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Exchange Communication Point Modeling in the context of the Enterprise Architecture

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Abstract

It is important to understand the performance and operation of an Internet Exchange Point to improve the management, and to reduce the cost associated with implementation and the information shared. Enterprise Architecture supports the design of systems, according to the business domain processes, network infrastructure and all the different applications running. Existing Enterprise Architecture modelling languages only provide a general concept of a network and do not represent specific information such as the protocols used, the internet protocols or the network addresses used for sharing information. This paper proposes a set of new concepts and attributes to the technology layer of reference language (ArchiMate) to enhance the representation and management of the network infrastructure. The ArchiMate language extensions are then used in modelling two Case Studies of Internet Exchange Point implementation in the Portuguese Public Administration. It was possible to compute which services will have impact in case of failure.

Keywords: *(Internet Exchange Point; Enterprise Architecture; ArchiMate; Meta-Modelling; Modelling Extension)*

1. Introduction

The content has developed gradually over the years from a static text web-page to an interactive web-pages with high definition multimedia requiring a very high bandwidth for processing and transmitting. With the constant evolution in internet, the organisation wants a different solution to exchange information, without the help of intermediary operators to provide the various service to avoid the expensive services and higher latency in the packages delivered as the data packages has to pass through several networks before it reaches its destination. This situation made companies to have a single point where all the members can connect according to the rules and protocols established within themselves. The concept of connecting and establishing a relation between a set of Internet Service Providers (ISPs), university, content providers, and other types of companies to share information from a physical point is called Internet Exchange Point (IXP). An IXP provides an infrastructure where any organisational member can connect and share information to reduce the interconnection cost and expand the access network (Soobron, Soobron, Soobron, Sukhoo, & Haw Hawabhay, 2014). One of the main requirements in the design, implementation and operation of computing infrastructure such as IXP is the information distribution model (Ghijsen, Van Der Ham, Grosso, & De Laat, 2012), which is capable of capturing the requirements of physical infrastructure and split up the information of the application from the operating systems. The main advantage of this kind of information model is being able to represent how these different types of data and objects can relate to each other in a single consistent way without being influenced by the proficiency of repository (Cisco, 2018). There are number of Enterprise Architecture (EA) frameworks (such as Zachman, TO-GAF and etc) existing today which is used for representing and modelling the information. Due to the complexity of how the information systems are interconnected and constant evolution of different technologies, there is always a need for constant update in EA frameworks to catch up with the trend. In order to do so, the organisation has to resort to the addition of extensions to achieve their scopes.

1.1. Problem of Study

This section presents the problems associated with the deployment of this research. To proceed with the implementation of the IXP in ArchiMate, it is necessary to verify all the domains for the representation. To address the challenges imposed on this work, it is important to comprehend if it is possible to implement the IXP in an EA framework using a given sets of information. Hence, this work will lay out and construct the concepts in ArchiMate to formulate and frame the specialisation of all these concepts, and then deploy the chosen specialisation of the concepts to the framework.

In order to specialise these concepts, this research addresses the following topics:

- Identifying the concepts presented in EA in order to understand which attributes exist and which ones can be added?
- How to add these new attributes to an existing EA?
- How the exiting meta-models can be updated with new attributes, without corrupting the integrity of the EA?
- How to maintain the consistency of the meta-models of modelling language?

1.2. Goals and Contribution

The nature and purpose of this work is to find a way to improve the meta-model of the EA modelling language to implement IXP in an abstract way and help in the future implementations of network. Implementing the IXP in EA can allow the alignment between business strategies and the network provider. It also allows the communication between the different aspects of an organisation, from business process to the applications that support its and the technologies behind these services. The main contributions of this work are:

- Adopting the selected EA ArchiMate modelling language and improve the modelling of network by adding new elements to the language.
- Designing and adding the following new elements and his attributes for the technology layer of ArchiMate.
    - Router- Adding as attributes name, IP address.
    - Switch- Adding as attributes name, MAC address.
    - Interface Router- Adding as attribute name, system table, protocol.
    - Interface Switch - Adding as attribute, name, system table, protocol.
    - Routing Table - Adding as attribute, name, a table with all the information for send a packet to the destination.
- Implementation of new meta-model and optimisation of the exiting meta-model for modelling language, ArchiMate.

1.3. Research Methodology

The objective of this project is do the modelling of elements in IXP by going through a set of steps, from the survey of the elements in existing EA to the addition of new elements, and to the implementation and evaluation of the final solution. The approach applied to this work is Design Science Research Methodology (DSRM), which focuses on the production of artifacts from a set of problems to implement the solution. There are six phases of DSRM according to Peffers, Tuunanem, Rothenberger, & Chatterjee (2007):

- Phase 1 - Identification of Problem and Motivation: This phase identifies the problem of investigation and proposed the solution to solve the problem described in this subsection 1.2.
- Phase 2 - Definition of objectives for the solution: Phase 2 is to identify the necessary requirements that should be followed to achieve the desired solution. It presents the proof of the concept of the main solution IXP with insights from the state-of-art IXP in the world. To complement the implementation of this work, it also explains the concepts of EA and the modelling language. This phase is described in section 2.
- Phase 3 - Design and develop the artifacts: In phase 3, the solution is proposed and implemented to solve the problems defined in phase 1. For this work, the solution is proposed in section 3 and the implementation in section 4. In section 3 it presents the list of

the attributes added and the new meta-model with the new attributes. In section 4 it describes how the new elements was added to the tool Archi.

- Phase 4 – Demonstration: This phase is the demonstration of the proposed solution described in section 3.
- Phase 5 – Evaluation: In this phase, the evaluation of the solution implemented for assurance. The evaluation methodology for this work is described in, section 5. It shows the implementation of the IXP in the ArchiMate with the new elements and cases used for verifying the importance of modelling an IXP in modelling language.
- Phase 6 – Conclusion: This phase draws conclusion of the solution implemented as well as describes the results obtained, as shown in section 6.

