

CONVINcE

D6.2.2

Publication Report #2

Editor: Samin Mohammadi (IMT-TSP)

Reviewer: Ulf Körner (LU)

Authors: Samin Mohammadi (IMT-TSP)

Reza Farahbakhsh (IMT-TSP)

Noel Crespi (IMT-TSP)

Nancy Perrot (OL)

Saeed Bastani (LU)

Bjorn Landfeldt (LU)

Adrian Popescu (BTH)

Yong Yao (BTH)

Erkki Harjula (UO)

Pawani Porambage (UO)

Siwar Ben Hadj Said (CEA)

1 EXECUTIVE SUMMARY

The goal of the document is to report the publication activities of the CONVINCe project partners during the project period. The report includes three main parts:

1) Potential events that are relevant to the general idea and scope of the project

As the project addresses the challenge of reducing power consumption in IP-based video networks, a list of the relevant journals, conferences, workshops and exhibitions has been prepared, including their name, scope and goal of each, with the goal of to make a brief and summarized check list of potential opportunities to publish and disseminate project outputs. This list covers most of the topics that is targeted by CONVINCe project, such as video encoding/transcoding, adaptive bit streaming, core/access networks, energy consumption in CDNs, SDN/NFV, routing protocols, power and QoE measurements and etc.

2) Detail information of the published scientific papers in the project

Partners have published in summary 48 scientific papers out of their activities in the projects. The main topics that are covered by the published papers are:

- Minimizing content access delay in the general CDN architecture,
- Energy consumption in content delivery networks,
- Performance evaluation of distributed data delivery on Mobile devices using WebRTC,
- Key establishment protocols in WSNs,
- Characterizing new links and content sharing strategies among OSNs users,
- Energy saving in content-oriented networks,
- Comparing performance measurements,
- New schemes to reduce energy consumption along the e2e routing path.

The papers have published in the high ranked international conferences, journals and workshops such as ICC'15, SNCNW'15, ASONAM'15, EUCNC'15 and IEEE Communication Magazine, ICC'17, GlobeCom'16, ICIN'16, EUCNC'16.

3) A summary of the partners' participation to the project's relevant events. Partners of the project participated to 26 scientific events such as international conferences and workshops, where the goal was to present the main results of the project technical activities including the published papers, to the community.

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2 DOCUMENT HISTORY AND ABBREVIATIONS

2.1 Document history

Version	Date	Description of the modifications
0.1	05.01.2017	Draft of ToC (IMT-TSP)
0.2	01.02.2017	Updated by published papers and participated events (integrated inputs)
0.3	07.02.2017	Updated by partners final comments – Final version for review
0.4	16.02.2017	Reviewed by LU
1	20.02.2017	Final Version

2.2 Abbreviations

CDNs	Content Delivery Networks
ITS	Intelligent Transportation Systems
C2R3	Cooperative Content Replication and Request Routing
QoE	Quality of Experience
HIP	Host Identity Protocol
WSNs	Wireless Sensor Networks
OSNs	Online Social Networks
IoT	Internet of Things

3 INTRODUCTION

The project leads significant scientific output and therefore publication is a significant component of the project output. Based on the project proposal, publication strategy has two different main goals, publishing scientific results of the project in worthwhile journals and conferences, and disseminating project outputs among researchers and industry by participating to related events. The purpose of this document is to gather the information on publications.

3.1 Document structure

This report covers the result of two main goals of Task 6.2:

- Scientific publications of the project activities
- Participation in workshops and conferences and other relevant events.

Both lead to present and disseminate project outputs.

In section 4, there is the list of possible related events and journals that can be targeted to publish papers and present project results. Section 5 presents the general information of published or submitted scientific papers. In section 6 we give a list of events that partners have participated to present project outputs so far. Section 0 concludes the document and summarizes the publication results.

4 POSSIBLE EVENTS TO BE TARGETED

Here is the list of possible journals, conferences, workshops and exhibitions that cover the main topic of project. This list can be considered by partners to publish their stand-alone papers, or joint paper addressing the main goals of the project. The list is also consisting of relevant workshops and exhibitions to attend and present project outputs.

4.1 Relevant Journals

- IEEE Communication Magazine

IEEE Communications Magazine provides timely information on all aspects of communications: monthly feature articles describe technology, systems, services, market trends, development methods, regulatory and policy issues, and significant global events.

- IEEE Network Magazine

IEEE Network, published bimonthly, offers readers topics of interest to the networking community. As such, IEEE Network provides a focus for highlighting and discussing major computer communications issues and developments.

- IEEE Transactions on Smart Grid

The IEEE Transactions on Smart Grid is a cross disciplinary and internationally archival journal aimed at disseminating results of research on smart grid that relates to, arises from, or deliberately influences energy generation, transmission, distribution and delivery.

- IEEE Transactions on Intelligent Transportation Systems

The IEEE Transactions on ITS is concerned with the design, analysis, and control of information technology as it is applied to transportation systems. The IEEE ITS Transactions is focused on the numerous technical aspects of ITS technologies spanned by the IEEE.

- Elsevier Journal of Computer Network

Computer Networks is an international, archival journal providing a publication vehicle for complete coverage of all topics of interest to those involved in the computer communications networking area.

- Elsevier Journal of Network and Computer Applications

The Journal of Network and Computer Applications welcomes research contributions, surveys and notes in all areas relating to computer networks and applications thereof.

- International Journal of Communication Systems (Wiley)

The International Journal of Communication Systems provides a forum for R&D, open to researchers from all types of institutions and organizations worldwide, aimed at the increasingly important area of communication technology. The Journal's emphasis is particularly on the issues impacting behavior at the system, service and management levels.

4.2 Relevant Conferences

- IEEE International Communication Conference (ICC)

ICC is an annual international [academic conference](#) as an opportunity to share pioneering research ideas and developments, it is also an excellent networking and publicity event, giving

the opportunity for businesses and clients to link together, and presenting the scope for companies to publicize themselves and their products among the leaders of communications industries from all over the world.

- IEEE GLOBECOM

IEEE GLOBECOM is one of two flagship conferences of the IEEE Communications Society, together with IEEE ICC. It is one of the most significant scientific events of the networking and communications community, a must-attend event for scientists and researchers from industry and academia.

- IEEE Conference on Computer Communications (INFOCOM)

INFOCOM addresses key topics and issues related to computer communications, with emphasis on traffic management and protocols for both wired and wireless networks.

- IEEE GreenCom

IEEE Greencom is an online conference on green communications, and is dedicated to addressing the challenges in energy-efficient communications and communications for green technologies.

- International Conference on Cloud Computing (CLOUD)

The IEEE Cloud is a prime international forum for both researchers and industry practitioners to exchange the latest fundamental advances in the state of the art and practice of cloud computing, identify emerging research topics, and define the future of cloud computing.

4.3 Relevant Workshops and Seminars

- ACM: Workshop on Energy-Efficient Data Centers

It is a workshop co-located with the ACM e-Energy conference, the International Conference on Future Energy Systems.

- IEEE/ACM: Extreme Green & Energy Efficiency in Large Scale Distributed Systems

The workshop aims to provide a venue for discussion of ideas that can demonstrate "more than small % solution" to energy efficiency and their applicability to "real world".

- IEEE(ICC): Next Generation Green ICT

This workshop is co-located with ICC conference, it aims to find an opportunity to detect, prevent, and automate solutions for energy efficiency as well as creating a more sustainable society. It has three main areas : Energy Efficiency in ICTs, ICTs for Energy Efficiency, and Green Broadband Access.

- IEICE: International Workshop on Energy Efficiency in Wireless Networks

The aim of Workshop is to present and discuss the latest research and development issues in the area of energy efficiency in wireless networks.

- IEEE Globecom: Green Standardization and Industry Issues for ICT and Relevant Technologies (GSICT)

This workshop is to collect results and visions of standards, regulations and public policies on global green revolutions relevant to information and communication technologies (ICT) and other relevant issues, including both the impact of ICT on the environments and the impact of environments on ICT.

4.4 Relevant “industry-oriented” opportunities

- IBC (<http://www.ibt.org/page.cfm/link=1029>)

IBC is the premier annual event for professionals engaged in the creation, management and delivery of entertainment and news content worldwide. Originally the International Broadcasting Convention, IBC has evolved from its technical broadcast roots and today it encompasses the whole breadth of media creation management and delivery, from online content to digital cinema, from automated workflows to high resolution capture and display.

- NAB (<http://www.nab.org/events/awards/overview.asp?id=2280>)

As the premier trade association for broadcasters, NAB advances the interests of our members in federal government, industry and public affairs; improves the quality and profitability of broadcasting; encourages content and technology innovation; and spotlights the important and unique ways stations serve their communities.

- Greentouch (<http://www.greentouch.org/>)

GreenTouch was a consortium of leading Information and Communications Technology (ICT) industry, academic and non-governmental research experts dedicated to fundamentally transforming communications and data networks, including the Internet, and significantly reducing the carbon footprint of ICT devices, platforms and networks.

4.5 Partners' intention to participate in conferences & exhibitions

Table 1 is based on the final CPP of the project and shows different partners intention to participate or disseminate in relevant conferences and exhibitions.

Table 1- Conferences & exhibitions relevant to the topics of CONVINCe project

Partner name	ACM MSWIM	GreenCom	IEEE IPDP	IEEE Cloud	IBC 2015	IBC2 016	IEEE IPDPS	QoMEX2015 & 2016	ACM SenSys	ACM EuroSys	INOC	ITC	COMM 2016	WWRF 2016	CES 2016	MWC 2016	IEEE GLOBACOM	ANGA 2015	ANGA 2016	IEEE SDN4FNS	GoGreen
Harmonic					x	x															
Orange Labs		x									x	x									
GreenSpector		x																			
CEA LIST	x	x							x	x							x				x
IMT		x		x																	
VTT							x														
University of Oulu	x	x							x	x	x						x				
Ericsson				x					x							x					x
Teleste					x	x												x	x		
BTH		x						x				x	x								
Lund University	x	x	x			x															
TelHoc		x														x					
SONY Mobile						x									x	x					

5 PUBLISHED SCIENTIFIC PAPERS

This section includes the scientific publications of the project which is the result of individual partners' activities and the published outcome of their research work out of the CONVINCe project.

In summary, CONVINCe has 48 published papers in 46 conferences and 2 journals where the project results are disseminated. The following table includes a summary of published/submitted scientific papers.

