

SERVICE AND USER-BASED DISTRIBUTED SELECTION OF CONTENT STREAMING SOURCE AND DUAL ADAPTATION

DISEDAN PROJECT

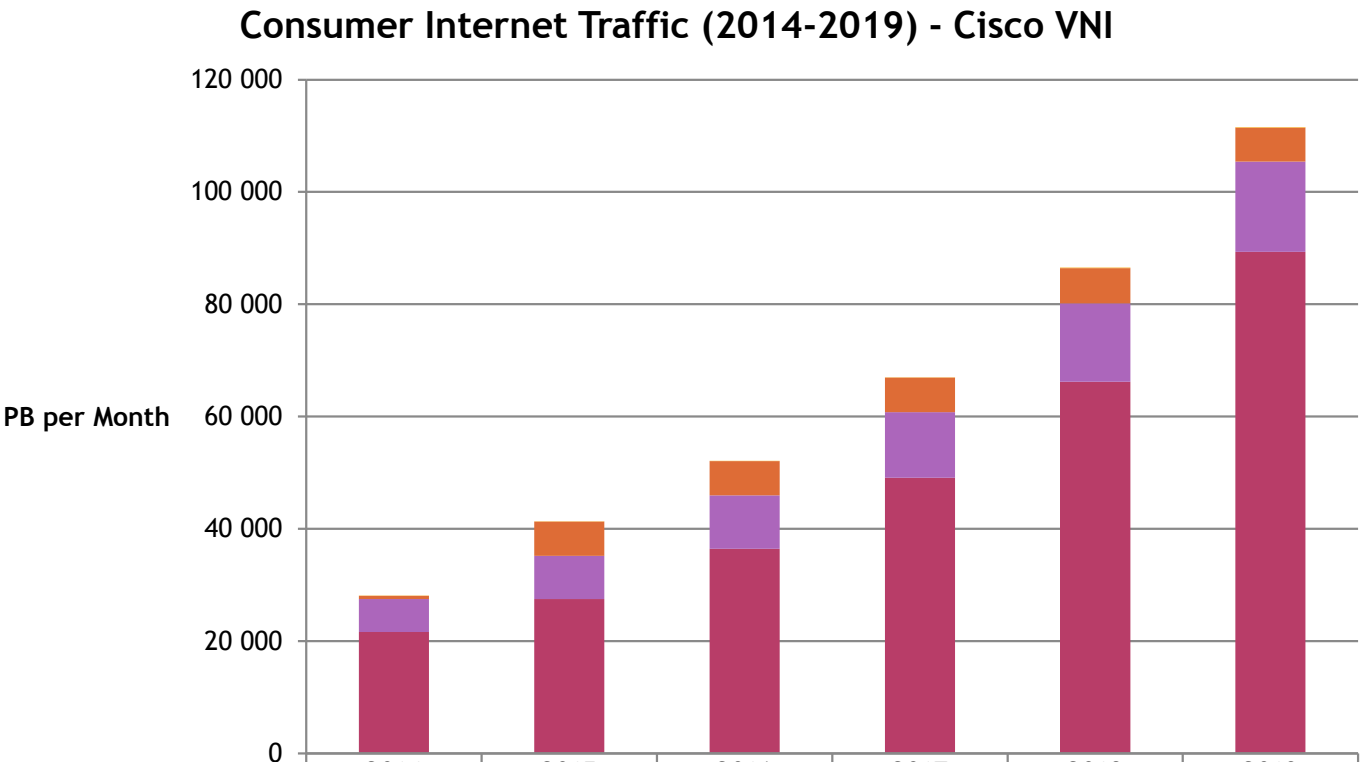
Start date: 01/01/2014
End date: 31/12/2015

Piotr Krawiec, Warsaw University of Technology

TABLE OF CONTENTS

- Scientific Background
- Key challenges
- Potential impact of the project
- DISEDAN Consortium
- Main Research results
- Publications, dissemination and other outputs
- Sustainability/Valorisation

SCIENTIFIC BACKGROUND (1/2)



