

This pilot implementation includes a simple *decisional scenario*, which selects the appropriate learning path for a person enrolled to vocational “Networking” courses. At first the person inputs the desired course and data about *prior certifications*. Depending on these inputs, he/she would be directed to a *starting quiz* with “radio buttons” (Fig. 1), that would direct either to a certain module of the course (e.g. “Cabling Networks” or “Routing and Packet Forwarding” in

the *Flowchart* of Fig. 2) depending on his/her *competence level* and *prior knowledge*, or to the final quiz (upper right flow in Fig. 2) which must be completed 100% correctly in order to *graduate*.

The instructional design was performed thanks to the access to dedicated servers provided by the company Swedish company VCP International.

The graphical elements (see the legend in the lower left corner) are typical to Business Process Management (BPMN) diagrams (BPD - Business Process Diagrams). BPDs are aimed to model complex business processes in an easy to use and understand manner.

### Courses

Which one of the following courses would you like to study?

☒ Cabling Networks  
☐ Routing and Packet Forwarding

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### Certifications

Please choose if you have one of the following certifications related to the course you wish to study.

☐ 49717 - Routing and Networking  
☒ 58240 - Cabling  
☐ None

**Submit**

BPMN is oriented on services. It provides a number of advantages to design business processes: a process flow modeling technique that is more conducive to the way business analysts work; its solid mathematical foundation is expressly designed to map to business execution languages. As it can be seen in Fig. 2, the flow-chart structure is event-driven. Processes are like (event-) interrupt service routines. They are represented like rectangles that indicate „tasks” – mostly activities performed by a person or user. User tasks can be represented by a screen in the GUI (Graphical User Interface) Web application and generally have some properties such as associated forms, duration, cost, assignment rules, alarms and actions, which can be executed on enter, on save or on exit from the activity etc.

## V. EDUCATIONAL SERVICES PORTABILITY

```

graph TD
    Start([Start]) --> IntroScreen[Introduction Screen]
    IntroScreen --> Intro[Introduction]
    Intro --> DecC1{dec c}
    DecC1 -- Y --> DecC2{dec c}
    DecC1 -- N --> DecC3{dec c}
    DecC2 -- Y --> SkipQuiz[skip first quiz]
    SkipQuiz --> FinalQuiz1[/final quiz/]
    FinalQuiz1 --> Finco1{finco}
    Finco1 -- Y --> True1[true]
    True1 --> End1[End]
    Finco1 -- N --> False1[false]
    False1 --> SubS1[sub s1]
    SubS1 --> SubS2[sub s2]
    SubS2 --> Finish1[finish1course]
    Finish1 --> FinalQuiz2[final quiz2]
    DecC2 -- 2 --> TakeQuiz[take quiz]
    TakeQuiz --> CablingQ[/Cabling Networking Q/]
    CablingQ --> Q11{q1-1}
    Q11 -- Y --> Q12{q1-2}
    Q11 -- N --> SubS1
    Q12 -- Y --> GoodPerf[good performance]
    GoodPerf --> FinalQuiz2
    Q12 -- N --> Q11Correct[q1-1 correct]
    Q11Correct --> SubS2
    DecC3 -- 2 --> DecC4{dec c}
    DecC4 -- Y --> GoodPerf2[good performance2]
    GoodPerf2 --> FinalQuiz3[/final quiz2/]
    FinalQuiz3 --> Finco2{finco}
    Finco2 -- Y --> True2[true1]
    True2 --> End2[End]
    Finco2 -- N --> False2[false1]
    False2 --> C2M1[c2_m1]
    C2M1 --> C2M2[c2_m2]
    C2M2 --> FinalQuiz4[final quiz2]
    DecC4 -- 2 --> RoutingF[/Routing and Packet F/]
    RoutingF --> Decro1{decro}
    Decro1 -- Y --> Decro2{decro}
    Decro1 -- N --> C2M1
    Decro2 -- Y --> FinalQuiz4
    Decro2 -- N --> C2M2
  
