Investeşte în oameni!
FONDUL SOCIAL EUROPEAN
Proiect cofinanţat din Fondul Social European prin Programul Operaţional Sectorial Dezvoltarea Resurselor Umane 2007 – 2013
Axa prioritară 1: „Educaţia şi formarea profesională în sprijinul creşterii economice şi dezvoltării societăţii bazate pe cunoaştere”
Domeniul major de intervenţie 1.5 "Programe doctorale şi post-doctorale în sprijinul cercetării"
Titlul proiectului: „Q-DOC- Creşterea calităţii studiilor doctorale în ştiinţe inginereşti pentru sprijinirea dezvoltării societăţii bazate pe cunoaştere”
Contract : POSDRU/107/1.5/S/78534
Beneficiar: Universitatea Tehnică din Cluj-Napoca

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA
FACULTY OF ELECTRONICS, TELECOMMUNICATION AND INFORMATION TECHNOLOGY

Eng. *Alexandru Florin ANTONE*

SUMMARY
PHD THESIS

Functional and evaluation structures in DVB digital television systems

PhD supervisor:
Prof.dr.eng. Radu ARSINTE

Cluj-Napoca
2013

Contents

Keywords: Digital Video Broadcasting, multiplex stream, statistical multiplexing, test beds, SAT IP

1. PhD thesis context and research motivation

Nowadays DVB is a mature technology, which evolves over 15 years, targeting the performance and compatibility issues established in the past. An essential thing is the mature engineering approach and the deliberate slow evolution and predictability, which allows an economic approach, both at provider's level as well at user's level, by reusing the existing technologies and controlled evolution of those. The emergence of the second generation DVB (with its versions DVB-S2, C2, T2) has pointed the success of this technology and has confirmed the wish of the user's community to enhance the capabilities to compete with the new distribution of audio/video/data technologies, in full progress.

Despite those arguments, DVB is a technology which is less addressed by the specialists, paradoxically due to its complex nature and interdisciplinary characteristics. Seen from the perspective of radio technology specialists it often reduces to the modulations used, while media experts "see" only the audio-video coding issues.

All these had determined, in 2010, at the end of second generation, the definition of a research direction that seeks to unify the DVB approaches, and to highlight the interaction of various components to enhance the capabilities of the standards. Absence at that time, and even today, of some common views of technology in Romanian academic domain, has determined the title of this thesis.

The complexity of this technology, highlighted from the beginning, convinced me that I could not approach all intimate topics of this technology, in a single paper, but that I can address some important topics, trying to make significant contributions.

These are reflected in the theoretical as well as practical, evaluation and implementation contributions. As a final argument, I would like to mention the fact that Romania face the final phase (2015) of transition to terrestrial digital television (the ones through satellite and cable being a fact in providers practices from Romania), therefore the importance of forming competences in this domain is essential.

The author's motivation during the development of this thesis is mainly due to successful collaboration between him and academic environment. Work on activities which may be considered related to this thesis has started during university years, and continued with collaborations from which resulted the completion of diploma and Masters, with research results.

The author's involvement in activities related to the approached one from the thesis started in the fifth year of university, along with approaching projects related to digital television, in the context of finding multimedia solutions for end-user. The goal was to develop a media center system for home network segment of DVB transmission chain.

Afterwards, the author had extended his interest, with Masters research, focusing on analysis and testing of DVB chain. The aim was to achieve an academic study on laboratory testing methods and real environment digital television system (DVB), to find elements that influence quality.

2. Thesis outline

Thesis content approaches tree major domains: evaluation of main components of ITU DVB model, evaluation of DVB distribution models through traditional channels (terrestrial, cable, satellite), and translation of DVB broadcasted information through alternative channels such as IP data networks.

The thesis contains 7 chapters.

Chapter 1 presents the thesis introduction, presenting the context, motivation, contributions summary and thesis structure.

Chapter 2 presents the state of the art of first and second generation DVB systems and the impact of multiplexing in digital TV systems, called "ITU-R distribution model in digital TV systems – building blocks". The chapter is divided in 4 sections:

- Section 2.1 presents the main definitions and theoretical background of first generation DVB systems.
- Section 2.2 presents the main concepts and theoretical background of second generation DVB systems.
- Section 2.3 presents the theoretical background of statistical multiplexing, and related studies of academic and commercial importance
- Within section 2.4 it was investigated the impact of statistical multiplexing in DVB systems, resulted in a paper presented at the conference ARSA 2012, namely [Antone & Arsinte, Investigating the Impact of Statistical Multiplexing in DVB Systems, 2012]; moreover, it was developed a real time evaluation of multiplexing services and coding parameters, using advanced methods and instruments, and an architecture proposal for re-multiplexing process. The research was described in 2 papers: [Antone & Arsinte, Advanced methods and tools for online evaluation of multiplexing services and encoding parameters in Digital Video Broadcasting, 2013] and [Antone & Arsinte, A study on the Optimal Implementation of Statistical Multiplexing in DVB Distribution Systems, 2013].