	2014	2015	2016	2017	2018	2019
Online gaming	27	33	48	78	109	143
File sharing	609	6 146	6 130	6 168	6 231	6 038
Web, email, and data	5 853	7 694	9 476	11 707	14 002	16 092
Internet video	21 624	27 466	36 456	49 068	66 179	89 319

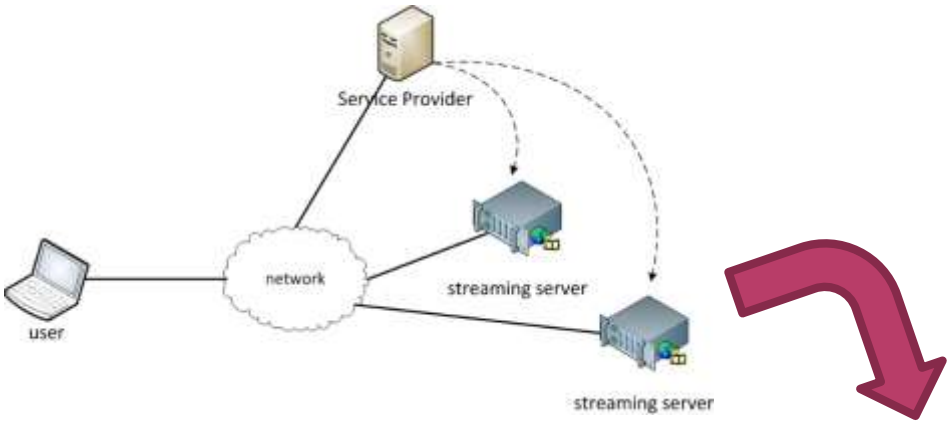
SCIENTIFIC BACKGROUND (2/2)

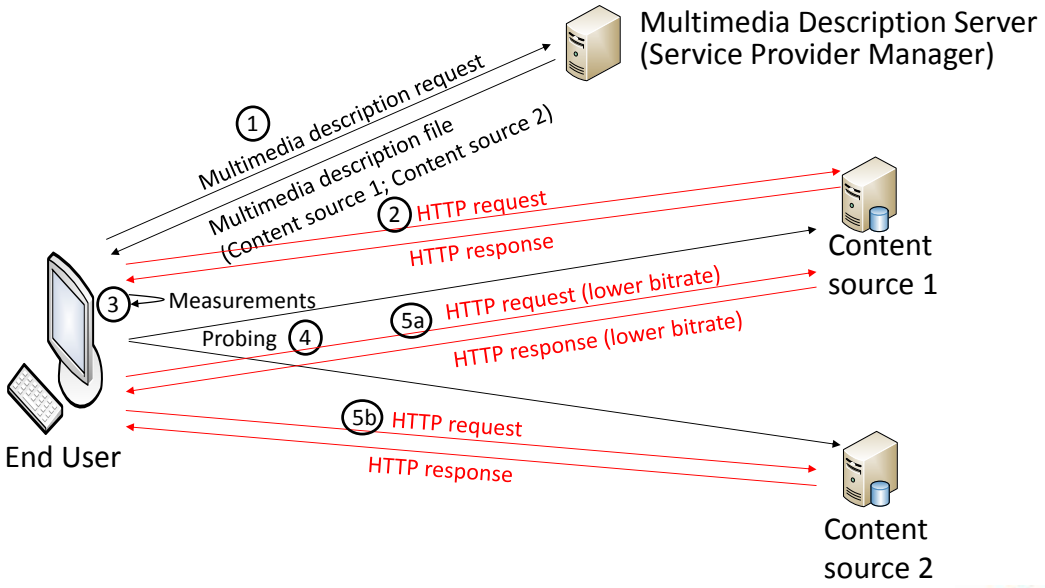
- In the last years, several new protocols and mechanisms for effective adaptive streaming have been proposed
  - Idea: continuously select the best (highest bitrate) representation of each chunk of video, whose bitrate is not higher than the network download rate
- Adaptive mechanisms are coping the market (Microsoft Smooth Streaming, HTTP Live Streaming, Adobe HTTP Dynamic Streaming, Dynamic Streaming over HTTP – DASH)
- DASH is called to be the reference into the market since it is open-standard and almost all the big companies are involved in its deployment
  - Hundreds of DASH-oriented papers have been published in the last few years
  - There are several open implementations of DASH