5.1 Summary of published papers

Table 2 - Summary of Published Scientific Papers

Paper Title	Journal/Conference name	Journal/Conference Date	Partner Name
REPLICA T7-16-128 - A 2048-threaded 16-core 7-FU chained VLIW chip multiprocessor	48th Asilomar Conference on Signals, Systems, and Computers	November 2-5, 2014	VTT
SAND-Assisted Encoding Control for Energy-Aware MPEG-DASH Live Streaming	The 24th International Conference on Software, Telecommunication and Computer Networks(SoftCOM 2016)	September 2016	VTT
Energy Consumption Evaluation of H.264 and HEVC Video Encoders in High Quality Live Streaming	The 12th IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob 2016)	October 2016	VTT
Outline of a Thick Control Flow Architecture	The 5th Workshop on Parallel Programming Models Special Edition on Task Parallelism	October 26-28, 2016	VTT
The REPLICA on-chip network	The 2016 IEEE Nordic Circuits and Systems Conference	November 1-2, 2016	VTT
Towards optimal content replication and request routing in content delivery networks	IEEE International Conference on Communications (ICC 2015), UK, London	8-12 June, 2015	LU
A Simulation Package for Energy Consumption of Content Delivery Networks (CDNs)	OMNeT++ Community Summit 2015, Switzerland, Zurich	3-4 September, 2015	LU
A Study on Energy Used to Deliver H.264/AVC and H.265/HEVC Video Content	2016 IEEE 21st International Workshop on Computer Aided Modelling and Design of Communication Links and Networks (CAMAD)	October 23-25 2016	LU
Cross-layer energy optimization for dynamic video streaming over Wi-Fi	19th International ICIN Conference - Innovations in Clouds, Internet and Networks 1st Workshop on Green Communication Systems	March 1-3 2016	LU
Resource management for OFDMA based next generation 802.11 WLANs	2016 9th IFIP Wireless and Mobile Networking Conference (WMNC)	July 11-13, 2016	LU

Performance Evaluation of Distributed Data Delivery on Mobile Devices Using WebRTC	IEEE International Wireless Communications & Mobile Computing Conference (IWCMC 2015)	August 24-27, 2015	UO
RADE: Resource-aware Distributed Browser-to-browser 3D Graphics Delivery in the Web	IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob 2015)	October 19-21, 2015	UO
Proxy-based End-to-End Key Establishment Protocol for the Internet of Things	IEEE ICC 2015 Workshop on SECURITY AND PRIVACY FOR INTERNET OF THINGS AND CYBER-PHYSICAL SYSTEMS,	8-12 June, 2015	UO
Efficient Key Establishment for Constrained IoT Devices with Collaborative HIP-based Approach	IEEE GLOBECOM 2015, At San Diego, CA, USA	2015	UO
Group Key Establishment for Secure Multicasting in IoT-enabled Wireless Sensor Networks	IEEE LCN 2015, At Clearwater Beach, Florida, USA	2015	UO
Group Key Establishment for Enabling Secure Multicast Communication in Wireless Sensor Networks Deployed for IoT Applications	IEEE Access	2015	UO
Secure and Efficient Reactive Video Surveillance for Patient Monitoring	Sensors 2016, 16(1), 32	January 2, 2016	UO
Secure End-to-End Communication for Constrained Devices in IoT-enabled Ambient Assisted Living Systems	IEEE World Forum on Internet of Things (WF-IoT)	December 14-16, 2015	UO
Quantitative Power Consumption Analysis of a Multi-tier Wireless Multimedia Sensor Network	European Wireless (EW'16)	May 18-20, 2016	UO
Energy-efficient peer-to-peer networking for constrained-capacity mobile environments	Doctoral dissertation, University of Oulu	July 1, 2016	UO
Energy-aware load monitoring for improving battery life of mobile peer-to-peer nodes	Sustainable Computing: Informatics and Systems 12, 43-54	December 2016	UO
Energy efficient motion detection in a high-resolution wireless surveillance camera node	15th International Conference on Mobile and Ubiquitous Multimedia	December 12-15, 2016	UO
The Quest for Privacy in Internet of Things Solutions and Future Research Directions: A Holistic Perspective	IEEE Cloud Computing, 2016	June 1, 2016	UO
Characterization of Cross-posting Activity for Professional Users Across Major OSNs	ASONAM 2015	25-28 August, 2015	IMT

Link Prediction for New Users in Social Networks	ICC 2015	8-12 June, 2015	IMT
How Far is Facebook from Me? Facebook Network Infrastructure Analysis	IEEE Communication Magazine	2015	IMT
Video Content Delivery Enhancement in CDNs based on Users' Social Information	GLOBECOM 2016, QoEMC Workshop	December 2016	IMT
A Cost and Carbon Emission-Efficient Virtual machine placement method for green distributed clouds	SCC 2016	August 2016	IMT
Popularity Evolution of Users on OSNs	ICC 2017	May 2017	IMT
Energy saving in content-oriented networks	CIE'45 proceedings	2015	OL
Optimal Placement of Controllers in a Resilient SDN Architecture	DRCN 2016	March 2016	OL
Estimates of the economic impact of energy savings in the E2E chain for Video on Demand and Over The Top services	Networks 2016	September 2016	OL
Energy-Efficient Load Balancing in SDN-based Data-Center Network	Networks 2016	September 2016	OL
Hypervisors vs. Lightweight Virtualization: a Performance Comparison	Workshop on Containers (WoC) at IEEE IC2E	March 2015	ER
Power Aware Media Delivery Platform Based on Containers	Workshop on Green Communications Systems at ICIN 2016	1-3 March, 2016	ER
Inspecting the Performance of Low-Power Nodes during the Execution of Edge Computing Tasks	IEEE CCNC'17 (edge computing workshop)	11.1.2017	ER
Power Consumption in Remote Gaming: an Empirical Evaluation	IEEE Global Internet Symposium (GI) 2016	April 11, 2016	ER, BHT
On the Performance of Uplink Transmission in Cognitive Radio Mesh Networks	Swedish National Computer Networking Workshop (SNCNW)	May, 2015	BTH
On Prioritized Uplink Transmission in Cognitive Radio Mesh Networks	EUCNC	June 29/July 2, 2015	BTH
CONVINcE : Greening of Video Distribution Networks	3rd International Symposium on Energy Challenges and Mechanics - towards a big picture	7-9 July 2015	BTH
Dealing with QoE and Power Consumption in Video Distribution Networks	COMM 2016: The 11th International Conference on Communications	June 9-11, 2016	BTH
On Energy Consumption in Mobile Multimedia Networks with OpenFlow Switch	COMM 2016: The 11th International Conference on Communications	June 9-11, 2016	BTH

CONVINcE: Towards Power-Optimized Video Distribution Networks	19th International ICIN Conference	March 1-3, 2016	BTH, Sony Mobile, Harmonic
QoE-Aware Sustainable Throughput for Energy-Efficient Video Streaming	SustainCom 2016	October 8 - 10, 2016	BTH
Managing OTT Traffic in a SDN/NVF Scenario	ICC - GCC 2017 (submitted)	May 21-25, 2017	BTH
On the Performance of Video Streaming in Energy-Aware Wireless Mesh Networks	EuCNC 2017 (submitted)	June 12-15, 2017	BTH
Quality of Experience on Smartphones: Network, Application and Energy Perspectives	1st Workshp on Green Communications Systems – ICIN	1-3 March 2016	BTH
Energy Savings for Video Streaming using Fountain Coding	1st Workshp on Green Communications Systems – ICIN	1-3 March 2016	TelHoc

5.2 Details on published papers

This section provides detailed information on the abovementioned papers. It also includes the connection to the project for each paper.

Lund University	
Title	Towards optimal content replication and request routing in content delivery networks
Authors and Affiliation	Payam Amani, Saeed Bastani, Bjorn Landfeldt. (Department of Electrical and Information Technology, Lund University, Sweden)
Event	2015 IEEE International Conference on Communications (ICC 2015), UK, London
Abstract	Cooperative content replication and request routing (C2R3) has emerged as a promising technique to enhance the efficiency of content delivery networks (CDN). Most existing approaches to C2R3 focus on efficient bandwidth usage and assume a hierarchical CDN architecture targeted towards the delivery of specific content types (e.g., video). Therefore, C2R3 problem of covering the broad range of content types with minimum content access delay in a general CDN architecture has attracted little attention. As a potential solution to C2R3, cooperative web caching techniques have become mature. However, these techniques were designed to improve performance indicators tailored to web contents only (i.e., hit rate and byte hit rate). Arguably, improving such indicators does not necessarily lead to optimal access delay especially when the current trend of user-generated contents with diverse popularities and sizes are taken into account. In this paper, we formulate C2R3 as an optimization problem with the objective of minimizing content access delay in a general CDN architecture. A new performance indicator is introduced, and two popularity-based cooperative algorithms are proposed to approach the NP-hard C2R3 problem. Under broad ranges of cache size and popularity distribution parameters, we compare the proposed methods with a cooperative recency-based web caching method. Our simulation results show that the popularity-based methods outperform the recency-based method, and demonstrate close to optimal performance in representative scenarios of real-world situations.
Connection to the project	In this paper, we have proposed an optimization model and a distributed algorithm for minimum-latency content distribution in CDNs. This work is in alignment with the goals of CONVINCe project due to the following reasons: first, energy consumption is proportional to content access delay, i.e. the higher the delay the higher the energy consumption per bit of content delivery. Thus, inarguably, improving the access delay will result in the enhancement of energy consumption, although the optimal solutions for the two cases may not coincide. Second, we have addressed the case of user-generated contents characterized by a heavy-tail popularity distribution which, again, conforms to the key objectives of CONVINCe project in addressing those challenges related to the new trend of content generation on the Internet.
Title	A Simulation Package for Energy Consumption of Content Delivery Networks (CDNs)
Authors and Affiliation	Mohammadhassan Safavi, Saeed Bastani. (Department of Electrical and Information Technology, Lund University, Sweden)
Event	OMNeT++ Community Summit 2015, Switzerland, Zurich
Abstract	Content Delivery Networks (CDNs) are becoming an integral part of the future generation Internet. Traditionally, these networks have been designed with the goals of traffic offload and the improvement of users' quality of experience (QoE), but the energy consumption is also becoming an indispensable design factor for CDNs to be a sustainable solution. To study and improve the CDN architectures using this new design metric, we are planning to develop a generic and flexible simulation package in OMNeT++. This package is aimed to render a holistic view about the CDN energy consumption behavior by incorporating the state-of-the-art energy consumption models proposed for the individual elements of CDNs (e.g. servers, routers, wired and wireless