Chapter 3 presents the domain of satellite digital television distribution, namely "Analysis and testing methods in DVB-S/S2 systems". This chapter is divided in 3 sections:

- Section 3.1 presents the concepts of DVB-S/S2 standards, processing of audio/video digital streams specific to broadcasting satellite environment
- Within section 3.2 it was developed a critical analysis of DVB-S2 MatLab simulation model, to identify the potential key points for improvement
- Within section 3.3 it is conducted a DVB satellite stream analysis using dedicated software: transport stream and service evaluation; and it is created an experimental system to assess the radio-frequency characteristics of DVB satellite signals using dedicated hardware tools

The elements presented in sections 3.2, 3.3 have been published in the paper: [Antone & Arsinte, An Experimental Study of Quality Analysis Methods in DVB-S/S2 Systems, 2010].

Chapter 4 presents the domain of cable digital television distribution, namely "Stream processing and distribution in DVB-C/C2 systems". The chapter is divided in 5 sections.

- Section 4.1 describes the state of the art and technical state of first and second generation DVB-C systems
- Within section 4.2 are presented the concepts and processing of digital cable television systems
- Within section 4.3 it was developed a critical analysis of DVB-C MatLab simulation model, to identify the potential key points for improvement

- Within section 4.4 is presented a channel capacity evaluation for different generation of transmission systems in end user networks. The results described in this section were presented at AQTR conference 2012, published in the paper [Antone & Arsinte, Modeling the Channel Capacity for Different Generations of In-Home Data Transmission System, 2012]
- Within section 4.5 it is presented a validation methodology for simulation, of DVB-C characteristic components. These results were published in [Arsinte & Antone, Investigating Methods To Simulate And Evaluate Signal Distribution In Analog And Digital TV Cable Networks, 2012]

Within chapter 5 is presented the domain of terrestrial digital television distribution, namely "DVB-T/T2 reception evaluation". The chapter contains 3 sections.

- Within section 5.1 are presented the main concepts of first and second generation DVB terrestrial
- Within section 5.2 it was developed a critical analysis of DVB-T MatLab simulation model, to identify the potential key points for improvement

Chapter 6 presents distribution methods for DVB streaming in data networks, namely "DVb Broadcasting by streaming in data networks". This chapter is divided in 6 sections.

- Within section 6.1 are presented the basic concepts that underlie the DVB distribution over data networks, namely the DVB IP architecture defined by DVB consortium
- Within section 6.2 are described the mechanisms used by main services defined by DVB IP, namely service discovery, selection and delivery
- In section 6.3 is presented the RTSP client controlling data delivery (digital audio/video information and related services) in real time
- Section 6.4 describes IP addressing and routing
- Section 6.5 presents the concepts and specifications of SAT IP system, an implementation solution based on DVB IP
- Within section 6.6 are presented two existing papers authored by the thesis author, namely [Antone & Arsinte, Methods for distribution of audio-video information over data networks, 2013] and [Antone & Arsinte, An implementation of SAT-IP concept in a local distribution system for DVB RF to DVB-IP translation, 2013]. It is developed a system for DVB redistribution in data networks, having as a final goal the validation of SAT IP concepts and specifications

Chapter 7 summarizes the main contributions and presents the main perspectives considered for further research. Finally some issues and ideas related to the work of the author are presented.

3. Thesis contributions

Within this thesis there were approached a couple of directions, from the DVB processing domain: developing evaluation methods for multiplexing services and multiplexing coding parameters, critical analysis of DVB-S2/C/T models, evaluation of DVB-S/S2 stream parameters at receivers side, evaluation through simulation the DOCSIS channel capacity in home network, investigate some distribution architectures for validation of a coherent drop-out connection and home network model in DVB-C networks, implementation of SAT IP concept in a local distribution system for DVB RF to DVB IP translation.

The thesis brings theoretical contributions as well as practical ones. They will be summarized during the next sections.

3.1.1 Directions regarding usability of statistical multiplexing in DVB

Within chapter 2 are presented the main contributions of the author in the domain of statistical multiplexing in DVB. It has been studied the impact and importance of statistical multiplexing of digital TV distribution systems, evaluation methods for service multiplexing and coding parameters in these systems and it was proposed a re-multiplexing architecture.