DISEDAN: KEY CHALLENGES (1/3)

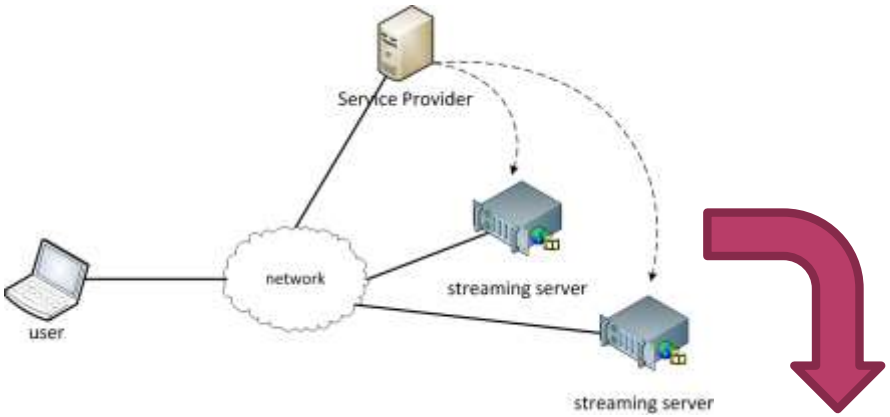
- DISEDAN researched on an effective solution for content streaming, consisting in:
  - multi-criteria optimized content source selection (hard problem) and
  - in-session adaptation and
  - multiple sources delivery
  - considering user context, servers availability and distribution mode, towards End User's QoE enhancement.
- The new concept is based on:
  - a two-step server selection mechanism (at Service Provider and at End User) making use of innovative algorithms that consider context- and content-awareness
  - a dual adaptation mechanism consisting of Media adaptation (also called media flow adaptation) and/or content source adaptation (by switching the streaming server) when the End User's QoE suffers degradation.
  - new encoding scheme and new multi-source delivery protocol.

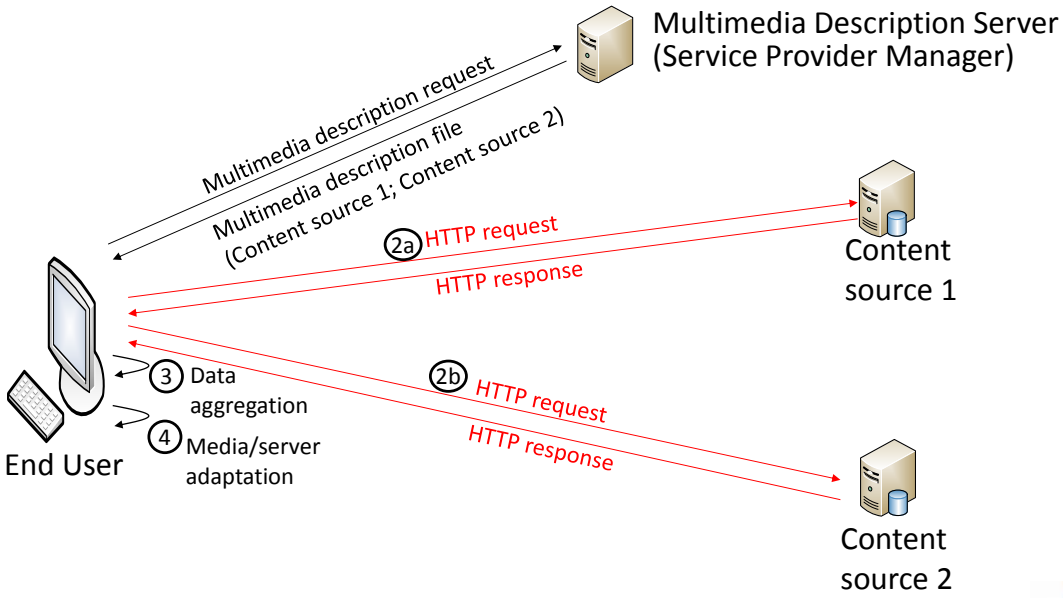
DISEDAN: KEY CHALLENGES (2/3)





DISEDAN: KEY CHALLENGES (3/3)





