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PhD Thesis Booklet

OSI Model Interaction Integration for Reliable Fault Tolerance in Real-Time Communication Sessions with A Performance Based Synchronization Algorithm

by

Stefano-Niko Orzen

Supervisor: Levente Adalbert Kovacs

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I. BACKGROUND

The purpose of this doctoral thesis is to complete the field of computer networks. In this study, I approached the persistent routing problem of the session layer data communications that are coordinated by the OSI model [ZIM80]. This problem was analyzed in terms of real-time communications, where research has a concise role and with effective applicability for the real world of information transmissions. During my documentation and analysis period, I realized that persistent routes lack fault tolerance methods for intermediate transmissions, these representing hard points in data transmissions.

Because data communications in real-time are based on forms of binary value manipulation, various situations can arise and overload processing tasks that require mandatory performance to be complied too. The performance criteria can be met in general, but there are also cases and contexts that stand out as exceptions which cannot be performed. The analysis of such contexts and cases consists from a process of qualitative and quantitative evaluation of the elements that can be measured in terms of performance. Not to be ambiguous, I mention that the performances of data communications are only numerical processing, while the communication values between two entities are in relation with the time required to perform these generic tasks.

From the data communication/time ratio report it can be seen that there is a need to transmit packets as a volume in the shortest possible time. The analysis of these intervals is comprised from an interdependence of components with various transmission actions. The performed steps between components are the result of an algorithmic instruction that norms the communication of real-time processes. All these actions are called interactions, and they are a method for recognizing a phenomenon that has its effect operated in the real-time[1] of a transmission. All in all, the action of one or more components, and the reactions that can occur due to unit(per component) or complete system limits, are the phenomenon result. In the context of persistent communications, interactions can occur very often, and are frequent during the selection of routes through self-adjusting parameters and routing devices of networks and systems.

The understanding of actions and reactions through interactions can be deduced with dependencies. These were properties that I identified as being between multiple levels of the OSI model during my documentation period, time in which I analyzed bibliographic elements with a focus on persistent routing issues that do not have a logical theoretical formulation. This is necessary to facilitate the understanding of how persistent routing works and its internals. For this reason, we choose the methodology of formalizing the concept of interaction for communications with current operating times, actions with effects that are globally and unanimously called as being performed in real-time [DAR10].

[1] Notion of informal description for the communication that takes place in the current moments of time, on each router participating in the transmission.

The concept that I defined to clarify the dependencies between limits, contains parameters and network phenomena that take place at the OSI session level. In order to distinguish between the current time and the variable operating times of data transmissions, I mention that real-time is a notion that recognizes the transition of a transmission in current time. The delay times of these transmissions have no way of being known previously, because data is communicated through multi-variable media, and unlike the field of telecommunications or electronics, the predefinition of networks do not require the data to be communicated within the exact limit of a specified time.

The most important thing to keep in mind for real-time routed data packets, is that their actual communication time is the one established by the protocol that in turn acts in agreement with network routers and switches. This cooperation establishes the efficiency for using available resources from the environment. In this way, data packets are transmitted without any obligation to respect time limits that do not have an autonomous protocol analysis as basis, but simply respect the dynamic conditions of the routing environment. The transmission actions are self-adapted to the qualitative requirements of the OSI session level technology that is used [BAU04].

The concept of interaction is a methodology for abstracting and recognizing the actions that take place in the functioning of communication technology complexities in real-time. In this manner the transposition of Interaction as a concept ,into the OSI model, through persistent session level routing becomes concrete, due to the functional performance analyzes that are found throughout the document.

I mention that the main proposals of this thesis are a synchronization algorithm and a concept through which I formalized the analysis of interactions in and between networks. These have the role of improving the operation of real-time transmissions and to integrate interactions in data environments, thus representing a contribution through which we highlighted the applicative role of the synchronization algorithm. All these things are shown in this document in deductible form and are explained concisely, the objectives proposed in this thesis being to provide solutions that can be seen as in line with global research trends.

