

Evaluation and Improvement of TV Channel Availability for IPTV Services

Dissertation

zur Erlangung des akademischen Grades

Dr. rer. nat

an der Fakultät für Mathematik, Informatik und Naturwissenschaften
der Universität Hamburg

eingereicht beim Fach-Promotionsausschuss Informatik von

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Juni 2012

Berichte aus dem Forschungsschwerpunkt
Telekommunikation und Rechnernetze

Band 9

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**Evaluation and Improvement of
TV Channel Availability for IPTV Services**

Shaker Verlag
Aachen 2012

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

Zugl.: Hamburg, Univ., Diss., 2012

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Printed in Germany.

ISBN 978-3-8440-1365-8

ISSN 1439-3573

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen

Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9

Internet: www.shaker.de • e-mail: info@shaker.de

Editorial

During the last decade the offering of TV programs via the Internet has become more and more common. As the Internet is based on the Internet Protocol IP the service is called IPTV. Currently, the largest number of IPTV subscribers is located in Western Europe and in the Asia Pacific region. In particular, France is still the leading country for IPTV covering about 23% of the total number of IPTV subscribers worldwide, which means that about 17% of the French population is presently already using an IPTV service. A typical way to offer IPTV to customers (by Telecoms and Internet Service Providers) is to offer this service via DSL based access networks. The transmission of TV programs leads to very large bandwidth requirements within the communication infrastructure if a large number of TV programs (> 100) has to be offered in parallel and possibly also in high quality (e.g., HDTV quality). Therefore, bottlenecks in the communication network may occur which may lead to a temporary unavailability of some of the more unpopular TV programs.

In this publication – representing the PhD thesis of the author – Junyu Lai tackles the difficult problem of predicting the availability of TV programs (TV channels) for IPTV systems with DSL based access networks. The main measure for the availability of the IPTV service applied by the author is the (user) Call Blocking Probability which estimates the expected unavailability of a given TV channel upon its request. In order to reduce the Call Blocking Probability (CBP for short) Mr. Lai introduces an access control algorithm for TV channels which favors more popular channels as compared to infrequently watched ones and turns out to decrease CBP quite strongly in numerous high-load situations. Another important contribution of the thesis is the study (by means of simulation) of practically very relevant peak-hour scenarios in IPTV systems complementing the conventional type of studies which focus on stationary scenarios. An additional valuable result provided by the author is an innovative algorithm (called intentional switching delay) which allows one to significantly reduce CBP in cases when users are zapping quickly through numerous channels. The large variety of results presented in this thesis is theoretically well-founded. At the same time they are also very relevant for practical use in such areas as dimensioning, tuning and optimizing of IPTV systems as well as for service availability analysis and improvement of IPTV services in high-load situations or in situations where user behavior is unfavorable from the point of view of the service provider.

This innovative research report should be a valuable source of information mainly for Internet Service Providers (ISPs) or Telecoms offering IPTV ser-

vices, but also to researchers, developers, (post-) graduate students, etc. who are interested in the analysis, assessment, tuning, construction and/or installation of efficient and highly available IPTV systems with DSL-based access networks.

Hamburg, in September 2012

Bernd E. Wolfinger

Abstract

In the recent past, increasingly more TV channels are provided and much higher bandwidth is required by each channel in service provider based IPTV systems. Therefore, bandwidth shortage problems may arise, which can induce unsatisfactory provisioning of Quality of Experience (QoE) for IPTV subscribers, in particular, with respect to the call blocking probability (CBP) and the channel availability (CA), two most important QoE metrics.

The most straightforward method to solve this issue is to proportionally increase the a priori bandwidth reservation. However, it may not be sustainable. In this dissertation, we focus on solutions with smarter use of the precious bandwidth resources. More specifically, our original contribution lies in the fact that we propose innovative schemes and algorithms to effectively decrease the CBP and consequently to improve the channel availability in bandwidth capacity limited IPTV systems. Moreover, these proposed methods can be easily implemented in a practical IPTV system, and can help the service providers to enhance the QoE of their subscribers.

Firstly, we introduce background knowledge related to IPTV systems. Besides, we study and propose two different user behaviour models to be used to depict user behaviour in both stationary and peak-hour scenarios. Next, we elaborate a state-vector-based simulation methodology to evaluate user CBP for a single link, for an entire delivery network with tree topology, as well as for IPTV systems with different channel formats. These evaluations are carried out for both stationary and peak-hour scenarios.

After that, a TV channel access control (TCAC) scheme is proposed with the aim to decrease the CBP. The proposed TCAC scheme is applied in both stationary and peak-hour scenarios. Simulation results show considerable QoE improvement introduced by using our TCAC scheme. We also elaborate an intentional switching delay (iSD) channel request admission control method to improve the channel availability in an IPTV system with users zapping channels sequentially. A series of comprehensive case studies have been conducted and show that our iSD method can effectively improve the channel availability, with only slightly degrading the average watching delay.

Last but not least, aiming to further improve the IPTV channel availability, we derive a combined algorithm, namely the combination of the TCAC scheme with the iSD method. Simulation results indicate that when the intentional delay introduced by the iSD method is large enough, additional gain can be obtained by applying this combined scheme.