DISEDAN: POTENTIAL IMPACT

DISEDAN proposes a solution that can be rapidly deployed in the market since it does not require complex architecture

- DISEDAN: Over the Top (OTT) style of working - over multiple network domains
- however it still can benefit of some existent networking QoS technologies and/or provisioning capabilities at Network Provider level
- compatible with existing standards, lightweight and portable

DISEDAN CONSORTIUM

Disedan

- **Warsaw University of Technology**
- LaBRI - University of Bordeaux
- University "Politehnica" Bucharest

CONSORTIUM (1/3)

- Warsaw University of Technology
  - **Jordi Mongay Batalla**, Andrzej Bęben, Piotr Krawiec, Piotr Wiśniewski
- Background and added value to DISEDAN:
  - Participation in two ICN-oriented FP7 projects: ALICANTE and COMET, where we specified and implemented service adaptation methods and new forwarding mechanism in ICN
  - Participation in Eurostars DELTA project, which is oriented to the implementation of ICN in commercial network
  - More than twenty papers on this thematic (GC, ICC, Telecommunication Systems Journal, Annals of Telecommunications, etc.)
  - Deployment of software for streaming content (both client and server)
  - **Specific contributions to DISEDAN**: studies and experimentation on stream-switching adaptation, management protocols and server technologies, implementation of a part of the DISEDAN system in a testbed

CONSORTIUM (2/3)

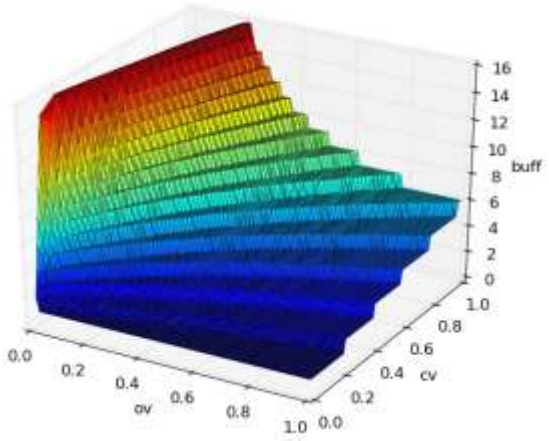
- LaBRI - University of Bordeaux
  - **Daniel Négru**, David Bromberg, Joachim Bruneau-Queyreix (PhD), David Bourasseau, Petros Anapliotis
- Background and added value to DISEDAN:
  - Participation in ICN/CAN-oriented FP7 ALICANTE IP project (2010-2013) (http://www.ict-alicante.eu/), where we designed and implemented context-aware features, as well as box-to-box P2P based streaming
  - More than a dozen papers in the fields of ICN, CCN, content delivery and adaptation mechanisms (conferences and journals)
  - **Specific contributions to DISEDAN**: Studies and experimentation on multi-criteria optimizations in multi-server content delivery; flexible design, implementation of a part of the DISEDAN system in a testbed, set-up of a dissemination/large-scale evaluation testbed on a website (http://mddash.homeb.tv:8080).

CONSORTIUM (3/3)

- University “Politehnica” Bucharest
  - **Eugen Borcoci**, Octavian Catrina, Cristian Cernat, Serban Obreja, Radu Iorga, Marius Vochin, Sorin Zoican
    - Ph.D student: Radu Badea
- Background and added value to DISEDAN:
  - **UPB team expertise relevant to DISEDAN : networked multimedia, QoS assurance, network and service management, performance evaluation,** networks architectures and Future Internet, communication protocols, traffic engineering, routing.
  - **Participation to previous projects -** in *networks and services* area: EuroNGI Network of Excellence (2003-2006), (www.eurongi.org); ENTHRONE I IP (2003-2005) (www.enthrone.org); WEIRD IP (2006-2008), (www.ist-weird.eu), EuroFGI - NoE (2006-2008) (www.eurongi.org), FP6 ENTHRONE II IP (2006-2008) (www.ist-enthrone.org); IST-FP7 -SMART-net Strep (2008-2011); FP7 ALICANTE IP (2010-2013) (http://www.ict-alicante.eu/)
  - **More than 40 papers** in the above areas (int’l conferences, journals)
  - **Specific contributions to DISEDAN**: Simulations studies on multi-criteria optimizations; flexible design and implementation of a part of the DISEDAN system in a testbed.