The theoretical contributions of the thesis in this domain are:

- A synthesis of the characteristics of first generation DVB systems
- State of the art of second generation DVB systems
- Study of the impact and importance of statistical multiplexing in DVB [Antone & Arsinte, 2012]

Practical contributions in this domain are:

- Implementing an experimental system to aim the evaluation of multiplexing in case of DVB-S/S2 streams
- Investigating the impact of statistical multiplexing using the mentioned system [Antone & Arsinte, 2013]
- Implementing a real time evaluation of DVB multiplexing services and coding parameters [Antone & Arsinte, 2013]
- An architecture proposal for re-multiplexing designed to modify the original content of the multiplex, without having access to the original multiplexor [Antone & Arsinte, 2013]

3.1.2 Streams analysis and testing methods in DVB-S/S2

Within chapter 3are presented the main contributions of the author in the domain of DVB-S/S2 stream analysis and testing in real environment, to identify the main evaluation parameters of first and second generation of DVB-S streams. Also it was conducted a critical analyze of DVB-S2 model.

The theoretical contribution of the thesis in the domain of DVB-S/S2 stream analysis and testing is:

- The study of concepts of DVB-S/S2 standards [Antone & Arsinte, 2010]

Practical contributions in this domain are:

- A critical analyze of DVB-S2 Matlab R2009 model ,by identifying the key improvements of the model, respectively: the proposal to replace the AWGN channel with other Rice or Rayleigh type for relevant results; replacement quasi-random data source with a data source type MPEG2/MPEG4
- Experimental estimation of service quality (transmission parameters, RF quality) in DVB-S/S2 systems [Antone & Arsinte, 2010]
- Analyze of DVB-S/S2 service structure, processing and results interpretation [Antone & Arsinte, 2010]
- Benchmarking the quality of DVB-S signals (RF component), by using classical instruments (network analyzers) and integrated tools (PC module SkyStar DVB-S) [Antone & Arsinte, 2010]

3.1.3 **Evaluation and simulation of DVB-C distribution in end-user network**

Within chapter 4 are presented the main contributions of the author in the field of evaluation and simulation of DVB-C end-user distribution. It has been approached two testing directions, in the first one it was evaluated the transmission chain through a simulation model, and in the second one it was investigated the models and tools for validation of a coherent drop-out connection and home network model in DVB-C networks

The theoretical contribution of the thesis in the field of evaluation and simulation the distribution in DVB-C end-user network:

- Introducing the concepts of DVB-C/C2 standards
- Studies of network configurations and topologies

The practical contributions in this domain are:

- A critical study of DVB-C Matlab R2009 model, by identifying the key improvements of the model, respectively: the signal generation block should be replaced with a MPEG/H264 compatible source, the AWGN transmission channel should be replaced with an appropriate one that takes into account reflections and noise terminal equipments
- Evaluation by simulation of channel capacity in DOCSIS and home networks [Antone & Arsinte, 2012]
- Investigations (in Microcap) of distributors architectures different to the one proposed in [Chen W. Y., 2003]
- Proposal of a validation methodology for simulations of DVB-C characteristics components [Arsinte & Antone, 2012]

3.1.4 **DVB-T evaluation**

Within chapter 5 are presented the main contributions of the author in the field of DVB-T evaluation. It was presented a critical analyze of DVB-T simulation model.

The theoretical contribution of the thesis in the field of terrestrial digital television DVB-T:

- A study of DVB-T/T2 concepts included in standards

The practical contribution in this field is:

- A critical analyze of DVB-T Matlab R2009 model ,by identifying the key improvements of the model, respectively: the test signal generation block should be replaced by a MPEG/H264 compatible source

3.1.5 **DVB broadcasting local system by distribution in data networks**

Within chapter 6 are described the main contributions of the author in the field of DVB information broadcasting by streaming in data networks. It has been studied DVB IP standard, as well as SAT IP specifications, and it was developed the implementation of SAT IP concept in a local distribution system for DVB RF to DVB-IP translation.