2. BACKGROUND

2.1. Internet Exchange Point

IXP provides an infrastructure to support the connection between several Autonomous Systems (AS) administrated by ISPs, where they can share information according to the rules and protocols established between them (PacketCH, 2019). The AS interconnected to exchange points can share information by doing multilateral peering with all the members in connection, which typically is a router server that allows any member to use the Border Gateway Protocol (BGP) for receiving the information about the route's destinations in the connection. Also, it can establish bilateral peering to share information directly with each other. Figure 1 shows the architecture of IXP. The central point of IXP is a switch which functions as a database and connects all the different AS of different organisations. This makes the switch a focal point for exchanging all the traffic. The different members can share information between them using Layer 2 as in Virtual Layer Access Network (VLAN) Ethernet or Layer 3. For example, in Figure 1, if an organisation from AS 50 wants to have a private connection or a shared connection with other members, it has to fulfil all the rules established by the members of IXP and then they can proceed peering to the switch or with any other member.

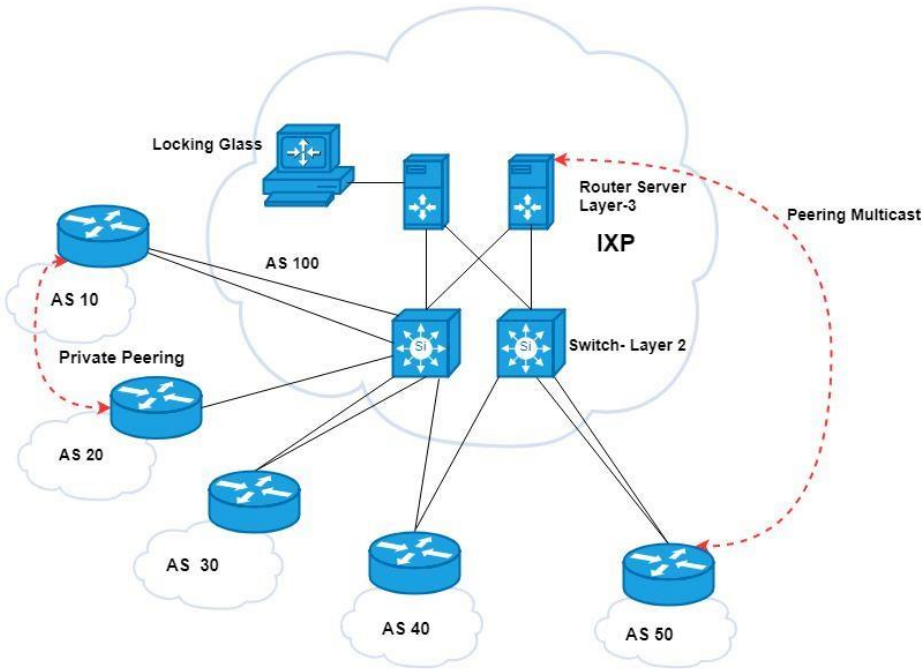

Figure 1 Architecture of Internet Exchange Point (Brito, Santos, Fontes, Perez, & Rothenberg, 2015).

There are several projects of IXP implemented in different parts of world. However, in this article it will only specify some of the most successful IXP, such as Deutscher Commercial Internet Exchange (DE-CIX) in Frankfurt, Amsterdam Internet Exchange (AMS-IX) in Amsterdam, London Internet Exchange (LINX) in London and the Gigabit Portuguese Internet eXchange (GigaPIX) in Portugal. The biggest IXP in the world was implemented in the year 1990 in Amsterdam, Holland for a non-profit purpose called AMS-IX. Currently, there are more than 750 networks connected to AMS-IX, such as content providers, television broadcasters, game companies and other types of networks. The DE-CIX in Frankfurt was implemented in the year of 1995 providing an infrastructure capable of connecting various types of ISPs like content providers, bandwidth content and other types of services (DE-CIX Management, 2019).

Nowadays, it has more than 800 clients in more than 60 countries including Frankfurt, Hamburg, Munich, Dusseldorf, Palermo, Marseilles, Madrid, Istanbul, Dubai, New York and Dallas. The LINX in London has more than 600 members connected to it, in more than 66 different countries.

In Portugal, the most successful IXP is called GigaPIX that connects most of the major telecommunication companies and some of the universities, which leads to a total number of 25 members connecting to it. The members are organisations such as Vodafone, NOS communication, *Serviços de Comunicações e Multimedia (MEO), Acesso e Redes de Telecomunicacões, S.A. (AR Telecom),* Network Telecommunication, Internet technologies in Angola and others. GigaPIX has access points in Porto and Lisbon in Portugal. Currently, there is also another IXP being developed in Portugal by Agency for Administrative Modernisation (AMA) and *Entidade de Serviços Partilhados da Administração Publica (ESPAP)* denominated *as Rede Operacional de Serviços Partilhados TIC (rSPtic)*, which will connect most of the public services, Ministry of Education, Ministry of Finance, Ministry of Culture, Ministry of Economy, Ministry of Science and higher superior and others organisation.

2.2. Enterprise Architecture

According to Lankhorst (2005), an EA is a group of principles, methods and models that are used for the conception and realisation of an organisational structure of a company in their process of business, information systems and infrastructure. This allows to capture the requirements of an organisation, which will be used to model the process of technological structure and the business process of an organization.

2.3. Enterprise Modelling Language

There are several frameworks used for modelling the principles, business, terminologies and processes of an organisation. The language that will be used throughout this work is the ArchiMate notation because it is a simple modelling language, where the concepts are well structured. It allows the integration of new concepts, without changing the architecture semantics and is also a widely used framework to design the business structures of a certain organisation. ArchiMate is an open and independent EA modelling language to describe, analyse and visualise the relationships between architecture domains. The ArchiMate language allows representing the relation and dependency of an EA in a simplest way to integrate the process of an organisation. It also provides possibility of adding new concepts on an existing concept or the specialisation of the existing concepts. The ArchiMate core language is divided in three layers: business, application and technology which specific the generic elements and their relationship.