MAIN RESEARCH RESULTS (1/3)

- WUT
  - Development of a novel approach for stream-switching adaptation, named **ABMA** (**Adaptation & Buffer Management Algorithm**), that selects the video representation based on the estimated probability of playout rebuffering
  - Development of SW modules for integration of ABMA algorithm with open source VLC media player (the source code is available on the website)
  - Deployment of ABMA+ : rebuffering-based adaptation algorithm based on simple table querying

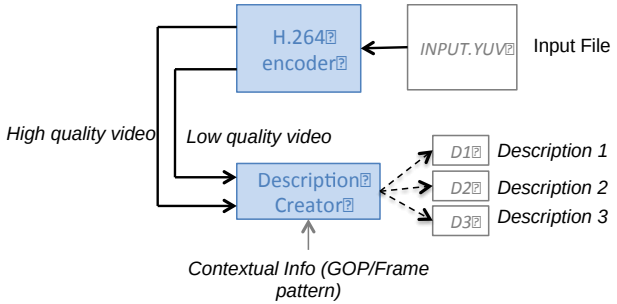


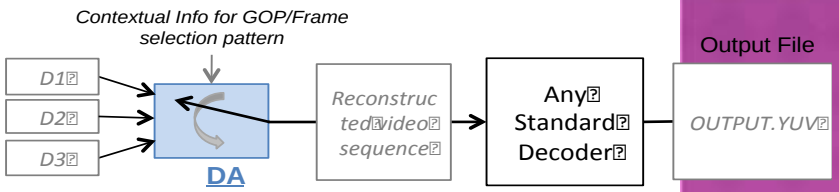
MAIN RESEARCH RESULTS (1/3)

- WUT
  - Specification of interoperability points between streaming protocol (DASH) and new H.265 (HEVC) codec. The proposed interoperability points offer higher compression for the HEVC content to be transmitted by using DASH streaming protocol
  - Research on the applicability of Evolutionary Multiobjective Optimization (EMO) algorithm to performing two-phase content server selection process
  - Design a novel dual adaptation algorithm dedicated for media delivery in Mobile Cloud Networks

MAIN RESEARCH RESULTS (2/3)

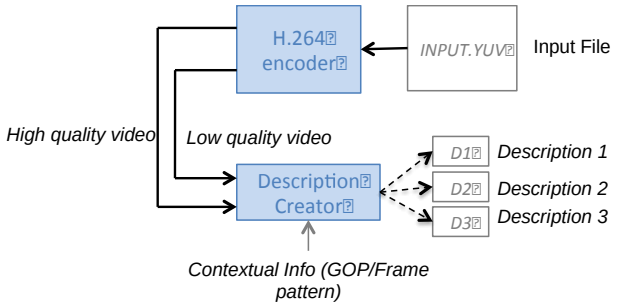
- LaBRI
  - Design and development of **Multiple-Description Dynamic Adaptive Streaming over HTTP (MD-DASH)** – a novel streaming protocol which merges multiple description coding (MDC) and HTTP-based streaming solution (DASH). MD-DASH enables multi-source media delivery.
  - Design of multiple description and quality-aggregable sub-streams encoding/decoding chain.
  - C++-based development of the MDC encoding/decoding chain to create and merge any codec standard-compliant descriptions

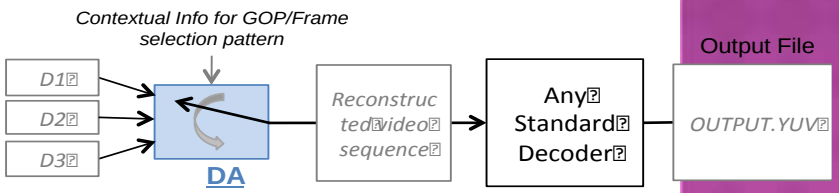




MAIN RESEARCH RESULTS (2/3)