Kurzfassung

In jüngster Vergangenheit stehen immer mehr Fernsehkanäle zur Verfügung und wesentlich höhere Datenraten werden von jedem Kanal in IPTV-Systemen benötigt, die von Internet Service Providern (ISP) bereitgestellt werden. Daher können Engpassprobleme bei den verfügbaren Bandbreiten auftreten, die bewirken können, dass die Qualität aus Sicht der IPTV-Benutzer (d.h. Quality of Experience, QoE) unbefriedigend wird, insbesondere in Bezug auf die Kanalblockierungswahrscheinlichkeit (engl. call blocking probability, CBP) und die Kanalverfügbarkeit (engl. channel availability, CA), zwei sehr wichtige QoE-Metriken.

Die nächstliegende Methode zur Lösung dieses Problems ist, die a priori Bandbreitenreservierung proportional zu erhöhen. Dies ist jedoch möglicherweise keine nachhaltige Lösung. In dieser Dissertation konzentrieren wir uns auf Lösungen, die einen intelligenteren Umgang mit den wertvollen Übertragungsbetriebsmitteln vorschlagen. Genauer gesagt besteht unser origineller Beitrag in der Tatsache, dass wir innovative Konzepte und Algorithmen vorschlagen, um die Verfügbarkeit von Fernsehkanälen in IPTV-Systemen zu verbessern, deren Bandbreitenkapazität begrenzt ist. Darüber hinaus lassen sich die vorgeschlagenen Methoden in einem IPTV-System leicht implementieren und können Dienst Anbietern helfen, die QoE aus Sicht ihrer IPTV-Benutzer zu verbessern.

Zunächst stellen wir benötigtes Hintergrundwissen in Bezug auf IPTV-Systeme vor. Außerdem präsentieren und untersuchen wir zwei verschiedene Modelle, die dazu benutzt werden können, das Nutzerverhalten in den Szenarien „Systemstationarität“ und „Hauptsendezeit“ zu charakterisieren. Anschließend erarbeiten wir eine Methode, die auf Simulation mittels Zustandsvektoren basiert, um die Kanalblockierungswahrscheinlichkeit aus Benutzersicht zu evaluieren für eine einzelne Leitung, für ein vollständiges TV-Verteilnetz mit Baumtopologie sowie für IPTV-Systeme mit unterschiedlichen Sendeformaten. Diese Auswertungen werden sowohl für stationäre als auch für Hauptsendezeit-Szenarien durchgeführt.

Darauf folgend wird eine Zugriffskontrollmethode für Fernsehkanäle (engl. TV channel access control, TCAC) vorgeschlagen mit dem Ziel, die CBP zu verringern. Die vorgeschlagene TCAC-Methode wird wiederum sowohl für stationäre als auch für Hauptsendezeit-Szenarien angewandt. Die Simulationsergebnisse zeigen erhebliche QoE-Verbesserungen bei Nutzung unserer TCAC-Methode. Wir erarbeiten zudem eine Methode mit absichtlicher Verzögerung der Umschaltvorgänge bei einem Wechsel des TV-Kanals (engl. intentional switching delay, iSD), um die Kanalverfügbarkeit in einem IPTV-System zu verbessern, das Benutzer beinhaltet, die sequentiell die Sender „zappen“. Umfassende Fallstudien wurden durchgeführt, die zeigen, dass unsere iSD-Methode die Kanalverfügbarkeit effektiv verbessern kann, mit nur einer leichten Verschlechterung der durchschnittlichen Wartezeit auf den Beginn der Bereitstellung des gewünschten Kanals nach einem Umschalten.

Schließlich leiten wir, mit dem Ziel der weiteren Verbesserung der IPTV-Kanalverfügbarkeit, einen kombinierten Algorithmus ab, der insbesondere die TCAC- mit der iSD-Methode kombiniert. Simulationsergebnisse zeigen, dass mit dieser kombinierten Methode zusätzlicher Gewinn erzielt werden kann, sofern die absichtliche Verzögerung, die durch die iSD-Methode eingeführt wird, hinreichend groß ist.

Acknowledgements

Though only my name is printed on the cover of this dissertation, the research that has gone into this dissertation would never be finished without a great many people's contributions. I owe my gratitude to all those people who have helped me from the outset to the very end.

First of all, my deepest gratitude is to my advisor Prof. Dr. Bernd E. Wolfinger, for his excellent guidance throughout the past four years. I feel amazingly fortunate to have such an advisor who is willing to teach me how to do high-quality research in a step by step manner, with great caring and patience. In addition, Prof. Wolfinger always helps me to find financial support for my academic conference attending.

The TKRN (Telecommunications and Computer Networks) research group has provided an excellent environment for my research. It has been a great pleasure working with my colleagues. I cannot forget how supportive Dr. Stephan Heckmüller was in my first two years. His comments on my work were always critical and helpful, which led one of our common works to win the best paper award of the SPECTS'2011 conference. I am grateful to Mr. Alireza Abdollahpouri, who is another very diligent PhD candidate at TKRN. We had a close cooperation. With him, I would not feel alone on the way to pursue the Doctorate. Many thanks to Mr. Andrey Kolesnikov, who always has been willing to help and give his best suggestions whenever I consulted him. I also would like to express my warm gratitude to the group members Dr. Klaus-Dieter Heidtmann, Dr. Martin Lehmann, Dr. Sudip Misra, Ms. Katrin Köster, and Mr. Torsten Meyer.

My father and my mother have always been my most important support during all these years, even if we are departed for thousands of miles. They are my constant source of love, concern, support and strength. Therefore, I sincerely thank them for all what they have done for me.

Last but not least, I would like to thank China Scholarship Council (CSC). My dissertation research has been sponsored by CSC under agreement number 2008605001, which ensured me to be able to focus on my research during my tenure as a doctoral student.

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