Persistent routing is a phenomenon that generates a communication route through designated segments, and is allocated between two entities to transmit data in real-time. This type of route is created through the communication media in order to be kept in an active state, as long as it is needed by the computation transmission process. Because the designated route may comprise network segments that cross networks, subnets, domains and systems, its performance is variable. These performances indicate properties that may be affected by external factors of the communication path [TAN04a], highlighting elements that can act on the transmission, and which can disrupt the communication process. At the same time, performances can show the causes that make the problem of a forced transmission interruption to become visible, and provide a first set of steps to grasp the problems solution.

1.1 Objectives

To solve the malfunctions of real-time communications, we have set a series of objectives that are presented in the following list. These are the steps that were performed to validate the study's contributions.

1) Definition of a logical operation plan for communications with an immediate action, plan that had also the role of formalizing the communication rules which create a communication protocol for OSI real-time sessions;
2) Carry out a correct functional analysis, in which hardware and software elements that route persistently data of real-time processes were presented;
3) Perform a probabilistic analysis on session communication time frames, with inclusion of unitary analysis of equipment, as well as complete analysis of structures which are comprised from multiple interconnected devices, networks and subnets, to transmit the data of a process with current actions;
4) Establish performance criteria through which network disruptive effects can be mitigated for real-time transmissions via persistent routes;
5) The creation of a synchronization algorithm to reorient the transmission of persistent routes of sessions, while ensuring the routing process with near real-time values of computer networks;
6) Theoretical formulation of the Interaction concept as being integrated in the OSI model, with the role of justifying the actions that happen between the technologies of the transport and session levels of the OSI model through performance metrics and parameters that are related to real-time communications;
7) Identification of limits and technical possibilities that could reside/exist in the developed contributions;
8) Description of future research directions that could complete this study, the contributions claimed here being based on the existing technological support of the real world;

The mentioned points are how I structured the study and how I managed to develop solutions based on performance criteria of communications, with actions in current moments of time, every stage completing the documentation, analysis and experimentation that were performed.

Criteria for establishing and operating real-time sessions that are transmitted via persistent routes are defined by formalized performance metrics through quantifications of time. All the time-based notions that were chosen in this study are necessary to analyze the performances of OSI based session processes. These allow the mathematical formulation of physical and logical capacities for communications, while providing the ability to structure the logical steps in order to describe the algorithms through which real-time communication networks are defined.

Criteria's are mandatory for establishing routes, and these are dedicated to the analysis of initial performance with a minimum level that can make persistent routing work. In this work, the most import ones are the following:

a) transmission capacity analysis of networks, where data will pass in near real-time intervals (immediate);
b) analysis of communication times according to UTC time zones, because the mechanisms that forward transmitted data through networks requires an optimal timing for packet flows;
c) analysis of the continuous availability to transmit data in real-time through networks;

These objectives are the main criteria that generate persistent routes. If the available bandwidth is sufficient, and information traffic is driven by fragmentation and priority allocation mechanisms, the continuous data transmission represents the critical point of the problem.

1.2 The Problem of Real-Time Communication through Persistent Routes

This problem can be identified through the methodology that persistent routes make use of, namely network equipment and environments structures, while recording events that indicate the existence of unique points prone to errors and failures. These may occur due to the complexities of unique elements [BHA14], and their need to be understood is concisely presented in the thesis.

In the scientific world branch that's dedicated to data packet communications, there has been the a recognition of the fact that real-time transmissions are highly dependent on user demands from applications and programs which use persistence in ensuring the technical performance routing processes. The reason for which persistence was chosen as a routing phenomenon to perform the functioning of such processes with immediate, is the complexity of routing dynamics. In [LAZ84], the routing cost and traffic cost is represented through the understanding that if certain network nodes and communication segments can maintain a communication flow in current time intervals, and without traffic fluctuations, it is not necessary to change the route path. In [TAN04a], the probability of switching or routing to other paths is defined by the update cost of routing tables. This process implies the required compute time to perform the criteria analysis of protocols operation that sustain a uniform continuity between end nodes.

1.3 Real-Time Process Analysis of OSI Sessions

Persistent routing was originally described in telecommunications, where the transmission process is guided by the open communication channel and is kept active throughout its required time [TAN04a]. In data environments however, network segments that are allocated priorly to the actual transmission, are the components that

run the whole process. These are currently chosen as being unique real-time transmissions, and in this manner, in case of equipment disturbances(which transmit the in-cause data packets) that imply the connection to be forcibly stopped, the communication problem of persistent routing is indicated.