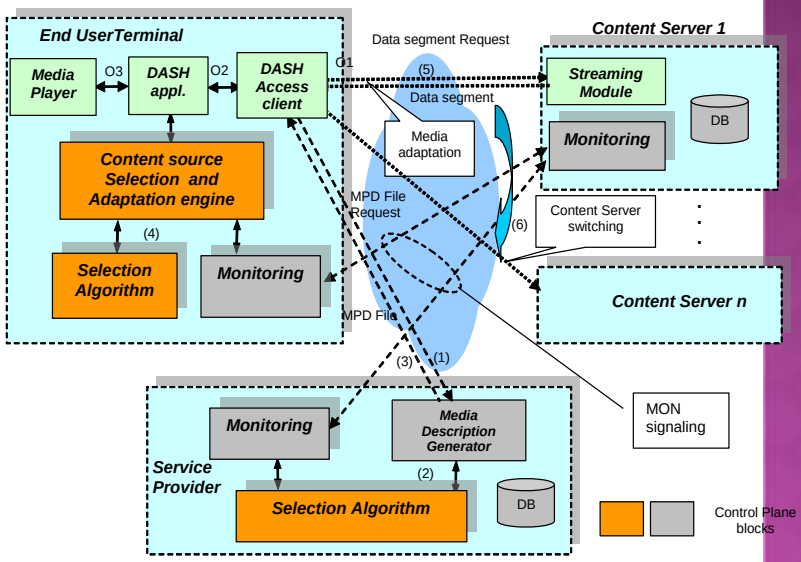
- LaBRI
  - Design and development of a novel per-stream adaptive bitrate algorithm taking into account content bitrate adaptation and server-switching
  - Javascript-based implementation of the MD-DASH protocol within DASH-Industry Forum's video player dash.js
  - Contribution to deeper understanding of caching strategies in content delivery. Study and design of online collaborative caching strategy.
  - Development of a high level middleware achieving the designed caching strategy and server selection





MAIN RESEARCH RESULTS (3/3)

- UPB
  - Contribution to deeper understanding of multi-criteria optimization in the case of server-path selection problems; study of different decisions trade-offs in various use-cases, based on static and/or dynamic parameters
  - Flexible design and implementation framework for DISEDAN system (family of incrementally different sets of implementations of Control Plane for Service Provider, Content Server, End User Terminal)
  - Development of SW modules for two-step path- server selection based on MCDA algorithms.
  - Simulation models and implementation of two versions SW (C++ for small - medium size networks; OMNET++ and C++ for large size networks)



MAIN RESEARCH RESULTS (3/3)

- UPB
  - Development of a set of SW modules for multi-content server and path selection system for media distribution. The set includes the functionalities at Service Provider, Content Server and End User Terminal
    - The MCDA selection algorithm is incorporated both at SP level and EUT one.
    - Two versions of the EUT software (Linux-based for fixed terminals and Android-based for mobile terminals)
    - Flexible monitoring system is implemented, giving the possibility to experiment a rich/thin set of solutions in terms of the information amount available for selection.

PUBLICATIONS (1/4)

- 29 scientific publications: 13 journal, 16 international conferences

- Selected publications:
- Chapters in books
  - [1] J. Mongay Batalla (WUT), “Adaptation of Content Source Resources and Media Streaming in Mobile Cloud Networks”. Chapter published on Resource Management of Mobile Cloud Computing Networks and Environments Book, edited by IGI-Global Eds. (2014).
- International Journals (1/2)
  - [1] J. Mongay Batalla, P. Krawiec, A. Bęben, P. Wiśniewski and A. Chydziński (WUT), “Adaptive video streaming: rate and buffer on the track of minimum re-buffering”. To be published in IEEE Journal on Selected Areas in Communications, 2016.
  - [2] J. Mongay Batalla (WUT), “Advanced Multimedia Service Provisioning based on efficient interoperability of adaptive streaming protocol and High Efficient Video Coding”. Springer Journal of Real-Time Image Processing, 2015
  - [3] J. Mongay Batalla, A. Bęben (WUT) and Y. Chen (LaBRI), “Optimized decision algorithm for Information Centric Networks”. Springer Telecommunication Systems Journal, 2015.