2.4. Language Extension Mechanism

The extension mechanism refers to the concept of adding more elements to the modelling language without damaging the semantic of the framework. According to the techniques of Unified Modelling Language (UML) of adding extensions, it can be described into heavyweight and lightweight ways. The heavyweight is implemented through the mechanisms of Meta Object Facility (MOF), which allows to use meta-models of the modelling framework. This way of adding the extension allows modification in existing meta-models and to create new meta-models without any restriction. The method heavyweight is more flexible, allowing the alteration of the concepts without any restriction which can affect the standardisation of the EA. The method of adding an extension in the lightweight does not allow the modification on the existent meta-models, however, it will allow adapting them

(Hadj Kacem, Hadj Kacem, Jmaiel, & Drira, 2006), which will lead to so-called profile. The method lightweight is more restricted to the changes in the EA, the user can change the meta-models according to their necessity but maintaining the standardisation of meta-models (Pena & Villalobos, 2010). In this project the modelling language used for the development of the proposed solution is ArchiMate. There are two ways of adding concepts in ArchiMate (The Open Group Standard, 2017):

- Adding attributes to the elements and relationships: This method of adding elements is implemented by the addition of profiles. A profile is a structure of data that can be defined apart from the modelling language and can be integrated with the concepts and the relation of modelling language, ArchiMate. The profiles allows to redefine a language in a strict way without contradicting the semantics of the framework (Chiprianov, Kermarrec, & Rouvrais, 2011).
- Specialisation of the existing elements and relations: It is a powerful way of adding new attributes to the elements that are already on the framework. If an existing element is not able to represent the process that you want to design, you can create a subset of the existing ones with new attributes.

2.5. Proposed Extension in Enterprise Architecture

Fajjari, Ayari, & Pujolle (2010) proposed a Virtual Network Specification (VN-SLA) based scheme of Extensible Markup Language (XML) to abstract the proprieties and relation of components in a network. The VN-SLA focuses on three distinct concepts, Party, Network Specification and Obligation. Party describes the parties involved in the installation of a virtual network which includes the parameters, Infrastructure Provider (InP), Virtual Network Provider (VPN) and clients. It is also possible to define which are the parties that will be the provider or consumer of resources. Network Specification describes the components of a virtual network, the association between them and the Service Level Specification (SLS) agreed by them. A SLS defines the application requirements. As for example, end-to-end delay, drop probability, latency and multi path bandwidth. The obligation defines the responsibility in terms of guarantees and penalties of the parties involved. This principle also verifies if the services levels are guaranteed by the supplier or not, and to charge the entities involved if it does not verify. VN-SLA scheme specifies the resources associated with the virtual network, maintaining control over the defined agreements and relations between the various participants who are interconnected in a network. This paper focuses on the concept of virtualisation, where the application is separated from operational systems and it is implemented based on the language of the XML.

Chiprianov, Alloush, Kermarrec, & Rouvrais (2011) proposed a Telecom ArchiMate profile relying on a Meta-modelling approach. This method enables the addition of the profiles in two ways by adding new attributes to the concepts of ArchiMate or by specialising the concepts that are already existing. The solution of Meta Modelling approach allows the use of the framework like Eclipse Modelling Framework (EMF) and Xpand to produce language specific tools such as graphical editor and code generation. The proposed solution is based on the specialisation of the concepts from the technology layer of ArchiMate using as example the Core Network Subsystem. It was modelled for an audio conference at organisation, it shows how to participate in an audio conference and the network who supports this design. This solution allows adding of new elements without changing the semantics of the others element. The fact that this solution was developed to alter the technological layer, its emphasis more with the requirements of this work.

Hilliard, Malavolta, Muccini, & Pelliccione (2010) proposed the MEGa-modeling Architecture Frameworks (Megaf) which is a framework to implement EA. The solution Megaf was implemented based on models of mega-modelling techniques to promote the use of each element of a business architecture or the addition of the new elements. It considers the views, viewpoints, stakeholders and system concerning the first elements of the class mega-model, which will allow the software engineer to define how to combine the elements or save it to produce the EA according to their expectations. The implementation of this solution was implemented based on the Eclipse plugin. Megaf reinforces the possibility of improving an EA which can meet the requirements of a specific organisation. Although this solution reinforces the relationship between a set of elements representing the modulation by adding new attributes or new rules, however they do not maintain the semantics of the architecture that is being changed.

Quartel, Engelsman, Jokers, & Van Sinderen (2009) proposed an extension that can be used in conjunction with ArchiMate called ARMOR. It implements a solution for modelling the goals, motivation and requirements of an EA and it can also be used in conjunction with others EA. This method extends the modulation of structure on ArchiMate by focusing on the concept of motivation from the point of view of the various companies, such as objectives and their intentions. In order to achieve this goal, it uses three concepts: Stakeholder domain, Principles domain, and Requirements domain. Stakeholder domain focuses on the interests of the companies including their concerns and evaluation of them. Principles domain identifies whether there is a need to define new strategies, missions, principles, and guidelines; however, it does not know how to implement it. The Requirements domain models the goals, requirement and the expectation that may difficult the design of an EA. They proposed an extension which can be used in conjunction with the ArchiMate in order to improve its objectives in relation to the concerns of a particular entity. The concepts of ARMOR cannot be expressed as new attribute or restriction for the different layers of the ArchiMate. This solution does not use the concept of adding the profiles whereby it does not allow the modification of concepts that already exist, and the main focus of this solution is the business layer.

3. PROPOSED SOLUTION

The purpose of this work is addition of new concepts to the modelling language ArchiMate through the specialisation of concepts to be able to model the IXP into more detailed way or other types of network provider. In our approach, the specialisation mechanism was used to add new concepts and attributes.

The motivation behind choosing of the ArchiMate for modelling the IXP was because it provides concepts for expresses, design and validates the different aspects of an EA such as the business process, the applications for these processes and the network infrastructure supporting these applications. It also has a powerful way to add new attributes to the existing concepts and relation, through the method of specialisation or adding profiles without modifying the syntax or semantics of the modelling language. It reduces the complexity and proposes a model for a better understanding of enterprise, the interconnections and inter-dependency between the processes, people, information and the EA systems (Feltus, HA Propor, & Haki, 2018).