	links, wireless devices, etc.) and for the various Internet contents (web pages, files, streaming video, etc.).
Connection to the project	In this paper, we have proposed a simulation package to be developed in OMNeT++ discrete event simulation software. The layered and modular architecture of the proposed package allows for incremental implementation of the simulation components, one at a time, and with regards to our demands in the CONVINCe project (mainly in WP3). The main purpose of this simulation package is to enable large-scale experiments about the behaviour of energy consumption in content delivery networks. This simulation package is aimed to assess and verify the models/protocols subject to development within the Task 3.3 of WP3 (energy saving in CDNs).
Title	A Study on Energy Used to Deliver H.264/AVC and H.265/HEVC Video Content
Authors and Affiliation	Mohammadhassan Safavi, Saeed Bastani and Zhi Zhang (Lund University, Sweden); Martti Forsell (VTT, Finland); Olli Mämmelä (VTT Technical Research Centre of Finland, Finland); Bjorn Landfeldt (Lund University, Sweden)
Event	2016 IEEE 21st International Workshop on Computer Aided Modelling and Design of Communication Links and Networks (CAMAD)
Abstract	We propose an end-to-end approach to describe the energy usage of video delivery within a content delivery framework, and use this to investigate the energy usage behavior of two popular coding schemes, namely, H.264/AVC and H.265/HEVC. Our study based on the proposed model is backed up by measurements of encoding and decoding energy usage of a sample video and shows that, from an end-to-end perspective, taking into account all the elements of a content delivery network, neither of the coding formats is always dominant in terms of energy saving. We also find that the popularity of video content is a key parameter for predicting which encoding scheme saves most energy. In particular, we find that H.265 encoded content results in lower energy usage if the content is highly popular. On the other hand, for a content with predicted low popularity, more saving is achieved if H.264/AVC is used. This leads us to calculate a hybrid content delivery scheme, where the contents with low popularity are encoded and delivered in H.264/AVC format, whereas content of high popularity are encoded and delivered in the H.265/HEVC format. Also, our findings offer new insights into which elements of energy usage should be the focus of future research
Connection to the project	Using an end to end model for energy consumption, we investigate for which popularity of content the two transcoding schemes (H.264 and HEVC) offer a better saving of energy use for video delivery by a content distribution network.
Title	Cross-layer energy optimization for dynamic video streaming over Wi-Fi
Authors and Affiliation	Zhi Zhang, Mehmet Karaca, Farnaz Moradi, Björn Landfeldt and Saeed Bastani (Lund University, Sweden); Anders Plymoth (Maxentric Technologies, USA); Rickard Ljung (Sony Mobile, Sweden)
Event	19th International ICIN Conference - Innovations in Clouds, Internet and Networks 1st Workshop on Green Communication Systems
Abstract	Dynamic Adaptive Streaming over HTTP (DASH) constitutes a large fraction of traffic in the mobile Internet. Mobile devices often use video delivery over Wi-Fi, which is a significant energy drain. Dynamic Power Saving Mode (DPSM) is one of the most widely-used approaches for Wi-Fi devices to save power and shorten packet delay. However, DPSM uses a fixed timeout before a device goes to sleep, leading to excessive energy use in many cases. In this paper, we propose a crosslayer lightweight dynamic timeout adjustment algorithm. The application layer measures the Round-Trip Time (RTT) of video segments in the current timeout setup, determines an updated

	<p>timeout, sets it to the medium access control layer and requests the next video quality based on the RTT and RTT change. We evaluate our algorithm via simulations in OMNeT++ and show that compared with the legacy Wi-Fi DPSM for DASH, our algorithm reduces the average power consumption in the radio front end while significantly improving the fairness among users. Moreover, the new algorithm retains video quality while achieving better energy efficiency. The improvement increases in significance with increasing number of users, which means that the new algorithm works well in dense scenarios.</p>
Connection to the project	<p>A crosslayer lightweight dynamic timeout adjustment algorithm is proposed for HTTP DASH based video streaming over WiFi. We show that, compared with the legacy Wi-Fi DPSM for DASH, our algorithm reduces the average power consumption in the radio front end while significantly improving the fairness among users and retaining video quality.</p>
Title	<p>Resource management for OFDMA based next generation 802.11 WLANs</p>
Authors and Affiliation	<p>Mehmet Karaca and Saeed Bastani (Lund University, Sweden); Basuki Endah Priyanto (Sony Mobile Communications AB, Sweden); Mohammadhassan Safavi and Bjorn Landfeldt (Lund University, Sweden)</p>
Event	<p>2016 9th IFIP Wireless and Mobile Networking Conference (WMNC)</p>
Abstract	<p>Recently, IEEE 802.11ax Task Group has adapted OFDMA as a new technique for enabling multi-user transmission. It has been also decided that the scheduling duration should be same for all the users in a multi-user OFDMA so that the transmission of the users should end at the same time. In order to realize that condition, the users with insufficient data should transmit null data (i.e. padding) to fill the duration. While this scheme offers strong features such as resilience to Overlapping Basic Service Set (OBSS) interference and ease of synchronization, it also poses major side issues of degraded throughput performance and waste of devices' energy. In this work, for OFDMA based 802.11 WLANs we first propose practical algorithm in which the scheduling duration is fixed and does not change from time to time. In the second algorithm the scheduling duration is dynamically determined in a resource allocation framework by taking into account the padding overhead, airtime fairness and energy consumption of the users. We analytically investigate our resource allocation problems through Lyapunov optimization techniques and show that our algorithms are arbitrarily close to the optimal performance at the price of reduced convergence rate. We also calculate the overhead of our algorithms in a realistic setup and propose solutions for the implementation issues.</p>
Connection to the project	<p>In this work, for OFDMA based 802.11 WLANs we propose an algorithm to tune the scheduling duration dynamically by taking into account the padding overhead, airtime fairness and energy consumption of the users.</p>

University of Oulu - Center for Internet Excellence	
Title	Performance Evaluation of Distributed Data Delivery on Mobile Devices Using WebRTC
Authors and Affiliation	Arto Heikkinen, Timo Koskela, Mika Ylianttila, Center for Internet Excellence, University of Oulu, Finland
Event	IEEE International Wireless Communications & Mobile Computing Conference (IWCMC 2015), August 24-27, Dubrovnik, Croatia
Abstract	Direct peer-to-peer connectivity between web browsers is becoming reality with the emerging and constantly developing WebRTC technology stack. This opens possibilities for new kind of plugin-free web applications, such as browser-to-browser file transfers and multi-party conferencing. In this paper, the performance of WebRTC on mobile devices is evaluated with different mobile device, wireless network connectivity and web browser configurations. The evaluation was conducted with a WebRTC test environment that was implemented based on PeerJS JavaScript library and PeerServer signaling server. The measurements include session establishment delay and overhead, session maintenance overhead, resource consumption of multiple simultaneous file transfers and efficiency of different file transfer approaches. Based on the results, the delay for establishing a WebRTC connection may in the worst cases exceed even 10 seconds making it a serious bottleneck. However, from the standpoints of memory consumption and CPU load, high-end mobile devices are very capable of running multiple simultaneous WebRTC connections for data transfers. The results of this paper provide new insight to researchers, application and browser developers and WebRTC standardization bodies.
Connection to the project	This paper is the foundation for our research work with WebRTC-based green video streaming/delivery solutions. Based on this preliminary evaluation of generic performance measurements with WebRTC, we can develop more energy efficient solutions for video networking utilizing WebRTC's video streaming capabilities while avoiding some bottlenecks such as slow connection establishment. The evaluation on different file transfer approaches can be utilized for developing more efficient and less energy consuming video-on-demand solutions. Our findings indicate that transmitting data between web browsers using multiple simultaneous data channels can improve the transmission performance. This can reduce also energy consumption as the radio interface needs to be active for a shorter period of time.
Title	RADE: Resource-aware Distributed Browser-to-browser 3D Graphics Delivery in the Web
Authors and Affiliation	Timo Koskela, Arto Heikkinen, Erkki Harjula, Mikko Levanto, Mika Ylianttila, Center for Internet Excellence, University of Oulu, Finland
Event	IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob 2015), October 19-21, Abu Dhabi, UAE [Accepted]
Abstract	With the introduction of novel standardized web technologies such as WebGL, 3D virtual environments (VEs) are making their way into the web. Concurrently, resource rich mobile devices, such as smartphones and tablets, have become the primary access medium for the web. This paper introduces a method called RADE that enables resource-aware P2P-assisted 3D asset delivery in a web browser using WebRTC. Use of P2P technology in 3D asset delivery can (1) decrease the load on 3D asset servers; (2) decrease the application response times; and (3) reduce the operational costs of VE service providers. The performance and resource fairness of RADE was evaluated in real-life wireless networks using a prototype implementation. Based on the results, RADE can significantly reduce the server load and the 3D asset delivery times especially when 3D asset servers are under heavy load. For instance, with a scarce server bandwidth of 2Mbps, use of RADE resulted in 55% shorter 3D asset delivery times on average. Although RADE has been developed for

	3D asset delivery, it is applicable for many types of web applications, including video delivery.
Connection to the project	This paper introduces RADE, a resource-aware approach for distributed data delivery between web browsers using WebRTC. Although the focus of the paper is in 3D asset delivery, the same resource-aware method can be used also for video delivery applications. This is supported by the fact that one of the main and most advertised features of WebRTC is video streaming between web browsers. Resource-awareness is an important factor when designing a energy-efficient distributed video delivery system. Energy consumption can be optimized by preferring the most energy-efficient nodes and battery life can be extended by preferring the nodes with the highest battery levels. We are planning to utilize this approach for video delivery and compare the energy-efficiency to a more traditional client-server based video delivery.
Title	Secure and Efficient Reactive Video Surveillance for Patient Monitoring
Authors and Affiliation	An Braeken, Pawani Porambage, Andrei Gurtov, Mika Ylianttila
Event	Sensors 2016, 16(1), 32
Abstract	Video surveillance is widely deployed for many kinds of monitoring applications in healthcare and assisted living systems. Security and privacy are two promising factors that align the quality and validity of video surveillance systems with the caliber of patient monitoring applications. In this paper, we propose a symmetric key-based security framework for the reactive video surveillance of patients based on the inputs coming from data measured by a wireless body area network attached to the human body. Only authenticated patients are able to activate the video cameras, whereas the patient and authorized people can consult the video data. User and location privacy are at each moment guaranteed for the patient. A tradeoff between security and quality of service is defined in order to ensure that the surveillance system gets activated even in emergency situations. In addition, the solution includes resistance against tampering with the device on the patient's side.
Connection to the project	This paper proposes a symmetric key-based security framework for the reactive video surveillance of patients that considers also system-level energy-efficiency.
Title	Secure End-to-End Communication for Constrained Devices in IoT-enabled Ambient Assisted Living Systems
Authors and Affiliation	Pawani Porambage, An Braeken, Andrei Gurtov, Mika Ylianttila, Susanna Spinsante
Event	IEEE World Forum on Internet of Things (WF-IoT)
Abstract	The Internet of Things (IoT) technologies interconnect broad ranges of network devices irrespective of their resource capabilities and local networks. In order to upgrade the standard of life of elderly people, Ambient Assisted Living (AAL) systems are also widely deployed in the context of IoT applications. To preserve user security and privacy in AAL systems, it is significant to ensure secure communication link establishment among the medical devices and the remote hosts or servers that are interested in accessing the critical health data. However, due to the limited resources available in such constrained devices, it is challenging to exploit expensive cryptographic operations in the conventional security protocols. Therefore, in this paper we propose a novel proxy-based authentication and key establishment protocol, which is lightweight and suitable to safeguard sensitive data generated by resource-constrained devices in IoT-enabled AAL systems.