The routing cost and update cost are defined by graph theory and through the means that represent transmissions according to topology ordering and device locality as information flow is performed. That is why I mention that the sum of arcs[2] is beneficial for the allocation of a communication route because the distances that are to be covered, are evaluated in terms of network transmission time.

The notions presented in the previous paragraph are related to a multitude of criteria that are necessary for the process to making the best decision on the route that will be selected.

The analysis of workloads for data transmissions that are related to persistent routing, is dependent on an optimal decision-making, which in turn requires an increased focus on each network component from a functional point of view. I have represented this decisional logic in a gradual way, as having determinants that imply the following decision-making characteristics:

1) listing of available segments from the communication media that will create persistent routing connections;
2) performance measurement and verification, a method that includes the amount of data from which packets are composed, the number of hops performed from equipment to equipment, in the network and subnet transmissions, data transmission speed in terms of available bandwidth, and existing time as being recorded in the network versus UTC time;
3) comparison of the available performances with the criteria needed to establish the persistent routing connection, and choosing the afferent corresponding transmission segments;
4) request of communication channels and priority services to establish and generate the connection;

From an application point of view, persistent routing is favored as an action in computer networks with priority and control over the transmissions from other types of protocols [BEH89].

The four points I listed above have been defined to introduce a note that transmissions happening in current intervals, through extended geographical regions, require a formalization of functions that are followed at the protocol level. In the formulas and defined relations of the State of The Art, these functions are defined based on studies conducted by the authors from [TAN04a], [TAN04b], [LAZ84], [BOL06], [IOA11], [IOA08] and others, while the decision support is illustrated to highlight the possibility of simplifying and reducing the vast range of technology to the computational problem.

[2] Conventional name from graph theory.

II. MOTIVATION

The scientific world of computer networks has managed to enable and meet a multitude of criteria for requirements that underly various aspects on how real-time processes work [BUR97]. However, when it comes to reliable communications with continuous availability and fault tolerance, there's a significant shortage of methods which should ensure the proper functioning of related processes.

In this study, the possibility for tolerating intermediate failures that may occur in persistently routed transmissions, was developed while being mainly focused on what can be achieved by adjusting the performance parameters of the devices that enable real-time processes.

Routing equipment holds a central role in information transmissions, and it imposes the use of minimum and maximum limits that shape the communicated data volume through the transmission media.

The simplest way to represent data communications is provided by the ratio between the transmitted bits per time-frame, and the obtained values stand as basis for the entire research and development from data communications.

Real-time transmissions is a separate field, which depends on much more sophisticated and demanding criteria than regular or normal Internet and network transmissions [CAM06]. All this is due to the fact that the mechanisms of protocols considered common, have no time limits for transmitting data, and all the research in their direction has been aimed at providing performances that do not disturb users of network services. In real-time on the other hand, things are much more complex, because the data that is transmitted between two entities in real-time, must reach their destination within a time limit that is set priorly by the protocol that connects the requesters of such a process.

Persistent routing is defined as a problem, because it's a network phenomenon that implies a directly generated process which can be affected by overloaded networks with timely delivery possibilities reduced [TAN04a].

Bandwidth does not impose difficult problems in the world of data transmission, but factors that lead to overloaded network segments are critical issues, where network availability, robustness and reliability are assigned as properties [TAN04b].

Due to the vast number of elements that form real-time communications, the functional chaining of various stages and thresholds(from one level of OSI communication to another), requires the association of indices and parameters to help formalize the analysis of transmission performances. In [LAZ84], these metrics are defined by their importance in streamlining data packet transmissions, having a key role in optimizing communication processes. In the following enumeration, I present the in-cause metrics together with their brief description, these being the basis for the developed solutions that are claimed in this thesis.

- C = Servers capacity to take over tasks;
- λ = Arrival rate of workloads to servers for processing;
- r = Waiting time for tasks that are in processing centers;
- R = Response time for tasks that are being processed;

- T = Time to complete the processing of tasks that reside in processing centers;
- U = Utilization degree of processing centers, in relation to the arrival rate of workloads;
- S = Processing time of the computing station;
- X = The volume of tasks processed in the entire point-to-point communication process;
- D = Volume of tasks/loads that are dropped due to network anomalies;

Optimizing real-time communications requires a concise knowledge of the various causes and problems that can occur in the interconnection of large data networks, and for the processes of real-time sessions, numerous research studies have been undertaken[3] such as [ARF14], [BAR14], [DAR10] and [HIR10].