3.1. New Meta-Model for ArchiMate

After validating the existing concepts, it is possible to conclude which concepts to add in the ArchiMate for modelling an IXP. The concepts added to this project are router, switch, interface switch, interface router and routing table as shown in the Figure 2. Figure 2 represents the meta-model of the technology layer of ArchiMate with the new elements proposed for this work.

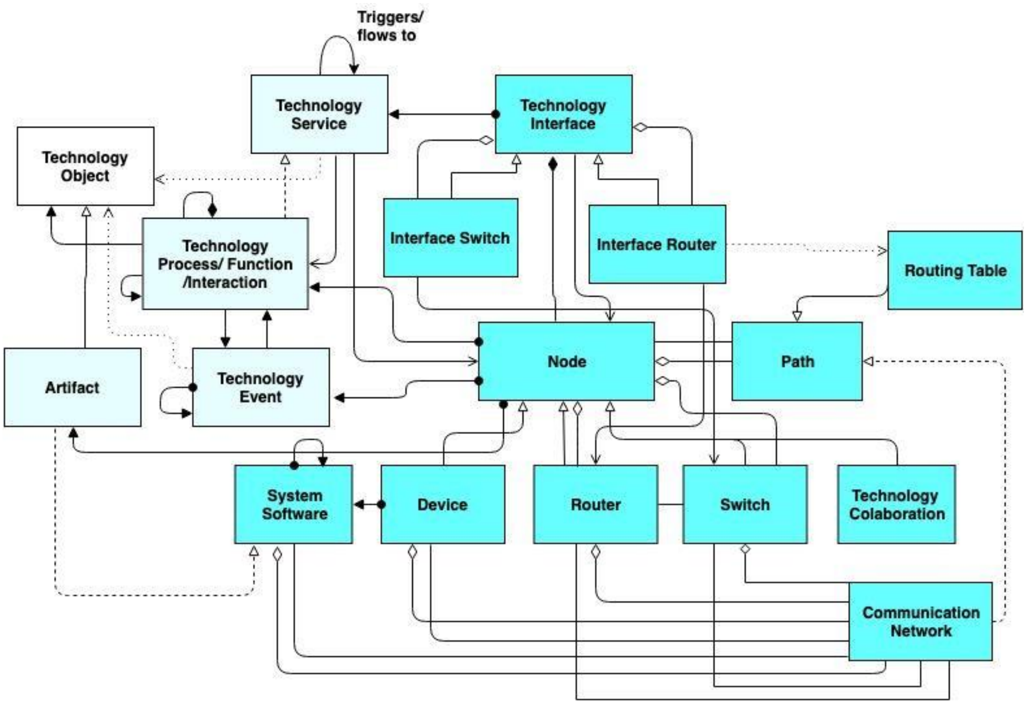

Figure 2 New proposed ArchiMate Technology model.

The router was added because just with element node it is not possible to identify the IP address of the devices. The switch was added because the element node cannot identify which MAC address is used for identifying the devices of different organisations. The element interface was added because with element infrastructure interface it is impossible to represent the active interfaces and the name of the protocol used for exchanging packets. The routing Table was added because with element path it is not possible to represent the list of routes and the IP address for where the router must send the packets over the network. The addition of these attributes will distinguish the different AS, the IP addresses used to identify the equipment, and the information used for exchange between the organisation to connect to the IXP.

Figure 3 is a detailed meta-model of the proposed concepts and how the elements are connected to each other also to show the relationship between the three layers of the ArchiMate core language.