Connection to the project	The paper proposes a novel proxy-based authentication and key establishment protocol, which is lightweight and suitable to safeguard sensitive data generated by resource-constrained devices in e.g. video surveillance networks.
Title	Quantitative Power Consumption Analysis of a Multi-tier Wireless Multimedia Sensor Network
Authors and Affiliation	Pawani Porambage, Arto Heikkinen, Erkki Harjula, Andrei Gurtov, Mika Ylianttila
Event	European Wireless (EW'16)
Abstract	Wireless multimedia sensor networks provide a platform of interconnected devices that are able to ubiquitously retrieve multimedia content. The provided content may include video and audio streams and still images in addition to traditional scalar data such as temperature, humidity or light intensity. In this paper, we implement a video surveillance application on a multi-tier wireless multimedia sensor network. The key contributions of this work are the implementation of the given network architecture on Libelium Waspmote platform and the evaluation of power consumption between single-tier and multi-tier architectures. We report power consumption of the system with respect to different scenarios and states such as video acquisition, processing, and uploading. The results demonstrate that with the selected hardware platform, the total energy consumption of a video surveillance scenario can be halved by using multi-tier compared with a single-tier architecture.
Connection to the project	The paper shows that the total energy consumption of a video surveillance scenario can be halved by using multi-tier architecture, compared to a single-tier architecture
Title	Energy-efficient peer-to-peer networking for constrained-capacity mobile environments
Authors and Affiliation	Erkki Harjula
Event	Doctoral dissertation, University of Oulu
Abstract	Energy efficiency is a powerful measure for promoting sustainability in technological evolution and ensuring feasible battery life of end-user devices in mobile computing. Peer-to-peer technology provides decentralized and self-organizing architecture for distributing content between devices in networks that scale up almost infinitely. However, peer-to-peer networking may require lots of resources from peer nodes, which in turn may lead to increased energy consumption on mobile devices. For this reason, peer-to-peer networking has so far been considered unfeasible for mobile environment. This thesis makes several contributions towards enabling energy-aware peer-to-peer networking in mobile environments. First, an empirical study is conducted to understand the energy consumption characteristics of radio interfaces and typical composition of traffic in structured peer-to-peer networks. This is done in order to identify the most essential obstacles for utilizing peer-to-peer technology in mobile environments. Second, the e-Aware model for estimating the energy consumption of a mobile device is developed and empirically verified to achieve 3-21% error in comparison to real-life measurements. Third, the e-Mon model for the energy-aware load monitoring of peer nodes is developed and demonstrated to improve the battery life of mobile peer nodes up to 470%. Fourth, the ADHT concept of mobile agent based virtual peers is proposed for sharing the peer responsibilities between peer nodes in a subnet so that they can participate in a peer-to-peer overlay without compromising their battery

	life. The results give valuable insight into implementing energy-efficient peer-to-peer systems in mobile environments. The e-Aware energy consumption model accelerates the development of energy-efficient networking solutions by reducing the need for time-consuming iterations between system development and evaluations with real-life networks and devices. The e-Mon load monitoring model facilitates the participation of battery-powered devices in peer-to-peer and other distributed networks by enabling energy-aware load balancing where energy-critical mobile nodes carry less load than other nodes. The ADHT facilitates the participation of constrained-capacity wireless devices, such as machine-to-machine nodes, in a peer-to-peer network by allowing them to sleep for most of their time.
Connection to the project	The dissertation gives a valuable insight into implementing energy-efficient networking systems for mobile environments, which is also one of the most important measures to improve energy-efficiency of video delivery systems.
Title	Energy-aware load monitoring for improving battery life of mobile peer-to-peer nodes
Authors and Affiliation	Erkki Harjula, Andrei Gurtov, Timo Koskela, Timo Ojala, Mika Ylianttila
Event	Sustainable Computing: Informatics and Systems 12, 43-54
Abstract	In this article, we propose an energy-aware load monitoring model, called e-Mon, for enabling energy-aware load balancing in Peer-to-Peer (P2P) systems. P2P is a scalable and self-organizing technology for utilizing computational resources of the end-user devices for the benefit of a computing system. In P2P systems, the need for fair balance of load is crucial since the end-users need to be incentivized to participate in the system. The short battery life, caused by additional strain on the computational resources of the end-user devices, is a significant negative incentive factor for mobile end-users of current P2P systems. The e-Mon model, proposed in this article, enables moving load from energy-critical to less energy-critical nodes in P2P systems. This is done by including the energy status of a peer node as one of the factors defining a node's load. The model helps saving the energy of mobile P2P nodes, particularly in cases when the remaining battery capacity is low. The article provides a thorough energy-efficiency evaluation demonstrating that e-Mon can significantly improve the battery life of mobile nodes by improving the quality and fairness of load balance between heterogeneous nodes. With a proper selection of a load balancing model for the application scenario, e-Mon is shown to achieve up to 470% battery life extension compared to the case with traditional load balancing with no battery monitoring.
Connection to the project	The paper proposes and evaluates an energy-aware load monitoring allowing moving load from energy-critical to less energy-critical nodes in mobile networking systems. This feature is necessary in distributed video sensor networks, making the paper valuable from CONVINCe viewpoint.
Title	Energy efficient motion detection in a high-resolution wireless surveillance camera node
Authors and Affiliation	Tenager Mekonnen, Erkki Harjula, Mika Ylianttila
Event	15th International Conference on Mobile and Ubiquitous Multimedia
Abstract	In this demo we present an energy efficient motion detection mechanism for a high-resolution wireless (battery powered) surveillance camera node. We use Raspberry Pi (RPI) as a camera sensor node to demonstrate two scenarios. In the first scenario, the RPI performs motion detection using Pyro-electric

	InfraRed (PIR) sensor, while in the latter we use an external low-power node to keep the RPi in low power mode and at the same time detect motion using PIR sensor. The main contributions of this demo are the power management implementation, a surveillance application and the evaluation of power consumption between the two scenarios.
Connection to the project	The work demonstrates power management mechanism of a raspberry pi based camera sensor node for surveillance application. The mechanism helps saving energy in video surveillance systems.
Title	The Quest for Privacy in Internet of Things Solutions and Future Research Directions: A Holistic Perspective
Authors and Affiliation	Pawani Porambage, Corinna Schmitt, Pradeep Kumar, Andrei Gurtov, Mika Ylianttila, Athanasios V. Vasilakos
Event	IEEE Cloud Computing, 2016
Abstract	The Internet of Things (IoT) is the current evolutionary paradigm of networking and the key driving force toward a smart world. Although privacy in the IoT is highly regarded to ensure the protection of users and personal information from the perspective of individual or cooperative users, it's insufficiently studied. As members of the always-connected paradigm of the massive IoT world, people can scarcely control the disclosure of their personal information. The biggest challenge is to allow users to experience the best utilization of IoT-based products and services with the fewest privacy threats and failures. This article provides a holistic view of the challenges of and issues related to preserving IoT privacy, as well as the existing solutions. Privacy by design (PbD) is identified as the key solution for many IoT privacy issues. The article also discusses hot topics in IoT privacy and future research directions.
Connection to the project	The paper provides a holistic view of the challenges of and issues related to preserving IoT privacy, accompanied by energy-efficient, low-cost, high-performance, and scalable algorithms.

University of Oulu - Center for wireless Communications	
Title	Proxy-based End-to-End Key Establishment Protocol for the Internet of Things
Authors and Affiliation	Pawani Porambage (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. pporamba@ee.oulu.fi), An Braeken (Vrije Universiteit Brussel, INDI, 1000 Brussels, Belgium. an.braeken@vub.ac.be), Pardeep Kumar (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. pkumar@ee.oulu.fi), Andruei Gurtov (Helsinki Institute for Information Technology (HIIT) and Department of Computer Science, Aalto University, FI-00076 Aalto, Finland. gurtov@cs.helsinki.fi), Mika Ylianttila (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. mika.ylianttila@ee.oulu.fi)
Event	IEEE ICC 2015 Workshop on SECURITY AND PRIVACY FOR INTERNET OF THINGS AND CYBER-PHYSICAL SYSTEMS, At London, UK
Abstract	The Internet of Things (IoT) drives the world towards an always connected paradigm by interconnecting wide ranges of network devices irrespective of their resource capabilities and local networks. This would inevitably enhance the requirements of constructing dynamic and secure end-to-end (E2E) connections among the heterogeneous network devices with imbalanced resource profiles and less or no previous knowledge about each other. The device constraints and the dynamic link creations make it challenging to use pre-shared keys for every secure E2E communication scenario in IoT. We propose a proxy-based key establishment protocol for the IoT, which enables any two unknown high resource constrained devices to initiate secure E2E communication. The high constrained devices should be legitimate and maintain secured connections with the neighboring less constrained devices in the local networks, in which they are deployed. The less constrained devices are performing as the proxies and collaboratively advocate the expensive cryptographic operations during the session key computation. Finally, we demonstrate the applicability of our solution in constrained IoT devices by providing performance and security analysis.
Connection to the project	This paper proposes a proxy-based key establishment protocol for resource-constrained networking devices in the context of the Internet of Things. The main objective of deriving this key establishment protocol is to obtain a secure end-to-end communication channel between two completely unknown devices. In Task 4.3, it is expected to develop energy saving mechanisms for security and privacy on terminals. This work is an initial attempt of deriving such lightweight energy security solutions.
Title	Efficient Key Establishment for Constrained IoT Devices with Collaborative HIP-based Approach
Authors and Affiliation	Pawani Porambage (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. pporamba@ee.oulu.fi), An Braeken (Vrije Universiteit Brussel, INDI, 1000 Brussels, Belgium. an.braeken@vub.ac.be), Pardeep Kumar (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. pkumar@ee.oulu.fi), Andrei Gurtov (Helsinki Institute for Information Technology (HIIT) and Department of Computer Science, Aalto University, FI-00076 Aalto, Finland. gurtov@cs.helsinki.fi), Mika Ylianttila (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. mika.ylianttila@ee.oulu.fi)
Event	IEEE GLOBECOM 2015, At San Diego, CA, USA
Abstract	The Internet of Things (IoT) technologies interconnect wide ranges of network devices irrespective of their resource capabilities and local networks. The device constraints and the dynamic link creations make it challenging to use pre-shared keys for every secure end-to-end (E2E) communication scenario in IoT. Variants of Host Identity Protocol (HIP) are adopted for constructing