Generally, real-time transmissions are presented by researchers as functional, but current studies have shown that a viable way to assign routing possibilities is via reliable fault tolerance. Most proposed solutions are slight improvements of existing technologies, and these are presented in the state of the art research stage of this thesis.

Since each contribution that is claimed in this study has the role of completing the field of computer networks, I will present in the following paragraphs, which is the level at which my personal contributions sustain the real-time transmissions that are organized through the OSI model ruleset.

The OSI model is the basic theoretical formulation of any communication network that is defined correctly, and is also conformant to ISO standards. For defined networks that use the OSI model rules, there are some specific criteria which need to be met, all this being imposed in order to achieve the goal set by the creators of the in-cause infrastructure.

Currently, the most intense researched criteria are fault tolerance and reliability, properties derived from the availability of resources, the robustness of programs that form communication protocols, and the integrity of information that is communicated through composite environments [BAU07].

In essence, this additional layer is a methodology through which I propose the analysis of interactions that occur between equipment and network protocols that run as an autonomous assembly, with the role of achieving certain performances. The signals and the network devices forward traffic, which leads to global network and system functionalities, and the numerous actions and reactions of the existing assemblies from interconnected global structures, are dependent on the performances of existing devices and environments.

As an example of the multitude of interactions that can happen in real-time communication processes, I mention the wait/delay times of data packets in session-level transmissions that terminate a faulty connection. In connection-oriented communications, data packets must be acknowledged by routers that transmit them, and by the computers that are the transmitters and receivers of the in-cause packet.

[3] Study in which robustness was demonstrated for these types of communications.

III. RESEARCH METHODS

The research methods of this thesis are composed from a theoretical cumulus of information which contains the means to explain theoretical function and functionality, mathematically express a multitude of events and the relations between them, and a simulation based approach for equivalating real-world scenarios.

The theoretical background understanding that can be found throughout the mentioned bibliography, has various sources and notions, but all of them are defined through the central core of Queue Theory and Markov Chains that analyze inter-momentary events.

The research methods perspective is to highlight the used methodology of this study, while being at the same-time sufficiently concise and explanatory for signifying the usefulness of each notion. Simulation, being the main tool that is able to represent the over the internet phenomenon, was selected as a practical research method and was used extensively in the performed study.

Most notions and notations used in this thesis are from various authors like [IOA11], [LAZ84] and [BOL06], and these represent a means for quantifying volumes of state representations for data packet transitions. While the notations are not the same in each author's mathematical representation, I have mostly been focused on describing their inspirational usefulness. This is for representing and solving various parts of the persistent routing problem, while also proving the Interaction Layer's validation for explaining the inter-dependencies between software-hardware networked components.

Computer networks technology is highly dependent on parameters that are like the ones presented in the state of the art of this thesis. The tuning of such parameters needs a logical means, and this is presented in the thesis as formulas, relations and equations, which provide a meaningful causality to understanding QoS actions and the reactions of an overloaded environment.

The persistent routing problem is not a simple task, although it implies the following of a new found path by each packet of an end-to-end process. In the context of this manuscript, the problem is dealt with in such a means that it is only implied by overload/denial of service, and it relies totally on finding the right quality indicatives on an alternate route. Each throughput that is measured and analyzed is directly resolved with the goal of being sustained(with minor value differences in response and service times) on alternative routes.

The theory of Queueing Systems and Markov Chains is used throughout various domains of the current world. Delays in the delivery of information are found in each and every field of IT that implies the use of a network, structure that has the role to carry information from one point to the other.

Thus, the used research methods are sufficiently concise and expressive for providing meaningful insight on how the proposed solutions have been contoured in the presented study.

IV. NEW SCIENTIFIC FINDINGS

In this study I have created solutions that can sustain the continuous development of Computer Networking Technology. Being that the defined solutions need to be usable with the current world technology, they enable a progressive facet of technology in an economically driven society.