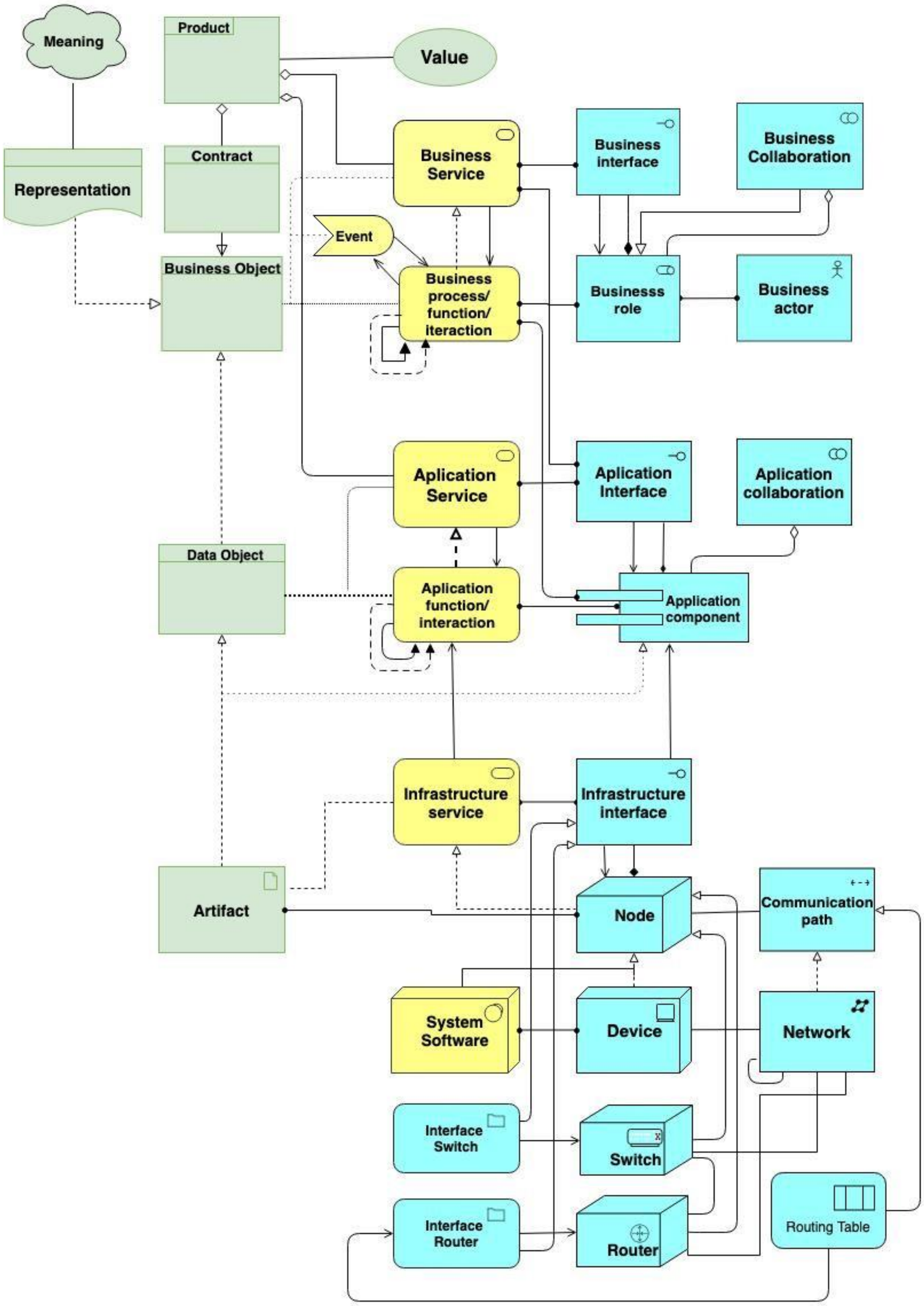

Figure 3 New Proposed ArchiMate Meta-Model.

4. IMPLEMENTATION

The deployment of the solution was done in Archi (Phillip Beauvoir, 2013) tool for creating ArchiMate models. This tool was developed as Eclipse plugin. The plugin of the program is available in the Git repository. Git is a distributed version control system for tracking changes in a source code during the software development. Archi was built upon the Remote Procedure Call (RCP) version 4.7 (Oxygen) and to implement any solution in Archi, you must configure your implementation platform. The version of Archi used for the implementation is 4.0 which support the ArchiMate 3.0. The addition of new elements was done with the help of a document from the Archi web site (Archi, 2016).

The list bellow shows the elements added, the designation, and their attributes.

- Router:
    - Name: Name of the corresponding interface.
    - IP Address: The identification of the router that will be used in the network for exchanging packets.

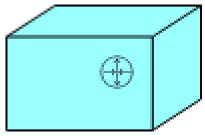

Figure 4 Router Notation.

- Switch
    - Name: Name of the switch interface.
    - MAC Address: The corresponding identification of switch interface.

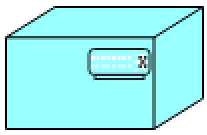

Figure 5 Switch Notation.

- Interface Switch
    - Name: Name of the system that are represented.
    - System Table: Name of all interfaces and their respective MAC addresses.
    - Protocol: Name of the respective protocol used for the interchanging packets.

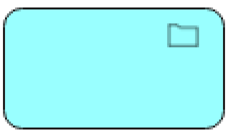

Figure 6 Interface Switch Notation.

- Interface Router
  - Name: Name of the system that are represent.
  - System Table: Name of all interfaces and their respective IP.
  - Protocol: Name of the respective protocol used for the interchanging packets.

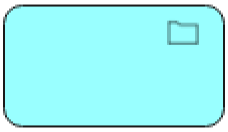

Figure 7 Interface Router Notation.

- Routing Table
  - Name: Name of the corresponding Interface.
  - Routes: Information about the destinations of packets to be sent, information about the gateway, net mask, IP destination and the Interface.

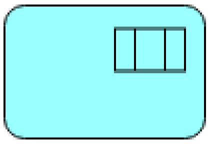

Figure 8 Routing Table Notation.

5. Evaluation

For the evaluation, an IXP was modelled in the Archi with the new elements added. Also, two cases of a process operated over the IXP was modelled for checking the alignment between the different domains in the proposed model. Figure 9 represents the IXP Portuguese implemented in Archi with new elements added. The design shows four organisations who wants to connect to the IXP such as University of Lisbon, Ministry of Finance, Ministry of Labour, Solidarity and Social Security and Ministry of Justice. The switch is where all the information exchange will go through. The element router is representation of each organisation.

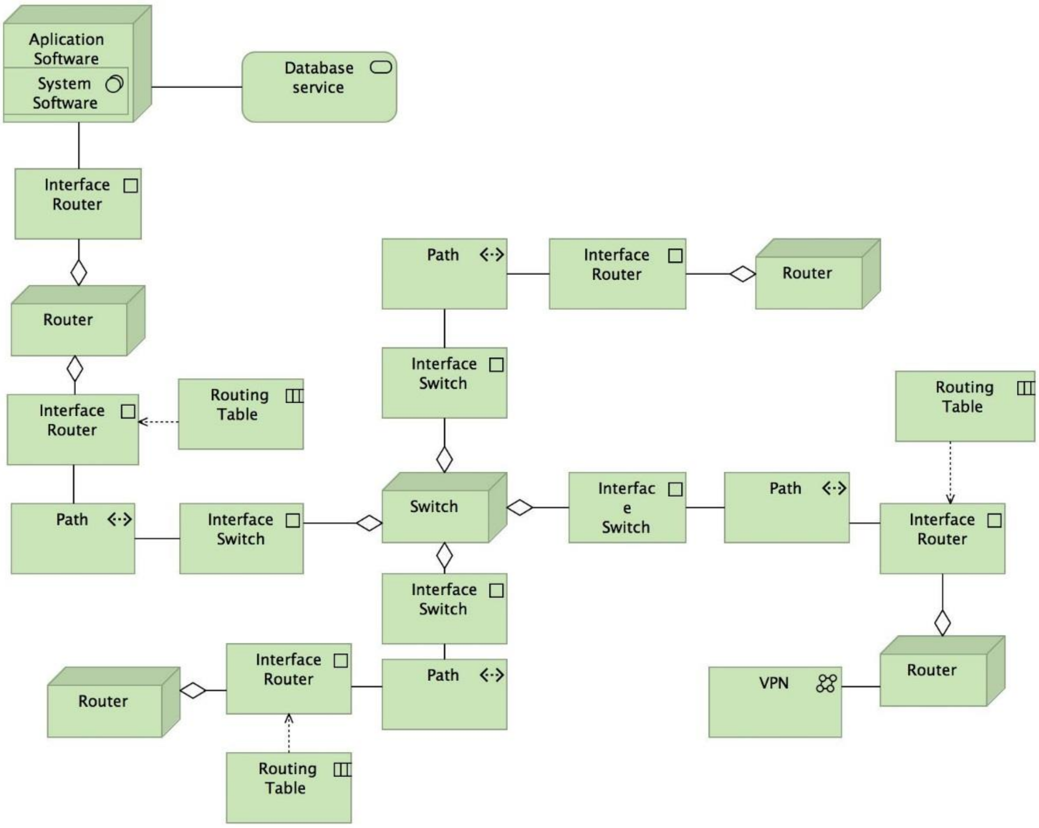

Figure 9 Infrastructure of an IXP model in Archi.