	dynamic and secure E2E connections among the heterogeneous network devices with imbalanced resource profiles and less or no previous knowledge about each other. We propose a collaborative HIP solution with an efficient key establishment component for the high constrained devices in IoT, which delegates the expensive cryptographic operations to the resource rich devices in the local networks. Finally, we demonstrate the applicability of the key establishment in collaborative HIP solution for the constrained IoT devices rather than the existing HIP variants, by providing performance and security analysis.
Connection to the project	This paper is an extension of IEEE ICC paper (Ref. [1] in paper). In this work, we exploit the well-known Host Identity Protocol (HIP) in a collaborative manner to establish secure end-to-end communication channels between two completely unknown devices. It is proven in the performance analysis that the proposed protocol exhibits a very low energy profile. In Task 4.3, it is expected to develop energy saving mechanisms for security and privacy on terminals. This work derives such lightweight energy security solutions with low energy consumptions. Furthermore, we have described an application scenario for E-health, where the protocol can be deployed to initiate secure E2E connections between scalar and multimedia sensors.
Title	Group Key Establishment for Secure Multicasting in IoT-enabled Wireless Sensor Networks
Authors and Affiliation	Pawani Porambage (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. pporamba@ee.oulu.fi), An Braeken (Vrije Universiteit Brussel, INDI, 1000 Brussels, Belgium. an.braeken@vub.ac.be), Pardeep Kumar (Communication Systems Group, IfI, University of Z"urich, Binzm"uhlestrasse 14, CH-8050 Z"urich, Switzerland. schmitt@ifi.uzh.ch), Andrei Gurtov (Helsinki Institute for Information Technology (HIIT) and Department of Computer Science, Aalto University, FI-00076 Aalto, Finland. gurtov@cs.helsinki.fi), Mika Ylianttila (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. mika.ylianttila@ee.oulu.fi), Burkhard Stiller (Communication Systems Group, IfI, University of Z"urich, Binzm"uhlestrasse 14, CH-8050 Z"urich, Switzerland. stiller@ifi.uzh.ch)
Event	IEEE LCN 2015, At Clearwater Beach, Florida, USA
Abstract	Wireless Sensor Network (WSN) is a fundamental technology of the Internet of Things (IoT). Group communications in the form of broadcasting and multicasting incur efficient message deliveries among resource-constrained sensors in IoT-enabled WSNs. Secure and efficient key management is significant to protect the authenticity, integrity, and confidentiality of multicast messages. This paper develops two group key establishment protocols for secure multicast communications among resource-constrained devices in IoT. The applicability of the two protocols are analyzed and justified by performance and security analysis.
Connection to the project	This paper proposes two group key establishment protocols for securing multicast communication in the context of IoT applications and discusses their performance in different scenarios. It is mentioned in Task 4.3, that one goal is to develop efficient keying algorithms and authentication solutions for secure group communication in multicasting scenarios of Wireless Multimedia Sensor Networks (WMSNs). Our solution provides an answer to the following research question.
Title	Group Key Establishment for Enabling Secure Multicast Communication in Wireless Sensor Networks Deployed for IoT Applications
Authors and Affiliation	Pawani Porambage (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. pporamba@ee.oulu.fi) An Braeken (Vrije Universiteit Brussel, INDI, 1000 Brussels, Belgium. an.braeken@vub.ac.be)

	<p>Pardeep Kumar (Communication Systems Group, IfI, University of Zürich, Binzmühlestrasse 14, CH-8050 Zürich, Switzerland. schmitt@ifi.uzh.ch)</p> <p>Andrei Gurtov (Helsinki Institute for Information Technology (HIIT) and Department of Computer Science, Aalto University, FI-00076 Aalto, Finland. gurtov@cs.helsinki.fi)</p> <p>Mika Ylianttila (Centre for Wireless Communications, University of Oulu, P.o.Box 4500, FI-90014 Oulu, Finland. mika.ylianttila@ee.oulu.fi)</p> <p>Burkhard Stiller (Communication Systems Group, IfI, University of Zürich, Binzmühlestrasse 14, CH-8050 Zürich, Switzerland. stiller@ifi.uzh.ch)</p>
Event	IEEE Access
Abstract	<p>Wireless sensor networks (WSNs) are a prominent fundamental technology of the Internet of Things (IoTs). Rather than device-to-device communications, group communications in the form of broadcasting and multicasting incur efficient message deliveries among resource-constrained sensor nodes in the IoT-enabled WSNs. Secure and efficient key management is in many cases used to protect the authenticity, integrity, and confidentiality of multicast messages. This paper develops two group key establishment protocols for secure multicast communications among the resource-constrained devices in IoT. Major deployment conditions and requirements of each protocol are described in terms of the specific IoT application scenarios. Furthermore, the applicability of the two protocols is analyzed and justified by a comprehensive analysis of the performance, scalability, and security of the protocols proposed.</p>
Connection to the project	<p>This paper is an extension of our work accepted for IEEE LCN (paper #3). The extensions of this work here include the detailed descriptions of mechanisms and schemes along with application scenarios and the discussion of performance, security, and scalability analysis. Similar to paper #3, this work also falls under Task 4.3 of CONVINCe project.</p>

Institut Mines Telecom- Telecom SudParis	
Title	Characterization of Cross-posting Activity for Professional Users Across Major OSNs
Authors and Affiliation	Reza Farahbakhsh(Institut Mines-Telecom, Telecom SudParis), Angel Cuevas(Universidad Carlos III de Madrid), Noel Crespi(Institut Mines-Telecom, Telecom SudParis)
Event	ASONAM 2015
Abstract	Online Social Networks (OSNs) are being intensively used by professional users (e.g., companies, politician, athletes, celebrities, etc) in order to interact with a huge amount of regular OSN users with different purposes (marketing campaigns, customer feedback, public reputation, etc). Hence, due to the large catalog of existing OSNs, professional users usually count with OSN accounts in different systems. In this context an interesting question is whether professional users publish the same information across their OSN accounts, or actually they use different OSNs in a different manner. We define as cross-posting activity the action of publishing the same information in two or more OSNs. In this paper we aim at characterizing the crossposting activity of professional OSN users across three major OSNs, Facebook, Twitter and Google+. To achieve this goal we perform a large-scale measurement-based analysis across more than 2M posts collected from 616 professional users with active accounts in the three referred OSNs.
Connection to the project	The techniques that are used for user profiling and behavior analysis can be reused on the user profiling part of our use case. Also in our use case, we need to understand what amount of information (specifically Video) has been shared in professional users interactions in social networks, which can be extract from this paper results.
Title	Link Prediction for New Users in Social Networks
Authors and Affiliation	Xiao Han(Institut-Mines Telecom, Telecom SudParis), Leye Wang(Institut-Mines Telecom, Telecom SudParis), Son N. Han(Institut-Mines Telecom, Telecom SudParis), Chao Chen(Chongqing University), Noel Crespi(Institut-Mines Telecom, Telecom SudParis), Reza Farahbakhsh(Institut-Mines Telecom, Telecom SudParis)
Event	ICC 2015
Abstract	Link prediction for new users who have not created any link is a fundamental problem in Online Social Networks (OSNs). It can be used to recommend friends for new users to start building their social networks. The existing studies use cross platform approaches to predict a new user's links on a certain OSN by porting his existing links from other OSNs. However, it cannot work when OSNs are not willing to share their data or users do not want to connect different OSN accounts. In this paper, we use a single-platform approach to carry out the link prediction. We explore the users' profile attributes (e.g., workplace, high school and hometown) which can be easily obtained during the new users' sign up procedure. Based on the limited available information from the new user, along with the attributes and links from existing users, we extract three types of social features: basic feature, derived feature and latent Connection feature. We propose a link prediction model using these social features based on Support Vector Machines. Eventually, we rely on a large Facebook data set consisting of 479; 000 users to evaluate our proposed model. The result reveals that our model outperforms the baselines by achieving the AUC value of 0:83; it also demonstrates that each of the proposed social features contributes significantly to the prediction model.
Connection to the project	Part of this approach is to cluster users and find similarity between them based on their profile information. The contribution of this study is related to our use

	case which is going to keep content near to end users at CDN networks based on similarity between users.
Title	How Far is Facebook from Me? Facebook Network Infrastructure Analysis
Authors and Affiliation	Reza Farahbakhsh(Institut-Mines Telecom, Telecom SudParis), Angel Cuevas(Universidad Carlos III de Madrid, Spain), Antonio M. Ortiz(Montimage, Paris, France), Xiao Han(Institut-Mines Telecom, Telecom SudParis), Noel Crespi(Institut-Mines Telecom, Telecom SudParis)
Event	IEEE Communication Magazine
Abstract	Facebook (FB) is today the most popular social network with more than one billion subscribers worldwide. To provide good quality of service (e.g., low access delay) to their clients, FB relies on Akamai which provides a worldwide content distribution network with a large number of edge servers that are much closer to FB subscribers. In this paper we aim at depicting a global picture of the current FB network infrastructure deployment taking into account both native FB servers and Akamai nodes. Towards this end, we have performed a measurement based analysis during a period of two weeks using 463 PlanetLab nodes distributed across 41 different countries. Based on the obtained data we compare the average access delay that nodes in different countries experience accessing both native FB servers and Akamai nodes. In addition, we obtain a wide view of the deployment of Akamai nodes serving FB users worldwide. Finally, we analyze the geographical coverage of those nodes, and demonstrate that in most of the cases Akamai nodes located in a particular country not only service local FB subscribers, but also FB users located in nearby countries.
Connection to the project	Understanding how a big CDN is deployed and a large customer of CDN is serving its services to end users, is very useful for our solutions which aims to improve the video content delivery in a large CDN.
Title	Video Content Delivery Enhancement in CDNs based on Users' Social Information
Authors and Affiliation	Praboda Rajapaksha, Reza Farahbakhsh, Samin Mohammadi, Matthew N. Dailey, Noel Crespi
Event	GLOBECOM 2016, QoEMC Workshop
Abstract	With the huge growth of multimedia communication and digital content availability, energy efficient content delivery became an important research topic with the goal of reducing energy consumption of the intermediary nodes while providing better services and QoE to the end users. In this paper we focus on the subject of reducing the overall network energy consumption in accessing user generated content over social media platforms. We propose an approach, namely SocialiVideo which enables users to directly share their generated video content among existing social connections. We combine the approaches used in CDNs and P2P networks together with social connections between people in order to shorten the path the data traverses on average, and improve the latency. SocialiVideo places video content in users' premises (e.g., set-top-boxes) and serve others using a P2P connection. To this end, we use users' geolocation information retrieved from their network data (IP address) as well as subscribed social networks (e.g. current city attribute in Facebook) and social characteristics (e.g. friends list, and activities, etc.). In-order to evaluate the performance of the proposed solution, we implement our prototype based on Facebook/Akamai content delivery approach and evaluates the performance with reference to the current solution of the Facebook. Based on the results, SocialiVideo unload the traffic of the network and CDN, thus reduces network energy consumption and provides advantages for multiple entities, including CDNs and ISPs, as well as better QoE for end users.
Connection to the project	This paper is mainly representing the experiments we did on SocialiVideo in WP3.
Title	Popularity Evolution of Users on OSNs