We must mention that the originality of the ideas outlined in this thesis is unquestionable, these being formed with the use of Markov Chains and Queueing Theory notions, which are a backbone for the analytical understanding of any Network Traffic problem. As numerous experiments, simulations and logical deductions were performed, I have been highly reluctant on keeping the pros and cons of all the proposed solutions in any reader's focus.

The new scientific findings of this thesis are mostly defined with the role of completing current theory and technology, while introducing a new means for tolerating faults in end-to-end real-time sessions. The created Synchronization Algorithm, OSI Interaction Layer, Protocol Plan and Mathematical Formulas are the new scientific results that represent a creational perspective which englobes a meaningful applicability.

In the following enumeration, the proposed solutions(new scientific findings) are enumerated along with the Computer Networks completions that they imply.

a) Synchronization Algorithm: a means for tolerating intermediate defects of real-time sessions, by rerouting data packets based on criteria evaluated performance parameters and metrics;
b) Interaction Layer: theoretical representation of the dependencies between the OSI session and transport layers, with the means to highlight how parameters inter-relate, and what features of real-time sessions can be improved at a functional level;
c) Protocol Logical Plan: logical representation of the actions and reactions that the Synchronization Algorithm would make for applying fault tolerance in an Interactive manner;
d) Mathematical Formulations: representations of the performance parameters dependencies, relations defined in order to logically express the common asset limits which need to be complied too by the synchronization algorithm;

As an additional contribution, we mention that the state of the art documentation is also a performed work that can't be found as either a review or as a book in the computer networks scientific literature, and thus is an original creation. This is because the research field does not specifically cover the real-time data packet routing of sessions feature, and real-time is a new, novel topic in computer networks that should not be confused with the notions from the electronics and telecommunications domains. Real-time in telecommunications is similar to the real-time notion of packet routing, but it is not the same as the underlying infrastructures and environments work based on different mechanisms, protocols, algorithms and structures.

V. OBJECTIVES AND RELATED WORK

This chapter is dedicated towards presenting the objectives and related work that's considered auspicious for this study, and which I have performed on routing technologies that run real-time communication sessions. Simultaneously, I will also describe succinctly the developed personal contributions together with their usefulness in the approached topic, as well as the future research directions for this type of real-time OSI session level transmissions.

The main contributions that are claimed in the thesis are the following:

- Integration of the concept of Interaction in the OSI model;
- A synchronization algorithm that was created for tolerating intermediate defects of persistently routed session level transmissions;
- A protocol proposal in which the execution steps of the synchronization algorithm can be applied to meet the purpose of fault tolerance for real-time communications;

The ideas outlined above involve a comprehensive theoretical consideration on the technological ensemble through which persistent routing is performed, allowing the attribution of reliable communication characteristic. Ensuring a real-time communication process to be part of reliability and dependability values, is given by the analysis on routing resources through which disruptive effects are mitigated, and routing is maintained as functional after the usage of routes that were selected in terms of performance.

Performance evaluation models were created in the form of dynamic simulation contexts, being the only possibility of affordable experimentation from this study. The representation of the persistent routing problem is described by mentions related to the performance aspects that lead to its occurrence. Disruptive effects were explained by using examples that were gradually analyzed with the methods of organizing communication networks in which transmission protocols of real-time type were applied.

The transmission sessions were divided into process analysis, with the wide possibilities of routing, and into networks analysis, having the operation of routing equipment at the center of attention, both for the presentation of the persistent routing problem, and for the representation of the proposed solution.

Being a solution that must be adapted to the field of communication networks, and in particular to the international norms applied at a global level, the presentation of the concept of interaction requires the analysis and troubleshooting of OSI session-level malfunctions through the synchronization algorithm. It is operated by performance metrics which are in accordance with the protocol rules that run transmissions. The protocol ruleset was created and analyzed both by technical comparisons, and by concrete analyzes of unitary equipment and networking environments. They are described in the study as a necessary criterion in fulfilling fault tolerance of real-time failures.

Any communication protocol makes use of functional criteria for guaranteed transmissions in terms of quality, as well as for communications based on algorithmic retransmission efforts. In this way, the operating criteria were established

by using routing indicatives that can be optimized with the desired parametric specification.

The synchronization algorithm is described as an applicable possibility to persistent routes from sessions, having the interactions between the transmission components as its formative elements.