5.1. Case 1

This case shows what could happen to a process of giving a scholarship in University if somethings fails in the network. If a student get access to study in university but he does not have conditions to pay the school, he/she can ask for a scholarship in his University. This process has to be repeated every year when the school starts according to the student's progress. If a student request for a scholarship the following steps would be carried out:

- The student must be registered in the University for the current year that he/she is applying for a scholarship.
- He/she has to have a document from Ministry of Finances that proves his/her economics status and deliver the documents to the University.
- After the University checks the veracity of the documents, it will grant the scholarship or declined it.

Figure 10 is the modelling process for asking scholarship in the University. As you can see it is possible to model all the processes from the infrastructure who support the application until the business process who support this case. For example, if the University asks information from the

Finances Ministry to check the economics status of a student and if there is a latency on the network or if the network fails, this can affect the business process of the University. By doing this model, it is possible to foresee which processes will be affected when there is a change in the network and how much will this change cost.

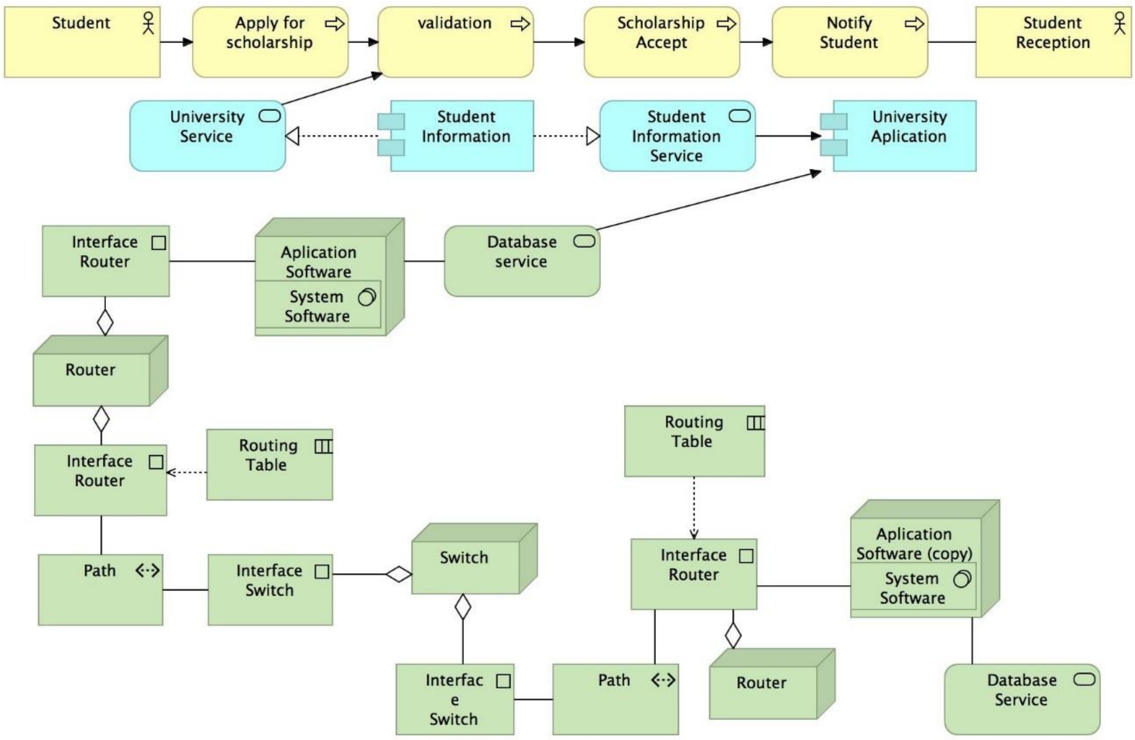

Figure 10 The model of case 1 in Archi.

5.2. *Case 2*

This case shows what are the processes to access a criminal record if someone from social security wants to check the information for a specific person to know if this person can adopt a child or not. This information will decide whether the person will be accepted to adopt a child or not by the Ministry of Labour, Solidarity and Social Security. The process for checking the information will have the following steps:

- The Ministry of Labour, Solidarity and Social Security will request Ministry of Justice to have access to the information.
- The Ministry of Justice will check if the person asking for that information has permission to access it.
- Then it will check the information inside a database with the current data from the user.

- Next it will generate a certificate about the person that they are asking.
- If the certificate contains any criminal record about the person, the process of adoption will be rejected otherwise it will be accepted.

Figure 11 is the model of a process the Ministry of Labour, Solidarity and Social Security for checking the criminal record of a person who requested for a child adoption. This is a critical process where if something happens in the network or if there is a delay in the information, it will affect a business process which will not be available to the applicants. This could delay the process for the adoption of a child. In this model it was possible to align all the processes from the technology infrastructure until the business process for getting the criminal record and acceptance for a child adoption process.