PUBLICATIONS (2/4)

- International Journals (2/2)
  - [4] J. Mongay Batalla (WUT), C.X. Mavromoustakis (UNic), G. Mastorakis (TEIC), D.Négru (LaBRI), E.Borcoci (UPB), “Evolutionary Multiobjective Optimization algorithm for two-phase content source selection process in Content Aware Networks”. **Submitted** to Springer Supercomputing Journal.
  - [5] J. Mongay Batalla, P. Krawiec (WUT), D Négru, J. Bruneau-Queyreix (LaBRI), E. Borcoci (UPB), A. Bęben and P. Wiśniewski (WUT), “On providing Cloud-awareness to client’s DASH application by using DASH over HTTP 2.0”, Journal of Telecommunications and Information Technology, 2015, vol. 4, pp. 54-64.
  - [6] E.Borcoci, M.Vochin, M.Constantinescu (UPB), J.M.Batalla (WUT), D.Negru, (LaBRI), "Server and Path Selection in a Light Architecture Content Streaming System with Dual Adaptation", Int'l Journal on Advances in Networking and services, NetSer15v8n12, pages: 92 - 105,
  - [7] E.Borcoci, R.Iorga, C.Cernat, M.Vochin, S.Obreja (UPB), J.M.Batalla (WUT), D.Negru (LABRI), "Design of a Flexible Over the Top Content Streaming System with Dual Adaptation", International Journal On Advances in Telecommunications, v 8 n 3&4 2015,
  - [8] P. Krawiec, J. Mongay Batalla (WUT), C. X. Mavromoustakis, G. Mastorakis, N. Chilamkurti, D. Négru, J. Bruneau-Queyreix (LaBRI) and Eugen Borcoci (UPB), “Efficient media streaming with collaborative terminals for smart city environment”. **Submitted** to IEEE Communications Magazine.

PUBLICATIONS (3/4)

- Selected papers:
  - A. Bęben, J. Mongay Batalla, P. Wiśniewski, P. Krawiec (WUT), “ABMA+ : lightweight and efficient algorithm for HTTP adaptive streaming”, ACM Multimedia Systems (MMSys), Klagenfurt (Austria), May 2016
  - J. Bruneau-Queyreix, D. Negru (LaBRI), J. Mongay Batalla (WUT) and E. Borcoci (UPB), "Multiple Description-DASH: Pragmatic video streaming maximizing End-Users' Quality of Experience", IEEE International Conference on Communication, Kulala Lumpur (Tailandia), May 2016
  - S.G.Obreja, R.Iorga, E.Borcoci, C.Cernat, M,Vochin (UPB), J. Mongay Batalla (WUT), J.Bruneau-Queyreix, Daniel Negru (LABRI), "Over the Top Content Streaming Adaptive System- Implementation and Validation", la CTRQ 2016, The Ninth International Conference on Communication Theory, Reliability, and Quality of Service
  - P. Wiśniewski, A. Bęben, J. Mongay Batalla, P. Krawiec (WUT), “On delimiting video rebuffering for stream switching adaptive applications”. IEEE International Conference on Communications ICC. London, UK. June 2015.

PUBLICATIONS (4/4)

- Selected papers:
  - J. Bruneau-Queyreix, D. Negru (LaBRI), J. Mongay Batalla (WUT) and E. Borcoci (UPB), “Home-Boxes: Context-aware distributed middleware assisting content delivery solutions”, ACM/IFIP/USENIX Middleware. Poster session. Bordeaux (France). December 2014.
  - G. Skourletopoulos, C. X. Mavromoustakis, G. Mastorakis, J. P. C. Rodrigues, P. Chatzimisios and J. Mongay Batalla (WUT), “A Fluctuation-Based Modelling Approach to Quantification of the Technical Debt on Mobile Cloud-Based Service Level”. IEEE Globecom 2015. San Diego. USA. December 2015.
  - O.Catrina, E.Borcoci (UPB) and P.Krawiec (WUT), „Two-Phase Multi-criteria Server Selection for Lightweight Video Distribution Systems”, 27th IFIP TC7 Conference June 2015 on System Modeling and Optimization, Integration of Optimization, Modeling and Data Analysis for Solving Real World Problems
  - J. Bruneau-Queyreix, D. Négru (LaBRI) and J. Mongay Batalla (WUT), “Home-Box based collaborative caching strategy: An asset for Content Delivery Networks”, International Conference on Telecommunications and Multimedia 2014. IEEE TEMU 2014. Heraklion (Crete), July 2014.
  - O. Catrina and E.Borcoci (UPB) “On Multi-Criteria Video Server Selection”, Submitted to Int’l Conference on Communication 2016 IEEE Comm2016, Bucharest 9-11, June 2016