Authors and Affiliation	Samin Mohammadi, Reza Farahbakhsh, Noel Crespi
Event	ICC 2017
Abstract	Popularity in social media is an important objective for professional users (e.g. companies, celebrities, and public figures, etc). A simple yet prominent metric utilized to measure the popularity of a user is the number of fans or followers she succeed to attract to her page. Popularity is influenced by several factors which identifying them is an interesting research topic. This paper aims to understand this phenomenon in social media by exploring the popularity evolution for professional users in Facebook. To this end, we implemented a crawler and monitor the popularity evolution trend of 8k most popular professional users on Facebook over a period of 14 months. The collected dataset includes around 20 million popularity values and 43 million posts. We characterized different popularity evolution patterns by clustering the users' temporal number of fans and study them from various perspectives including their categories and level of activities. Our observations show that being active and famous correlate positively with the popularity trend.
Connection to the project	This paper studies the popularity evolution of users in social networks to find the reasons of their popularity. It helps to find a good solution to identify popular users to use in Socialivideo in WP3.
Title	A Cost and CARbon Emission-Efficient Virtual machine placement method for green distributed clouds
Authors and Affiliation	Ehsan Ahvar , Shohreh Ahvar , Zoltan Adam Mann, Noel Crespi , Joaquin Garcia-Alfaro and Roch Glitho
Event	SCC 2016
Abstract	Distributed clouds have recently attracted many cloud providers and researchers as a topic of intensive interest. High energy costs and carbon emissions are two significant problems in distributed clouds. Due to the geographic distribution of data centers (DCs), there are a variety of resources, energy prices and carbon emission rates to consider in a distributed cloud, which makes the placement of virtual machines (VMs) for cost and carbon efficiency even more critical than in centralized clouds. Most previous work in this field investigated either optimizing cost without considering the amount of produced carbon or vice versa. This paper presents a cost and carbon emission-efficient VM placement method (CACEV) in distributed clouds. CACEV considers geographically varying energy prices and carbon emission rates as well as optimizing both network and server resources at the same time. By combining prediction-based A* algorithm with Fuzzy Sets technique, CACEV makes an intelligent decision to optimize cost and carbon emission for providers. Simulation results show the applicability and performance of CACEV.
Connection to the project	The aim of paper is aligned with the Convince project to optimize both network and server resources in order to reduce consumed energy.

Orange Labs	
Title	Energy saving in content-oriented networks
Authors and Affiliation	Nicaise Choungmo Fofack, Ali Ridha Mahjoub, Mohamed, Yassine Naghmouchi and Nancy Perrot
Event	CIE'45 proceedings
Abstract	By allowing in-network caching, content-oriented networks may significantly decrease the network congestion, shorten the access delays, and reduce latency when delivering contents. On the other hand, a massive deployment of caches may subsequently increase the operational expenditures (OPEX), and particularly the energy bill of telecommunication operators. In this paper, we address the energy saving problem in content-oriented networks. This consists in determining which caches and which links could be switched off to minimize energy consumption in such a way that all demands are met while respecting capacity constraints. We propose a novel Mixed Integer Linear Programming (MILP) Formulation of the problem to solve the related object caching and traffic routing problem on arbitrary graph-based network topologies. We use CPLEX to solve our model to optimality. Then, we assess several network performance metrics. After all, we develop a routing on shortest path-based heuristic in order to compare our solutions with those given by the standard shortest path-based routing. Finally, we discuss the numerical results. We show that: 1) The metrics of interest provide additional insights on the impact and/or gain of introducing energy-aware caches in a real telecommunication network; 2) The benefits of our model compared to a routing on shortest path-based model: 38.72 % of energy saving is reached using our MILP model.
Connection to the project	The aim of this work is to propose a way to design in-network caching, used to cache videos in the network, while minimizing the energy consumption. It is thus directly connected to the WP3 which is focused on energy saving in the network.
Title	Optimal Placement of Controllers in a Resilient SDN Architecture
Authors and Affiliation	Nancy Perrot, Thomas Reynaud
Event	DRCN 2016
Abstract	The SDN (Software Defined Networking) paradigm brings flexibility to the network management and is an enabler to reduce the energy consumption of the networks. However deploying a set of SDN controllers to manage a Wide Area Network is still a challenge as it implies to determine the right number of controllers to install and their locations within the network. In this paper, we give the key performance criteria that should be taken into account to provide a "good" placement in terms of Quality of Service and we propose an integer linear programming formulation of the resilient controller placement problem. This formulation provides the optimal number of controllers and their location while embedding QoS and load balancing constraints for several level of backup controllers.
Connection to the project	This paper addresses the optimization of the number of required controllers to design a SDN network and their optimal placement within the network. Minimizing the number of required controllers minimizes the energy needed by resources and is a first step to better manage the use of sleep mode in a SDN network.
Title	Estimates of the economic impact of energy savings in the E2E chain for Video on Demand and Over The Top services

Authors and Affiliation	Kinga Pilarska, Nancy Perrot, Bernard Liau
Event	Networks 2016
Abstract	In this study we provide an economic analysis of the energy consumption savings obtained by introducing research results of the European project CONVINCe for Video On Demand and Video “over the top” (OTT) services. This should allow positioning quantitatively possible savings in the end-to-end chain, including service suppliers (head-ends), networks and customers (terminals). The key performance indicator is the average consumption of energy for one hour of Video. The energy savings that could be achieved implementing the results of the project in head-end, networks and terminals parts are evaluated economically for the European market. We obtain an order of magnitude of some hundred millions Euros savings per year. It remains small at the European level. However, at the level of the service, it represents between 10 to 12% savings.
Connection to the project	This paper presents the main results of tec-eco studies of Convince WP1.
Title	Energy-Efficient Load Balancing in SDN-based Data-Center Network
Authors and Affiliation	Yannick Carlinet, Nancy Perrot
Event	Networks 2016
Abstract	The Software Defined Networking (SDN) paradigm brings flexibility in the network management and can be used in order to reduce the energy consumption of the Data Center (DC) networks. In particular, two main leverages can be exploited to reduce brown energy consumption: a sleep mode on hosts in the DCs and geographical load balancing of the requests. In this paper, we propose a mixed integer linear programming formulation to compute the optimal requests assignment to data centers, with both a multi-period approach and a period-by-period assignment. We evaluate the impact of knowing future requests with respect to the optimal assignment. In addition, we provide an efficient on-line algorithm that could be implemented in an operational setting. The evaluation of the algorithm is based on real traffic traces, and shows a reduction up to 42% in the brown energy consumption.
Connection to the project	This paper deals with savings of energy which could be obtained thanks to geographical load balancing between DC.

VTT	
Title	REPLICA T7-16-128 - A 2048-threaded 16-core 7-FU chained VLIW chip multiprocessor
Authors and Affiliation	Martti Forsell, Jussi Roivainen
Event	Proceedings of the 48th Asilomar Conference on Signals, Systems, and Computers, November 2-5, 2014
Abstract	<p>Processor-based solutions are getting increasingly popular over dedicated logic/accelerators among embedded system designers due to their flexibility and programmability. The drawbacks - weaker performance and higher power consumption - are usually compensated with multicore and application-specific technologies. Unfortunately, these optimizations - exploiting parallelism and heterogeneity - lead to direction that makes programming difficult and result to less flexible designs. REPLICA is VTT's effort to solve the performance and programmability problems of current multicore processors without tampering flexibility. For performance, it addresses the essence of parallel computing - cost-efficient synchronization, high intercommunication bandwidth and latency toleration - with a new collection of architectural techniques: multithreading, sparse/multimesh network-on-chip and wave-based synchronization. Programmability is made simple by supporting efficient execution of synchronous parallel algorithms and flexibility is provided with parametric nature of the architecture allowing for highly different configurations. In this paper we introduce a 2048-threaded 16-core prototype of the REPLICA chip multiprocessor. The main principles of the architecture as well as the structure of the prototype are explained. Preliminary comparison to current alternatives is given.</p>
Connection to the project	Introduction of the 16-core prototype of VTT's REPLICA architecture that will be used as the baseline for comparison against commercial alternatives and tuned for CONVINCe video computing and energy saving.
Title	SAND-Assisted Encoding Control for Energy-Aware MPEG-DASH Live Streaming
Authors and Affiliation	Mikko Uitto and Antti Heikkinen
Event	The 24th International Conference on Software, Telecommunication and Computer Networks(SoftCOM 2016)
Abstract	<p>Adaptive HTTP video streaming has gained popularity in providing live feed from the events to mobile consumers. For reaching the widest possible audience, video service providers usually need to generate multiple video representations from the input stream suitable for different clients, which can increase the server-side energy consumption and processor load. HTTP streaming enables client adaptation against network fluctuations, but the server is usually unaware of the client(s) network capacity and device characteristics. With this knowledge, the server could control and allocate the encoding resources better according to the client(s) needs and reduce the server energy consumption and load. In this paper, we provide energy-aware dynamic encoding control for MPEG-DASH live streaming, which can benefit especially when representations are unpopular or network is under congestion. To achieve this, we utilize messages between client and encoding server based on the upcoming MPEG standard initiative Server and Network Assisted DASH (SAND). The results indicate that our dynamic encoding control signaling can reduce energy consumption in the server, create storage savings and therefore decrease also server costs.</p>