The theoretical contribution in the field of DVB broadcasting through data networks distribution:

- Study of standards for DVB distribution over data networks, DVB IP [Antone & Arsinte, 2013]
- Study of concepts and specifications of a provider standard (SES Astra) SAT IP [Antone & Arsinte, 2013]

The practical contributions of the thesis in this domain are:

- Validations of SAT IP specification by developing an experimental system for redistribution of DVB satellite streams over a local data network [Antone & Arsinte, 2013]
- Identify the main methods of content distribution and transport control over data network streams [Antone & Arsinte, 2013]

4. Scientific activity

➢ **BDI indexed journal papers:**

1. **Alexandru Florin Antone**, Radu Arsinte , "An Experimental Study of Quality Analysis Methods in DVB-S/S2 Systems", Acta Technica Napocensis Electronics and Telecommunications, Volume 51, Number 4, 2010, pp.7-12, ISSN 1221- 6542 (indexing ProQuest, EBSCO)

- Paper cited in:

Vatcharakorn Netharn, Surasee Prahmkaew, Siriwhaddhanah Pongpadpinit, „Improve Receive Signal over Ku-Band Satellite Communications Based on Fuzzy Logic", International Journal of Scientific & Engineering Research, Volume 4, Issue 1, January-2013 - ISSN 2229-5518

2. Marius Danciu, Mihaela Gordan, Aurel Vlaicu, **Alexandru Florin Antone**, "A Survey of Augmented Reality in Health Care", Acta Technica Napocensis Electronics and Telecommunications, Volume 52, Number 1, 2011, pp. 13-2, ISSN 1221- 6542 (indexing ProQuest, EBSCO)
3. Radu Arsinte, **Alexandru Florin Antone** , "Investigating Methods To Simulate And Evaluate Signal Distribution In Analog And Digital TV Cable Networks", Acta Technica Napocensis Electronics and Telecommunications, Volume 53, Number 1, 2012, pp. 37-42, ISSN 1221- 6542 (indexing ProQuest, EBSCO)
4. **Alexandru Florin Antone**, Radu Arsinte, „Advanced methods and tools for online evaluation of multiplexing services and encoding parameters in Digital Video Broadcasting", Acta Technica Napocensis Electronics and Telecommunications, Volume 54, Number 2, 2013, pp. 48-53, ISSN 1221- 6542 (indexing ProQuest, EBSCO)

5. **Alexandru Florin Antone**, Radu Arsinte, „A Study on the Optimal Implementation of Statistical Multiplexing in DVB Distribution Systems", Informatics and IT Today (IIT), Editura Sci-pub, Volume 1, Number 1, 2013, pp. 19-27, ISSN 1339--147X (Indexing DOAJ)

- **BDI/publication/volume indexed with ISSN/ISBN conference papers:**

1. **Alexandru Florin Antone**, Radu Arsinte, "Modeling the Channel Capacity for Different Generations of In-Home Data Transmission Systems", 2012 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR 2012) Theta 18 - Cluj-Napoca, 24-27 Mai, 2012 IEEE Catalog Number CFP12AQT-PRT, ISBN: 978-1-4673-0701-7(0704-8), pp. 261-265, indexing IEEExplore, ACM Digital Library
2. **Alexandru Florin Antone**, Radu Arsinte, "Investigating the Impact of Statistical Multiplexing in DVB Systems", The 1st Virtual International Conference on Advanced Research in Scientific Areas (ARSA-2012) - Slovacia, 3-7 Decembrie, 2012, Proceedings of the Virtual International Conference on Advanced Research in Scientific Fields 2012, ISBN 978-80-554-0606-0, ISSN 1338-9831
3. **Alexandru Florin Antone**, Radu Arsinte, "An implementation of SAT-IP concept in a local distribution system for DVB RF to DVB-IP translation", The 7th International Conference INTER-ENG 2013 Interdisciplinarity in Engineering (Inter-Eng 2013), Târgu-Mureş, 10 - 11 Octombrie 2013, accepted (Indexing Elsevier Proceedia)

- **Communicated papers:**

1. **Alexandru Florin Antone**, Radu Arsinte, "Methods for distribution of audio-video information over data networks", Simpozionul Studenţesc de Electronică şi Telecomunicaţii, (SSET 2013), Ediţia a IX-a, 24 Mai 2013, Cluj-Napoca

- **Scientific reports:**

1. **Alexandru Florin Antone**, Documentation and study of DVB models used in first and second generation systems, Research report number 1, Technical University of Cluj-Napoca, January 2012
2. **Alexandru Florin Antone**, The implementation of complex signal processing models in DVB second generation systems, Research report number 2, Technical University of Cluj-Napoca, July 2012
3. **Alexandru Florin Antone**, Development of processing and testing structures in DVB systems, Research report number 1, Technical University of Cluj-Napoca, January 2013

- **Participation within institutional and research projects:**

1. POSDRU/107/1.5/S/78534 - "Q-DOC- Creşterea calităţii studiilor doctorale în ştiinţe inginereşti pentru sprijinirea dezvoltării societăţii bazate pe cunoaştere", 2010-2013