Real-time communications researchers all use limited simulation programs or test networks. These are nothing more than tools used for creating specialized or general contexts which are at disposal, and are a means to analyze and understand the problems, ideas, questions and abilities that are proposed as a goal to be fulfilled.

All the mentions of the study are sustained by their publication as scientific articles in conferences and journals such as INES 2016 and 2017, ISECT 2014, 2016, 2018, CINTI 2016, SACI 2013, 2014 and 2015, SOFA 2014, SISY 2014 and 2017, etc. . The articles in question validate the undertaken study, because each experiment presented in Chapter III of the thesis was accepted by the scientific community in terms of originality and mentions, for improving the field of computer networks. The articles published so far, either in events or in scientific journals, are listed below, being introduced to highlight the submitted doctoral work.

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2) S.N. Orzen, L. Kovacs, Internet Time as Virtual Time for Real-Time Session Routing, 2020 IEEE 24th International Conference on Intelligent Engineering Systems (INES), Reykjavik, Iceland, DOI: 10.1109/INES49302.2020.9147175, ISBN: 978-1-7281-1059-2, 2020;
3) S.N. Orzen, M.Stratulat, Performance Queues for Fault Tolerant Sessions, 2018 International Symposium on Electronics and Telecommunications (ISETC), Timisoara, Romania, DOI: 10.1109/ISETC.2018.8583983, ISBN: 978-1-5386-5925-0, 2018;
4) S.N. Orzen, S. Babii, Network Events in the Dynamic Selection of Real-Time Session Fault Tolerant Routes, 2017 IEEE 21st International Conference on Intelligent Engineering Systems (INES), Larnaca, Cyprus, DOI: 10.1109/INES.2017.8118574, ISBN:978-1-4799-7678-2, 2018;
5) S.N. Orzen, S. Babii, Data Packet Header Actions in Fault Tolerance of Persistent Routing Sessions, 2017 IEEE 15th International Symposium on Intelligent Systems and Informatics (SISY), Subotica, Serbia, DOI: 10.1109/SISY.2017.8080551, ISBN:978-1-5386-3855-2, 2017;
6) S.N. Orzen, M. Stratulat, S. Babii, C. Cosovan, Routing Tables as Big Data Searchable Structures for Achieving Real-Time Session Fault Tolerant Rerouting, 2016 IEEE 17th International Symposium on Computational Intelligence and Informatics (CINTI), Budapest, Hungary, DOI: 10.1109/CINTI.2016.7846415, ISBN:978-1-5090-3909-8, 2016;
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9) S.N. Orzen, M. Stratulat, S. Babii, C. Cosovan, Fault Tolerance of Propagated Errors in Persistent Real-Time Routing Processes with a Synchronization based Algorithmic Method, 2015 IEEE 10th Jubilee International Symposium on Applied Computational Intelligence and Informatics, Timisoara, Romania, DOI: 10.1109/SACI.2015.7208219, ISBN:978-1-4799-9911-8, 2015;
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11) S.N. Orzen, S. Babii, Time Resolution for Defining an Optimal Path with Neural Networks and Graph Structuring, 2014 IEEE 12th International Symposium on Intelligent Systems and Informatics (SISY), Subotica, Serbia, DOI: 10.1109/SISY.2014.6923564, ISBN:978-1-4799-5996-9, 2014;
12) S.N. Orzen, S. Babii, User-Centered End-to-End Optimal Persistent Routing, 2014 5th IEEE Conference on Cognitive Infocommunications (CogInfoCom), Vietri sul Mare, Italy, DOI: 10.1109/CogInfoCom.2014.7020433, ISBN:978-1-4799-7280-7, 2014;
13) S.N. Orzen, Network Protocol Design for Persistent Performance Routing, 2014 11th International Symposium on Electronics and Telecommunications (ISETC), Timisoara, Romania, DOI: 10.1109/ISETC.2014.7010775, ISBN:978-1-4799-7267-8, 2014;
14) S.N. Orzen, Interaction Understanding in the OSI Model Functionality of Networks with Case Studies, 2014 IEEE 9th IEEE International Symposium on Applied Computational Intelligence and Informatics (SACI), Timisoara, Romania, DOI: 10.1109/SACI.2014.6840086, ISBN: 978-1-4799-4694-5, 2014;
15) S.N. Orzen, Domain Relations in Trees Arborescence for Interaction Search on Persistent Routing Availability, 2014 IEEE 12th International Symposium on Applied Machine Intelligence and Informatics (SAMI), Herl'any, Slovakia, DOI: 10.1109/SAMI.2014.6822380, ISBN:978-1-4799-3442-3, 2014;
16) S.N. Orzen, Mathematical Expressiveness for Computational Network Interaction, 2013 IEEE 8th International Symposium on Applied Computational Intelligence and Informatics (SACI), Timisoara, Romania, DOI: 10.1109/SACI.2013.6608943, ISBN:978-1-4673-6400-3, 2013;