Connection to the project	This paper introduces how suitable signaling mechanism between client(s) and encoding server will always produce wanted content and therefore reduce power consumption of the encoding server.
Title	Energy Consumption Evaluation of H.264 and HEVC Video Encoders in High Quality Live Streaming
Authors and Affiliation	Mikko Uitto
Event	The 12th IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob 2016)
Abstract	Green computing and energy efficiency has become an important issue in today's rapidly growing multimedia transmission. Meanwhile users want high-quality content to be viewed anywhere, content producers must think alternatives for cutting expenses in the server. Usually multiple substreams from the original video feed are needed for clients with unique device characteristics, which can notably load the video encoding server leading also to increased energy consumption. Furthermore, social sharing applications using live video streaming can consume battery notably, which also drives developing energy-efficient video coding solutions. Therefore, it is essential to find ways for optimizing and selecting the proper tools for energy-efficient content production already in the server. In this paper, we evaluate the energy and power consumption for the existing top-rated open source video encoders in proportion to video quality and bit rate. The selected video coding formats include current dominant H.264 Advanced Video Coding (H.264/AVC), latest standard High Efficiency Video Coding (HEVC) and Google's royalty free VP9. The results show that the selected H.264 encoder (x264) has the lowest energy consumption, but the worst compression efficiency. On the contrast, x265 for HEVC has the best compression efficiency, but suffers from increased energy consumption. For our experiments, VP9 provides the best trade-off between compression efficiency and energy consumption.
Connection to the project	This paper evaluates the power consumption of four selected open-source software video encoders including H.264, HEVC and VP9 coding formats.
Title	Outline of a Thick Control Flow Architecture
Authors and Affiliation	Martti Forsell, Jussi Roivainen, Ville Leppänen
Event	The 5th Workshop on Parallel Programming Models Special Edition on Task Parallelism
Abstract	The recently invented thick control flow (TCF) model packs together an unbounded number of fibers, thread-like computational entities, flowing through the same control path. This promises to simplify parallel programming by partially eliminating looping and artificial thread arithmetics. In this paper we outline an architecture for efficiently executing programs written for the TCF model. It features scalable latency hiding via replication of instructions, radical synchronization cost reduction via a wave-based synchronization mechanism, and improved low-level parallelism exploitation via chaining of functional units. Replication of instructions is supported by a dynamic multithreading-like mechanism, which saves the fiber-wise data into special replicated register blocks. The architecture facilitates programmers with compact, unbounded notation of fibers and groups of them together with strong synchronous shared memory algorithmics. According to evaluations, the architecture is able to efficiently handle workloads featuring computational elements with the same control flow, independently of the number of elements. In its turn, this pays out

	as improved performance and lower power consumption due to elimination of redundant parts of computation and machinery.
Connection to the project	Outline of an improved REPLICA architecture performs 15% better than the baseline REPLICA (and reduces power consumption by 15%). It will be compared to against the commercial alternatives for CONVINCe video computing and energy saving.
Title	The REPLICA on-chip network
Authors and Affiliation	Martti Forsell, Jussi Roivainen, Ville Leppänen
Event	The 2016 IEEE Nordic Circuits and Systems Conference
Abstract	General purpose chip multiprocessors (CMP) are challenging to on-chip intercommunication network designers since one would need low latency, high bandwidth independently of the communication patterns, support for cost-efficient synchronization, and low energy consumption to support arbitrary applications. Currently popular ring-based networks provide straight-forward design, far superior performance than bus-based alternatives and extensibility over crossbars. As the number of processors cores increases, however, the effective bandwidth between most parts of a ring remains constant implying higher capacity solutions are needed to support scaled-up CMPs. In this paper we describe the on-chip network of our REPLICA CMP. It is based on an acyclic bandwidth-scaled multimesh topology and uses routing with elastic synchronization mechanism. To avoid congestion and hot spots in shared memory access traffic can be randomized with a programmable hashing function. The performance of the network is evaluated preliminarily on our experimental 4-core and 16-core REPLICA FPGA implementations and REPLICA simulator.
Connection to the project	Introduction of REPLICA on-chip network and improved hashing that improves the throughput (and therefor potentially also power consumption) by 6.4%. Improved REPLICA will be compared to commercial alternatives for CONVINCe video computing and energy saving.

ERRICSON	
Title	Hypervisors vs. Lightweight Virtualization: a Performance Comparison
Authors and Affiliation	Roberto Morabito, Jimmy Kjällman, Miika Komu
Event	Workshop on Containers (WoC), IEEE IC2E, March 2015
Abstract	Virtualization of operating systems provides a common way to run different services in the cloud. Recently, the lightweight virtualization technologies claim to offer superior performance. In this paper, we present a detailed performance comparison of traditional hypervisor based virtualization and new lightweight solutions. In our measurements, we use several benchmarks tools in order to understand the strengths, weaknesses, and anomalies introduced by these different platforms in terms of processing, storage, memory and network. Our results show that containers achieve generally better performance when compared with traditional virtual machines and other recent solutions. Albeit containers offer clearly more dense deployment of virtual machines, the performance difference with other technologies is in many cases relatively small.
Connection to the project	Performance overhead measurements with different virtualization technologies.
Title	Inspecting the Performance of Low-Power Nodes during the Execution of Edge Computing Tasks
Authors and Affiliation	Roberto Morabito
Event	IEEE CCNC'17 (edge computing workshop)
Abstract	The more stringent requirements of many applications services – especially in terms of latency and bandwidth – is leading to the migration from data center based architecture towards a mobile-edge computing paradigm. This emerging network architecture aims to increase the overall infrastructure efficiency by delivering low-latency and bandwidth-efficient services. In this context, a not fully investigated aspect is represented by the possibility of placing edge-computing tasks on low-power nodes. This paper seeks to provide insights for future deployments, by conducting an empirical study on the performance evaluation of a Single-Board Computer and a Small-Form Factor Computer when acting as a mobile-edge computing server. Our results aim to determine the potentiality and the performance bounds for these devices, during the execution of applications characterized by different performance requirements.
Connection to the project	Benchmarking of the energy efficiency of single-board computers in the context of IoT and video applications.
Title	Power Aware Media Delivery Platform Based on Containers
Authors and Affiliation	Jimmy Kjällman, Miika Komu, Tero Kauppinen (Ericsson)
Event	Workshop on Green Communications Systems at ICIN 2016
Abstract	Use of mobile devices for media consumption has become popular and is expected to grow significantly in the coming years. Optimizing energy consumption in this context can bring several benefits, especially to users of battery-powered devices where the consumption is directly noticeable. In this paper we describe a platform where the cloud computing model and container-based virtualization is utilized for deploying and executing functions that optimize media streams for improved energy efficiency.

Connection to the project	This short paper introduces our concept of using containers and distributed clouds for deploying functions that optimize media streams for saving energy in terminals.
Title	Power Consumption in Remote Gaming: an Empirical Evaluation
Authors and Affiliation	Miika Komu, Roberto Morabito, Tero Kauppinen, Jimmy Kjällman (Ericsson), Yong Yao (BTH)
Event	IEEE Global Internet Symposium (GI) 2016
Abstract	<p>The thin-client approach for gaming is becoming more popular. For instance, Nvidia Shield, Valve Steam and Shinra technologies have offerings based on the concept. In remote cloud gaming, the game is being executed and processed in the cloud while the user receives a video and audio stream of the game, in a very similar way as with remote desktop clients. At the same time, clouds are moving towards the end-users as "edge clouds" with different standardization bodies, such Open Mobile Edge Cloud and Open Fog Consortium, giving momentum for the efforts. Were remote gaming approaches to utilize edge clouds, the games could be played without installing any infrastructure at the homes of end-users while keeping network delays to the latency-sensitive games low. While waiting for such edge-cloud deployments to substantiate, even regional clouds could be utilized for the purpose. In such environments, remote cloud gaming can already now be utilized by game companies as an alternative to traditional download-and-install games in order to support, e.g., anti-piracy protection. While the incentives for the game companies are relatively clear, the end-user experience has been investigated mainly from the viewpoint of latency. In this paper, we fill a research gap related to energy efficiency by showing that mobile phone users can save between 12 and 32 % power by utilizing remote gaming instead of playing with a native app. Our prototype is based on GamingAnywhere open-source software for which we have also integrated a gamepad for easier controls. We show power measurements both with a 2D and 3D games, and also additional measurements with a smart TV-stick.</p>
Connection to the project	The paper shows that energy savings around 12 - 32% can be achieved in mobile terminals by offloading rendering of games to remote servers, compared to running them natively on the devices.

BTH	
Title	On the Performance of Uplink Transmission in Cognitive Radio Mesh Networks
Authors and Affiliation	Yong Yao, Adrian Popescu
Event	Swedish National Computer Networking Workshop (SNCNW) 2015
Abstract	In cognitive radio mesh networks, the unlicensed users are allowed to use spectrum opportunities under the restriction of protection of licensed users. The transmission operation of unlicensed users packets is typically done through multiple mesh routers. In the case of a large amount of packet retransmissions, the performance of the whole network system may degrade. To solve this problem, a queuing buffer based priority scheme for mesh routers is suggested. Based on this scheme, the uplink transmission performance of unlicensed users in cognitive radio mesh networks is studied under the condition of imperfect spectrum sensing. Numerical evaluation results show the feasibility and effectiveness of the suggested priority scheme.
Connection to the project	This paper is about the transmission performance evaluation of Cognitive Radio Mesh Networks (CRMNs). A new priority scheme is suggested for mesh routers to reduce the total packet retransmission rate along the e2e routing path in CRMNs. While according to the section 4.2.3 in the deliverable D1.1.2, the conclusion is therefore that the suggested priority scheme can reduce the total energy consumed along the e2e routing path in CRMNs.
Title	On Prioritized Uplink Transmission in Cognitive Radio Mesh Networks
Authors and Affiliation	Yong Yao, Adrian Popescu
Event	European Conference on Networks and Communications (EUCNC) 2015
Abstract	In cognitive radio mesh networks, the unlicensed users are allowed to use spectrum opportunities under the restriction of protection of licensed users. The transmission operation of unlicensed users packets is typically done through multiple mesh routers. In the case of a large amount of packet retransmissions, the performance of the whole network system may degrade. To solve this problem, a queuing buffer based priority scheme for mesh routers is suggested. Based on this scheme, the uplink transmission performance of unlicensed users in cognitive radio mesh networks is studied under the condition of imperfect spectrum sensing.
Connection to the project	This poster paper proposes a priority scheme for CRMNs by giving priority to the relayed packets over the local SU packets. The numerical results show that the total packet retransmission rate along the e2e routing path in CRMNs can be decreased, such thus reducing the total energy consumed along the e2e routing path in CRMNs.
Title	CONVINcE : Greening of Video Distribution Networks
Authors and Affiliation	Adrian Popescu
Event	3rd International Symposium on Energy Challenges and Mechanics - towards a big picture, 2015
Abstract	CONVINcE is a 2.5 years CELTIC-Plus project started in September 2014 that addresses the challenges of reducing the power consumption in IP-based video distribution networks. An end-to-end approach is adopted in the project, from