```

□ Screen    // Question    ◇ Decision  
 ▭ Sub-scenario    ▣ Exit point

**First Course(decisional part)**

**Second Course(decisional part)**

1087



c2\_m1

Created 15.12.2009 by Adrian NEDELCU

Description

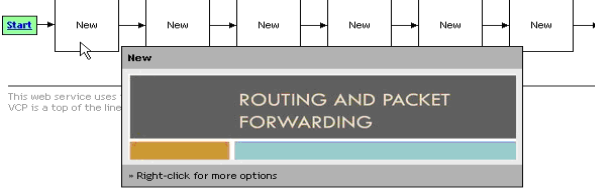
Flowchart

Size: Normal

Direction: Horizontal

Mouse-over: Preview

XPDF



c2\_m1

Created 15.12.2009

Description

Flowchart

Size: Normal

Direction: Horizontal

Mouse-over: Preview

XPDF

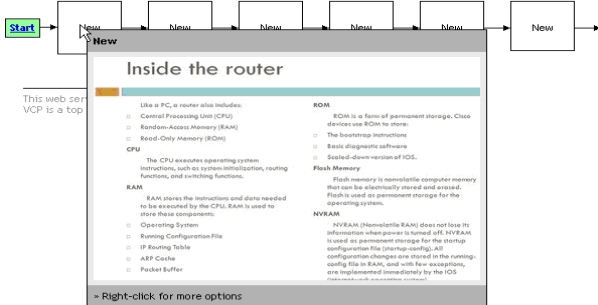


Fig. 3. Blocks of “c2\_m1” - course 2, module 1

## VI. CONCLUSIONS AND FURTHER DEVELOPMENT

The pilot implementation of VET based on Business Programming of services proved to be platform-independent. The focus was on decisional aspects of trainees' guidance in the LMS/LRC, “routing” them through individualized learning paths. The future development could take into consideration more key-point indicators [12] that are computed for semi-automated resource allocation and course-modules' aggregation based not only on prior certifications but also on credits and “vouchers” (paid fees or sustainable

financing schemes recorded at trainees' enrollment and flexible in time).

Another important option is the open-source business programming of these educational services. One of the options is “Intalio Designer” [13], built on top of the popular Eclipse platform. Intalio Server is a native BPEL 2.0 (Business Process Execution Language) process server based on the J2EE architecture and certified for a wide range of hardware platforms, operating systems, application servers, and database servers.

### Routing and Packet Forwarding quiz

1.

What is the usage of a router?

- ☒ It connects a network to another network
- ☐ It connects two switches
- ☐ Receives a signal and sends it over all ports
- ☐ Segments a network into multiple collision domains

2.

Which of the following matches a router component with its function?

- ☐ FLASH - stores the bootstrap program
- ☐ ROM - stores the startup configuration file
- ☐ NVRAM - stores the running configuration
- ☒ RAM - stores the instructions and data needed to be executed by the CPU

3.

How can a router determine the best path to forward a packet?

- ☐ By encapsulating the packet
- ☒ Using the routing table
- ☐ Using ARP
- ☐ None of the above

4.

Which two commands can a technician use to determine if router serial ports have IP addresses that are assigned to them?

- ☐ Show ip config
- ☐ Show ip config
- ☒ Show interfaces

### Cabling Networking Quiz

1.

When is a straight-through cable used in networking?

- ☐ When connecting a router through the console port
- ☐ When connecting one switch to another switch
- ☒ When connecting a host to a switch
- ☐ When connecting a router to another router

2.

Which UTP cable lengths are specified by ANSI/TIA/EIA568-3 standards?

- ☐ horizontal channel maximum of 20 meters up to 10 meters total end-to-end length
- ☒ horizontal channel maximum of 10 meters and total end-to-end length up to 100 meters
- ☐ up to 10 meters for interconnecting patch panel
- ☐ up to 10 meters for connecting individual devices to wall jacks

3.

Backbone cabling refers to:

- ☐ connect the telecommunication room to a LAN
- ☐ connect a router to a router
- ☒ connect the telecommunication room to the equipment room

4.

What devices are used to interconnect networks?

- ☐ hosts
- ☐ switches
- ☒ routers
- ☐ hubs



### final quiz

1.  
Which are the devices that have the ability to break up broadcast and collision domains ?  
☐ Switches  
☐ Hubs  
☒ Routers  
☐ All the above
2.  
What kind of interfaces can routers have to connect to a network ?  
☐ LAN  
☐ WAN  
☒ both
3.  
What kind of device is used to segment a network into multiple collision domains ?  
☐ a router thus increasing performance  
☒ a switch thus creating a point-to-point logical topology on each port  
☐ a hub thus reducing cost  
☐ a router thus creating a point-to-point logical topology on one port