17) S.N. Orzen, Performance Design and Criterion Analysis for Efficient Data Routing, Scientific Bulletin of the "Politehnica" University of Timisoara, Transactions on Automatic Control and Computer Science, Series AC, no.1, ISSN: 1224-600X, 2014;
18) S.N. Orzen, Requirements for Time Based Graph Structuring with Specialized and Generalized Path Choice Routing, Scientific Bulletin of the "Politehnica" University of Timisoara, Transactions on Automatic Control and Computer Science, Series AC, no.2-4, ISSN 1224-600X, 2013;
19) S.N. Orzen, The Concept of Interaction Resolutionally Applied in Distributional Computer Networks Connectivity, INCER 2013, Bucharest, Romania, 2013;
20) S.N. Orzen, Distributed Systems and Artificial Intelligence in Programming (Proof of Concept), Development and Application Systems 2012, Suceava, Romania, 2012;
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22) S.N. Orzen, The Design of Programmability in Information Technology, POSDRU Workshop, no.2, 2012;
23) S.N. Orzen, Ș. Holban, Data Representation for Communication Networks - Information Integration and Programmability, Scientific Bulletin of the "Politehnica" University of Timisoara, Transactions on Automatic Control and Computer Science, Series AC, no.1, ISSN: 1224-600X, 2013;
24) Ș. Holban, S.N. Orzen, Artificial Intelligence in Distributed Systems Programming, POSDRU Workshop no.1, 2011;

5.1 Contributions – Thesis Groups

The goal I set to myself during the study, was to make a contribution and improvement in the field of computer networks, and I have achieved this with the use of the Java Modeling Tools simulation stack. With this tool, I created simulation models that can represent real-world operational cases.

I have also performed a rigorous documentation from the scientific literature to find the information that's necessary for the integration of real-time communication technology at the session level of the OSI model.

For this, I presented the current state of the art research for real-time communications by using persistent routes, a documentation through which the theoretical and practical directions for the development of data transmission systems was clarified. At the same time, through the current state of the art research, I identified the performance metrics that are essential for the analysis of transmission routes.

The own contributions that I mention as original and authentic, represent the personal ideas that I've developed to propose useful solutions for solving the problem of persistent real-time routing, respectively for analyzing the malfunctions

between real-time technologies. These are presented in the following subsections in two thesis groups.

5.1.1 Thesis Group 1 (Representation of the Problem)

I have defined a method for recognizing and representing the persistent routing problem in real-time, with linked actions that clarify the modeling of interactions between interconnected components of computer networks.

All this is conceived with a protocol logic proposal for the developed synchronization algorithm, and for the analysis of interactions from real-time communication sessions which is pointed below with regard to causality and usefulness.

- I've created the synchronization algorithm as a basis for understanding the effects that need to be properly acted upon in order to tolerate disturbances of the real-time transmission processes. It's purpose is to tolerate intermediate defects that may occur in routed OSI sessions. The algorithm in question works by rerouting data packets through routers that can retrieve and further transmit data packets related to an end-to-end session(between endpoints, the sender and receiver);
- As a representation of the problem and to define it's solution, I've created the necessary method for applying the synchronization algorithm so that it can work correctly. The method in itself has the possibilities to analyze the performances of each routing device autonomously, while also activating the synchronization process of the algorithm by reorienting the connections between routes at intermediate levels of networks, subnets, systems and subsystems;

Relevant own publications pertaining to this thesis group: 10 – 24;

5.1.2 Thesis Group 2 (Created Solutions and their Applicability)

I have integrated the concept of interaction into the OSI model to facilitate the logical analysis of effects, actions, reactions and malfunctions that may occur in the cooperation between OSI level 4(transport) and OSI level 5(session) technologies. I've also solved the context of malfunction for real-time transmissions by using the analysis of interactions and by methodically applying the synchronization algorithm while also assigning the reliability feature to the real-time routing of OSI sessions. Pointed out below are the performed steps in order to achieve the proposed solutions.