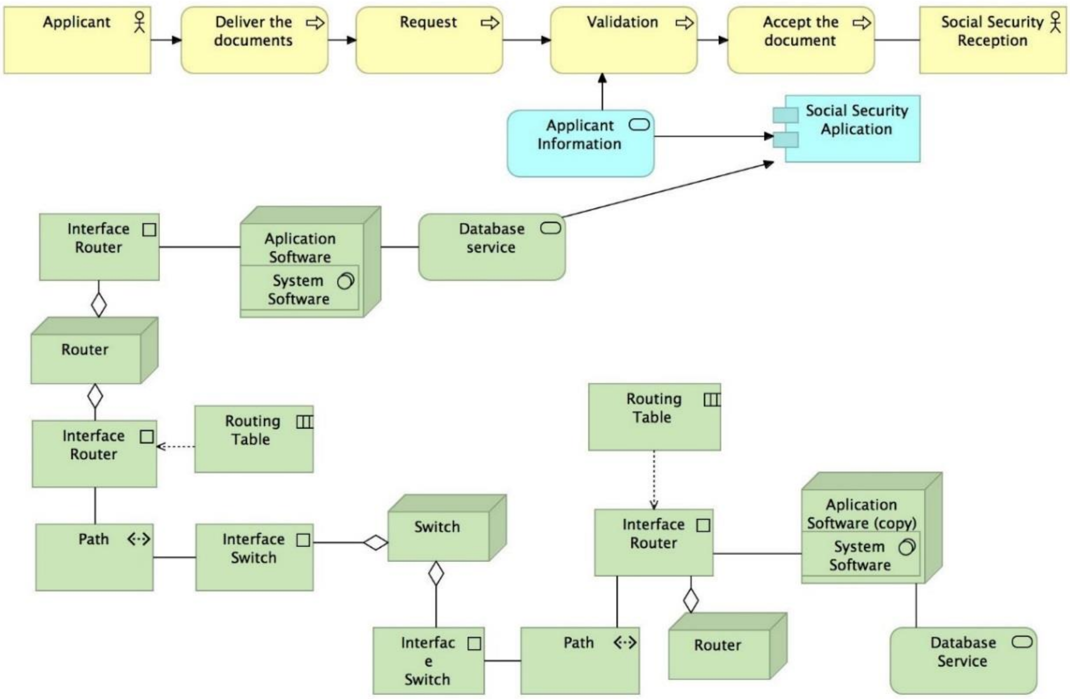

Figure 11 The model of case 2 in Archi.

5.3. *Results Analysis*

After the evaluation, it was identified that now it is possible to align the business process with the technology infrastructure. From the model proposed it is possible to see if an element of technology infrastructure is changed or removed, how it impacts the processes in business domain. For instance, if a link fails during the criminal record verification of someone or if the information has some latency it could lead to the wrong conclusion. As an example, if the router fails during the process of checking the record, the application of social security will no longer work and the process for the adoption will no longer be available to the applicants. The reds ones in the Figure 12 is the service that is going to be affected if the routes in the routing table is not working.

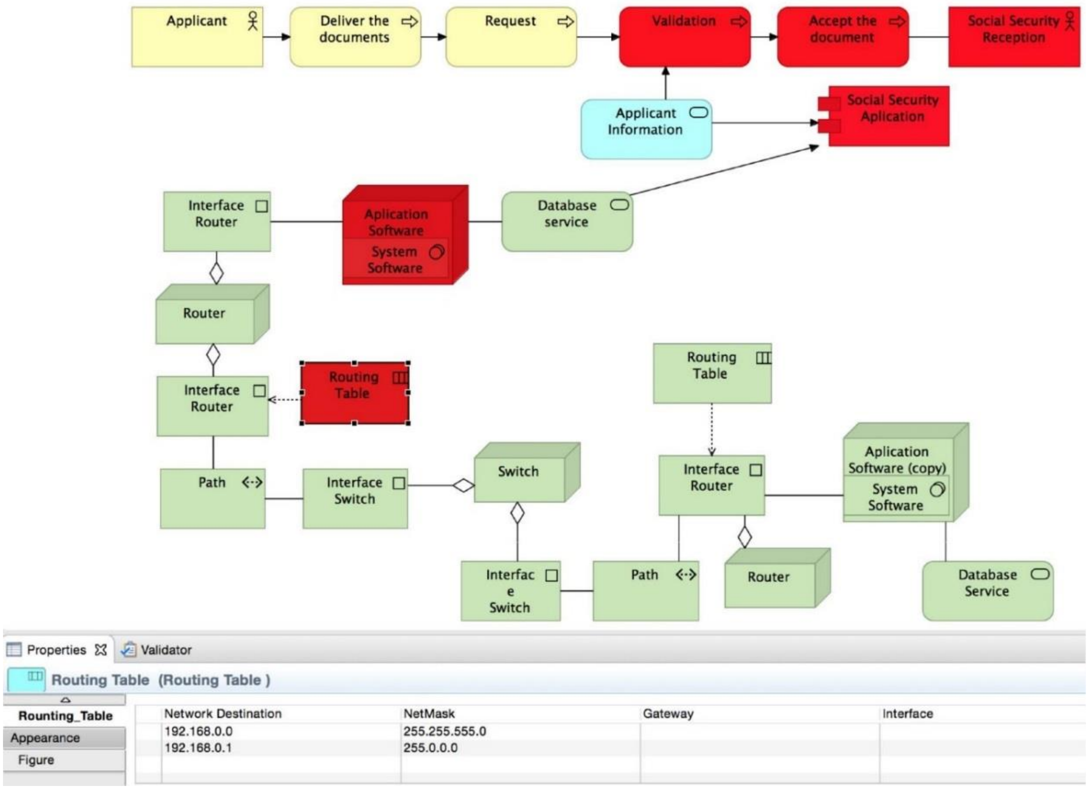

Figure 12 Example of the impact in the process of adoption when the route fails or change.

In the process for the attribution of scholarship, if one of the routes in the routing table of Ministry of Finances fails, it could delay the process of the attribution of the scholarship. If the routes fail, it is possible to compute which applications can no longer run, and what services can no longer be offered to the students. The process that can be affected are university application, the student information, validation, scholarship accept, student reception.

Figure 13 is an example of the process that could not be available if the routes in the routing table changes during the connection between the University and Ministry of Finances. The red ones are the list of elements that will be affect by this change.

With the model before the addition of new concepts it was not possible to show what processes will be affected if the routes changes in the routing table and the elements of network provider supporting the different elements. With this model the organisation can see how critical a failure in the hardware can be and how robust the infrastructure should be to adapt these changes.