DISSEMINATION AND OTHER OUTPUTS

- Contact with operators
  - Presentation to Orange and NASK – Poland
  - Presentation to TELEKOM - Romania
- PhD:
  - UPB: two PhD students have defended their PhD Theses focused, in part, on the thematic of DISEDAN – Radu Badea- Ph.D student
    - *Marius Vochin* (one chapter: Contributions to policies and selection algorithmsfor paths-servers in content aware networks - dedicated to DISEDAN system)
    - *Radu Alexandru Badea* (one chapter: Performance Models for Content Servers, is fully dedicated to DISEDAN system)
  - LaBRI: one PhD student (Joachim Bruneau-Queyreix) actively participated in DISEDAN reasearch and he is writing the PhD Thesis at this moment in the thematic of DISEDAN

DISSEMINATION AND OTHER OUTPUTS

- B.Sc. and M.Sc. Students
  - WUT: 1 B.Sc. and 2 M.Sc. students have dedicated their diploma work/thesis to DISEDAN topics
  - UPB: 3 B.Sc. and 1 M.Sc. students have dedicated their diploma work/thesis to DISEDAN topics
  - LaBRI: 2 M.Sc. students have dedicated their diploma thesis to DISEDAN topics
- Other dissemination at Universities
  - WUT has introduced three lectures dedicated to Multimedia streaming in Future Internet
  - UPB has presented DISEDAN concepts and solutions at Master courses
  - LaBRI has launched project based on DISEDAN concepts and MD-DASH protocol

SUSTAINABILITY / VALORISATION

- Industry domain
  - A possible follow-up of DISEDAN proof of concept : the development of a complete system, applying DISDEAN approach
  - **Any industry interest? – yes: recently positive feedback received on DISEDAN solution**
    - **TELEKOM Operator** – Romania –DISEDAN solution is considered to be of interest for development of new enhanced streaming services
    - **ORANGE Operator Poland**- DISEDAN approach could be of interest for the operators which build a strategy oriented on OTT – CDN solutions. This is also the case of ORANGE Romania.
    - ORANGE opinion:
      - The explosive growth in video traffic across the Internet is both a challenge and a huge opportunity for operators carrying this traffic to the content consumers. Services delivery from the CPs is currently typically handled by traditional CDNs that deliver OTT of operator networks.
      - Operators can focus on delivering a differentiated QoE and a "pay as you use" model to better satisfy the subscribers and additionally provide revenue opportunities from the CPs that have been flooding their network with ever-higher-quality OTT video offerings.

SUSTAINABILITY / VALORISATION

- **Academy/research domain**
  - DISEDAN-based, use case studies –material and lab. framework
    - Objective: multi-criteria optimizations and DASH techniques advanced studies
    - Where: university master and Ph.D studies - in the area of content streaming
  - **Research continued on DISEDAN solutions in correlation with topics as**
    - Information Centric Networking
    - DASH technology development
    - Further development of OTT style of service delivery
    - Investigation on possible of DISEDAN concepts extension (multiple server- multipath selection, multiple description – multipath adaptive streaming) for efficient content delivery in novel contexts (e.g. 5G networks)

SUSTAINABILITY / VALORISATION

- Software:
  - Development of SW modules for path- server selection based on MCDA algorithms
  - Development of two versions of the End User Terminal (client) software (Linux and Android)
  - Development of a high level middleware achieving the designed caching strategy and multi-criteria server selection
  - Javascript-based implementation of the MD-DASH protocol within DASH-Industry Forum's video player dash.js
  - Development of Adaptation & Buffer Management Algorithm (ABMA)

- Patent opportunities:
  - Two steps server selection mechanism
  - Media adaptation based on the estimated probability of video rebuffering

THANK YOU!