- I've defined a protocol proposal in which the execution steps of the synchronization algorithm can be applied to fulfill the purpose of fault tolerance in real-time communications. It is intended to

operate the algorithm and mainly the algorithmic actions are performed by a comprehensive performance analysis on the elements that are part of the rerouting process;

- I've created simulation models through which I validated the existence of the real-time communication problem of the OSI session layer, representing through them the possibilities of solving the disfunctions from this type of communications;
- I've created the mathematical relations that represent the technical possibility of achieving and estimating the limits within which the synchronization algorithm must be time-framed. Through these limits, an analysis can be performed in modeling and evaluating the performance characteristics that must be met by the devices and software that are integrated in the rerouting of data packets from OSI sessions;
- I have established the applicability of the proposed solutions in mitigating the failures of real-time data transmissions, through the experimental analysis that's based on real-time performances;

Relevant own publications pertaining to this thesis group: 1 – 9;

For the previously presented thesis groups I performed a concise theoretical documentation on the technological ensemble through which persistent routing is performed. Through them, I assigned the reliable communication characteristic to computer networks that route session-level data. The ensurance that a real-time communication process is part of the reliability framework, is given by the analysis of routing resources through which disruptive effects are mitigated. In this way, the routing process is maintained as functional, through the use of network segments that were chosen in terms of performance.

All these contributions, which include the decision charts for the proposed improved protocol, the synchronization algorithm, and the autonomous analysis of interactions, are solutions that I consider auspicious in the research on computer networks. Some of the published articles have been cited in other doctoral theses, or in scientific papers that are also indexed in international databases such as IEEE, DBLP, ISI Thomson Reuters and Google Scholar. As an additional contribution, I would also like to claim the documentation undertaken in the articles, this being concise, and covering a wide range of bibliographic reference elements that have a high degree of novelty and engineering applicability in various fields.

To conclude this subchapter, I mention that the study was carried out with an experimental methodology composed of conventional X64 hardware and discrete event simulation software that ran on the computing platform with java microcode virtualization. The methodology was good enough to perform realistic experiments, and from an analytical point of view, I created relations[4] that are claimed as part of the synchronization algorithm logic and the concept of interaction formulation.

[4] Relations and formulas claimed with a basis on reference works from the field.

5.2 Future Research Directions

The study I developed is at a level where the addressed issue, persistent route communication of real-time sessions, can be supported, completed and analyzed on several levels. As an author, I realized that the conducted study and the claimed contributions can be applied in several technological areas that make use of real-time communications. In addition to real-time transmissions, infrastructure technologies could benefit from performance improvements both at the network level of the OSI model, and at the data and physical link levels of the same organizational model. In the following list, I will briefly describe what are the possible continuations and research directions that I consider complementary ideas to this document.

1) Creating experiments that have the purpose of applying the terms presented in this thesis, but in other simulators that are able to represent discrete events, and to analyze network phenomena.

2) To create the algorithmic mechanisms that apply the execution steps of the claimed synchronization algorithm in a communication protocol that reflects the protocol logic that I also designed and described in Chapter III of the thesis.

3) Designing methods for accessing computing equipment and resources to find more optimal coding methodologies for real-time transmissions.

4) Defining a hybrid computing architecture for communication equipment that can streamline the volume of data that's transmitted in real-time through composite networks that have structures specially created to serve this purpose.

5) Implementation of the synchronization algorithm on several performance evaluation models, with different computation laws, which can present in a special/different manner, the interactions between transport technologies and the criteria for establishing real-time sessions.

6) Formalization of temporal evaluation metrics for data communications that have the dispersion of packets in adjacent environments as an existing facility and possibility. This could give to the reorientation of real-time connections, an increased index to meet the fault tolerance effect, and even a normal value to the core network and infrastructure services.

I conclude this document by saying that this study was a great opportunity for me to improve the field of computer networks, completing a small step in the continuous development that this interesting field offers to people that are passionate about computer networks.

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