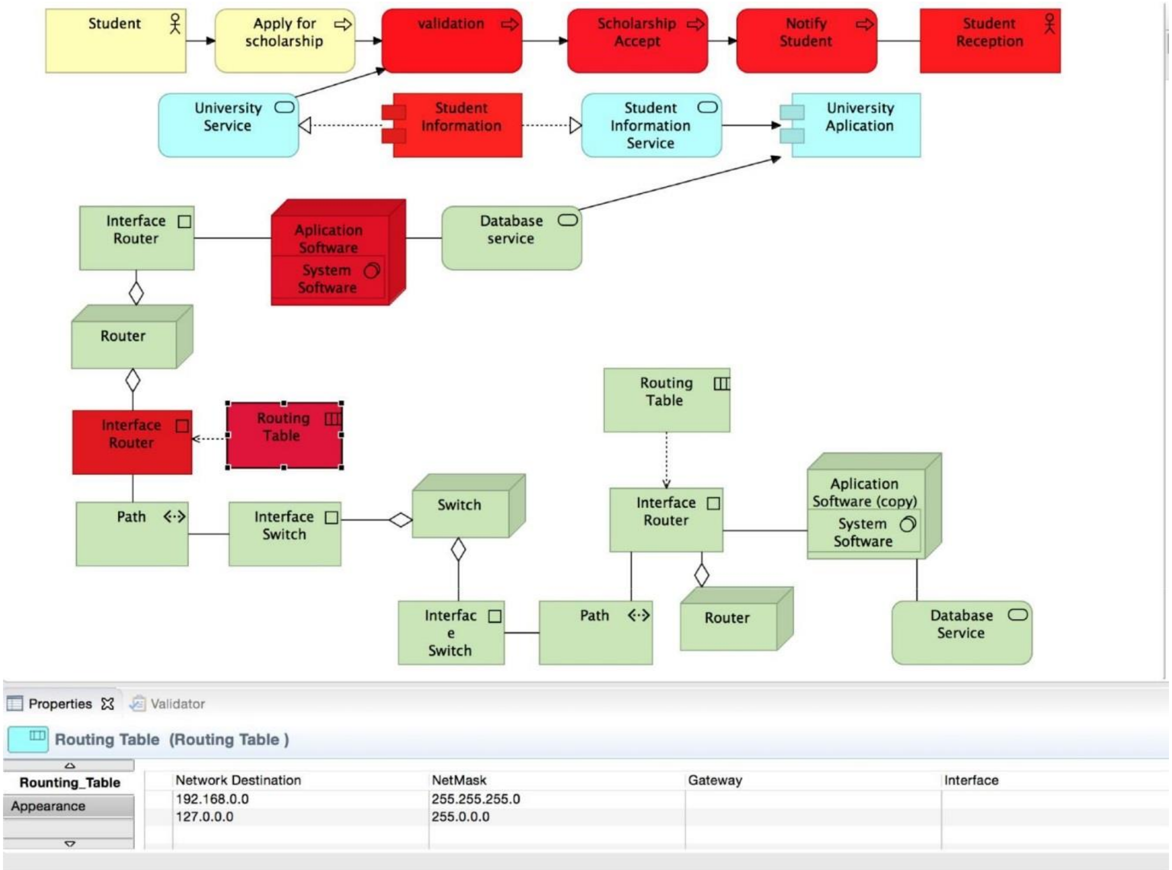

Figure 13 Example of the impact in the attribution of scholarship when a route fails or change.

6. Conclusion And future work

IXP is point of connection where a set of organisations can connect and share information according to the rules established within them. The concept of IXP has been explored from several years, to find new ways to improve the traffic exchange and protocols for the routing. The main goal of this work is to add more concepts to already existing modelling language ArchiMate. Today, there are several IXP points in the world, and some of the most successful IXP point is localised in Amsterdam, London and Frankfurt. In Portugal, the two major IXP are rSPtic implemented by AMA and ESPAP to connect all the public services and the GigaPIX which connects all the university and other telecommunication operators.

There are several modelling languages which can be used for modelling process, network and other types of activities like ArchiMate. However, the ArchiMate framework does not have enough elements to represent the network. Hence, this project proposed new elements to add on the existing model such as router, switch, routing table, interface router and interface switch to overcome the shortcomings of existing elements.

To evaluate the new elements added, firstly this work explained why IXP was modelled in EA language instead of using the network simulation tools. Next, a used case was considered for the evaluation, where the connection between University of Lisbon and Ministry of Finance was established first, and then verified if an entity from on organisation can access the resources from the other. For example, University of Lisbon wants to grant scholarships to student with poor financial background. For that the University will have to request and consult Ministry of Finance for the financial background check. To do so, University of Lisbon needs to establish connection to the IXP first, then access information from Finance Ministry to check student's economic status to ensure that the university is granting scholarship to the deserving students.

The modelling of IXP in EA demonstrate how the changes in technology domain can have impact in process running in the business domain. In the used case, it was verified that a change in the routes or a fail in the hardware will have a big impact in the process. Also, it was possible to compute which applications can no longer work, which services will not be offer to the clients and which process will have impact. Further uses of this relation could be of helping the company to make decisions, facilitating the introduction of new elements on the network and for clarifying how the new organisation will be connecting in the IXP.

To sum it up the proposed model allows the alignment between the strategic objectives of an organisation to the network provider who is supporting it and it allows to see the impact of changing the information on the network infrastructure. The purpose of this work was to add new concepts in ArchiMate language model, and it was successfully achieved.

During the implementation of this work it was identified a few limitations. One of the limitations identified was in the implementing the new elements in the code of Archi because the information about how to add it was not very structured and the document used for adding it was from the previous version of ArchiMate as the coding in the Git for the Archi has changed significantly. Another limitation was with the evaluation of the new elements introduced for the modelling language ArchiMate. The evaluation was done with the used cases, but it was still not enough to evaluate the concepts introduced. With a real scenario of IXP where the elements introduce could be tested the results will be better. In the future, more attributes or elements can be added to represent and cover wider concepts of the network. Also defining the extension for the modelling language with new attributes and elements for other domains like applications can be considered.

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