Fig. 4. The “Cabling Networks” and “Routing and Packet Forwarding” quiz.  
The Final Quiz that must be passed for graduation

```

1409 <Documentation>Condition: Reply in scenario "Networking", Question "4." is "routers"
1411 <ExtendedAttributes>
1413   <ExtendedAttribute type="link" Name="UnitURL"
1414     Value="http://maestro.euprojects.org/services/Scenario/unit_show.cfm?UnitID=1410" />
1421 </ExtendedAttributes>
1427 <NodeGraphicsInfos>
1429   <NodeGraphicsInfo ToolId="VCP"
1431     Height="40" Width="60"
1433   >
1435     <Coordinates
1437       XCoordinate="720" YCoordinate="630"
1439     />
1441   </NodeGraphicsInfo>
1443 </NodeGraphicsInfos>
1445 <IsForCompensationSpecified>false</IsForCompensationSpecified>
1447 </Activity>

```

Fig. 5. Fragment of the XPDL file that makes the educational service portable to other platforms

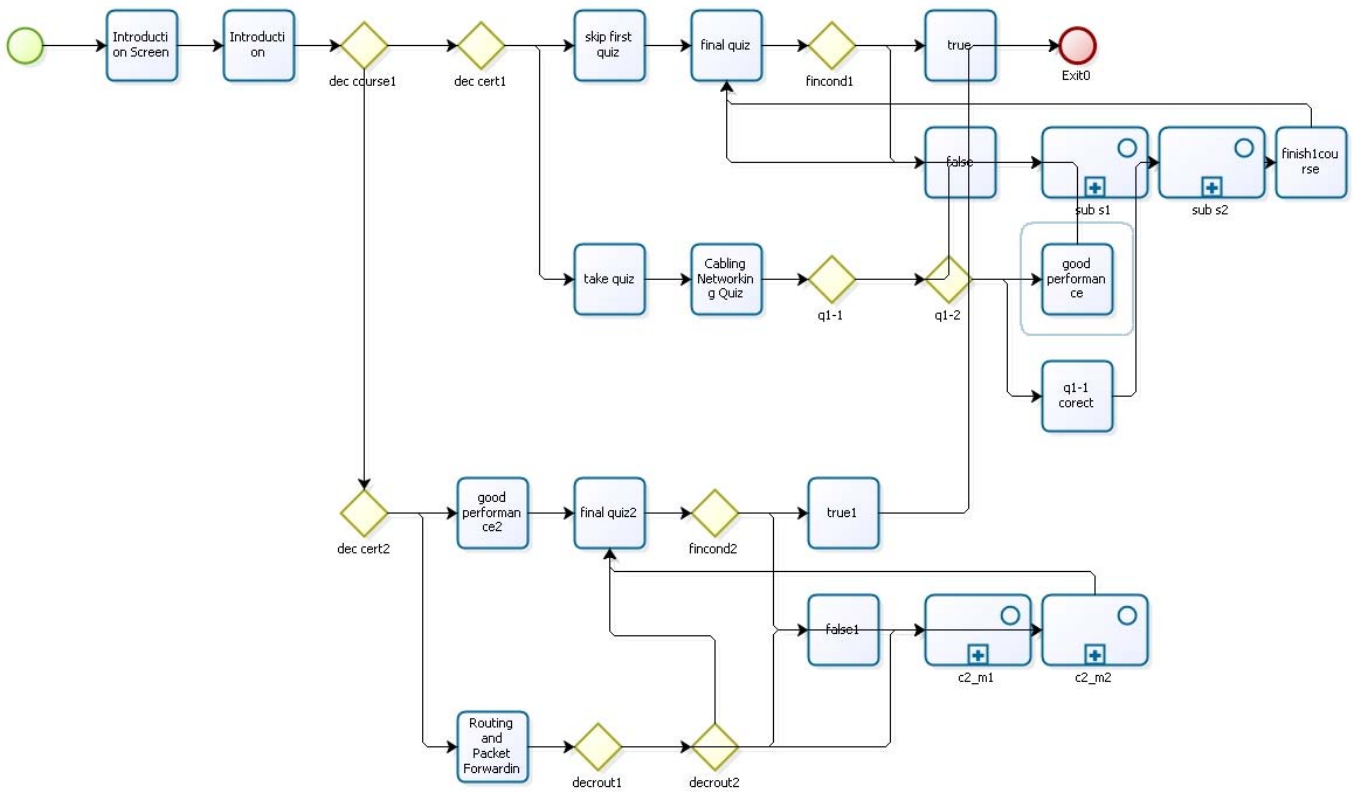


Fig. 6. The educational service logic imported on the BizAgi platform

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