	the Head End, where contents are encoded and streamed, to the terminals, where they are consumed, also embracing access and core networks, Content Distribution Networks as well as Video Distribution Networks. A number of 18 industrial and academic partners from 5 European countries are participating in the project. Project leader is Thomson Video Networks in France and scientific project leader is Blekinge Institute of Technology in Sweden.
Connection to the project	It is the overview presentation of the project with focus on the main research questions considered in CONVINCe.
Title	Dealing with QoE and Power Consumption in Video Distribution Networks
Authors and Affiliation	Adrian Popescu
Event	COMM 2016: The 11th International Conference on Communications
Abstract	The paper is about the problem of reducing the power consumption in Video Distribution Networks (VDNs) under the condition of best performance provision in terms of Quality of Experience (QoE) measured at the end user. Related to this, it has been observed that, given an end-to-end video distribution network, it is the last networking segment ending to terminal that has the dominant role in the provision of end-user performance. On the other hand, the rest of the video distribution chain can be optimized such to reduce the power consumption under the requirements of provision of specific Quality of Service (QoS) parameters.
Connection to the project	The paper first provides an overview of VDNs, which is followed by a short presentation of the CONVINCe project. The second part is focused on the problems of performance provision in VDN in terms of best possible Quality of Experience and minimum end-to-end power consumption.
Title	On Energy Consumption in Mobile Multimedia Networks with OpenFlow Switch
Authors and Affiliation	Yong Yao and Adrian Popescu
Event	COMM 2016: The 11th International Conference on Communications
Abstract	In mobile multimedia networks, the video flow usually operates in an end-to-end manner from Head-End to mobile terminals. However, measuring the energy consumption associated with a video flow is a sophisticated process due to the complexity related to this. In the paper, a theoretical measurement approach is suggested to estimate the energy consumption of a video flow through mobile multimedia networks enhanced with the support of OpenFlow switch. Two different power models are built up to compute the traffic related energy consumption at the network element side. The numerical derivation of these two theoretical models is presented.
Connection to the project	This paper is about the numerical estimation of power consumed by traditional and open-flow switches for packet transmission in video distribution networks
Title	CONVINCe: Towards Power-Optimized Video Distribution Networks
Authors and Affiliation	Raoul Monnier (Harmonic), Adrian Popescu (BTH) and Rickard Ljung (SONY)
Event	19th International ICIN Conference
Abstract	CONVINCe is a CELTIC-PLUS project dedicated to minimizing the power consumption in IP-based video distribution networks, from the headend to the terminal. The entire video distribution chain is considered in the project, covering a wide range of entities involved in this process. Examples of these entities are headend, edge cloud, Content Distribution Network (CDN), core backbone network, Radio Access Network (RAN) as well as fixed and mobile

	terminals. Related to this, one of the most difficult research questions is regarding the provision of minimum end-to-end power consumption for video streams combined with the best possible Quality of Experience (QoE) obtained at the terminal. It requires solving a number of sophisticated research questions, among them modelling and optimization problems.
Connection to the project	This paper addresses several important issues of doing power-optimization in video distribution networks
Title	QoE-Aware Sustainable Throughput for Energy-Efficient Video Streaming
Authors and Affiliation	Markus Fiedler, Adrian Popescu and Yong Yao
Event	SustainCom 2016
Abstract	This work motivates and details the concept of QoE- aware sustainable throughput in the area of video streaming. ST serves as a mean to compare video streaming solutions in terms of Quality of Experience (QoE) and power efficiency (PE). It builds upon the QoE Provisioning-Delivery Hysteresis (PDH) and denotes the maximal throughput at which QoE deteriorations can be kept below a quantifiable level, which in turn allows to compare the PE of different video streaming solutions on QoE-fair grounds. In this work, we are particularly focusing on delivery problems stemming from outage-prone links, as they are typical for mobile systems. Well-adapted to the nature of the video-associated data streams and disturbances, a stochastic fluid flow model is used that allows for straightforward calculation of sustainable throughput values. We also discuss the application of the sustainable throughput for comparisons among different streaming solutions and their offered QoE and PE, respectively.
Connection to the project	This paper motivates and details the concept of QoE- aware sustainable throughput in the area of video streaming.
Title	Managing OTT Traffic in a SDN/NVF Scenario
Authors and Affiliation	Adrian Popescu, Yong Yao, Dragos Ilie, Markus Fiedler and Patrik Arlos
Event	ICC - GCC 2017 (submitted)
Abstract	The emerging concepts Software Defined Networking (SDN) and Network Functions Virtualization (NFV) lay the ground for system softwarization of future and services, under the umbrella of 5G. Towards this goal, the IEEE SDN Initiative has produced two fundamental documents, where the major technical challenges, scenarios and the business openings are presented. A special topic if regarding the Video Distribution Networks (VDN), particularly in relation to existing difficulties in handling demand laid on the network, as well as in relation to challenges in providing the expected Quality of Experience (QoE) and other performance demands like, e.g., minimum energy consumption.
Connection to the project	The contribution of this paper is regarding the presentation of the most important elements associated with the virtualization of Over-The-Top (OTT) video distribution networks.
Title	On the Performance of Video Streaming in Energy-Aware Wireless Mesh Networks
Authors and Affiliation	Yong Yao, Adrian Popescu, Markus Fiedler and Rickard Ljung (SONY)
Event	EuCNC 2017 (submitted)

Abstract	<p>Mobile multimedia has today become a promising application for end users and service providers. With reference to the existing systems for mobile communications, this application further demands for solving several important technical problems, especially regarding video streaming over wireless networks. An interesting approach is in form of Wireless Mesh Network (WMN) based networks, where the individual video flows operate in an end-to-end (e2e) manner along a particular networking scenario including several mesh routers. That means, a particular mesh router may be traversed by multiple video flows. This situation may become even more complicated in the case of a large amount of packet retransmissions, which may deteriorate the performance of video flows. To investigate the problem, a two-level Modulated Markov Poisson Process (MMPP) based queueing model is built up and the transport performance of e2e video streaming in WMN based mobile multimedia system is analyzed. Four metrics are used to study the system performance, namely e2e throughput, e2e delay, e2e error-rate and traffic-related energy consumption. Numerical analysis and evaluation studies are done. Based on the reported results, two different solutions are suggested and discussed with regard to the trade-off among these metrics.</p>
Connection to the project	This paper suggests a new queueing model to study the transmission performance and energy consumption in multimedia wireless mesh network.
Title	Quality of Experience on Smartphones: Network, Application and Energy Perspectives
Authors and Affiliation	Selim Ickin (Ericsson, Sweden) and Markus Fiedler (Blekinge Institute of Technology, Sweden)
Event	19th International ICIN Conference - Workshop
Abstract	<p>For service and mobile operators, it is important to monitor and keep high user engagement levels. Quality of Experience (QoE) on video streaming applications is an important engagement measure for video consumer customers. In this paper, video QoE (with the focus on stalling events) is studied from network, application, and energy perspectives with various instrumentations on a smartphone. This enables the understanding of inter-relation between the perspectives and also how they influence the video QoE. Results show that packet delay variation and the maximal burst size in the network level; interpicture times in the application layer; and also fluctuations in the energy consumptions are strong indicators for QoE. Enabled by extensive QoE experiments and energy measurements on smartphones, we obtain a set of telling QoE models capturing the impact of jitter and freezes, and quantifying the insights that energy consumption can be both reduced or increased in the case of stalling events during a video stream.</p>
Connection to the project	The paper studies the video QoE (with the focus on stalling events) from network, application, and energy perspectives with various instrumentations on a smartphone. This enables the understanding of inter-relation between the perspectives and also how they influence the video QoE.

TelHoc	
Title	Energy Savings for Video Streaming using Fountain Coding
Authors and Affiliation	Anders Plymoth (TelHoc AB, USA), Zhi Zhang (Lund University, Sweden)
Event	19th International ICIN Conference - Workshop
Abstract	Reducing energy and power consumption is important for many reasons, including extending the lifetime of battery operated devices and reducing energy bills. An important source of energy loss in wireless networks comes from retransmissions of lost packets. Many of the transmission protocols in use today were designed mainly to be used in wired IP networks, and therefore performs badly in wireless scenarios. We present a protocol that more efficiently handles packet losses in wireless network with a special emphasis on video streams, and show that the use of fountain coding can reduce power consumption and save energy, especially in multicast settings. We show that fountain coding minimizes the number of retransmissions in lossy wireless networks. Our initial tests for video multicast scenarios with up to 10 users in networks with high loss rates show that power can be reduced by up to 200%.
Connection to the project	The paper presents a protocol that used in Convince to handle packet losses in wireless network with a special emphasis on video streams, and show that the use of fountain coding can reduce power consumption and save energy.

Beside the published papers from different partners, CEA is also filling a patent for a green routing algorithm (GoGreen). They are preparing a conference paper entitled "GoGreen Routing in 5G Backhaul Networks". After finishing the patent application, it is intended to submit the paper to IEEE Globecom 2017 or IEEE PIMRC 2017. Also, CEA intends to extend the paper and submits it to IEEE Transactions on Green Communications and Networking.

The abstract of the paper comes in the following. "In future 5G network, one of the main challenges is reducing the power consumption in networks, while preserving the quality of service (QoS) perceived by the end-user. In this paper, we propose a fast heuristic, called GoGreen routing algorithm, that computes routing paths that reduces network power consumption and, at the same time, ensures a good bandwidth for the user traffic. This heuristic uses a k-shortest path algorithm and considers two metrics namely available bandwidth and link power consumption metrics. Moreover, we proposed two versions of our algorithm namely GoGreen (approach 1) and GoGreen (approach 2) depending on metrics priority. Through extensive simulations we showed that GoGreen (approach 1) with a reasonable low value for k could reduce network power consumption and ensure a good QoS comparable to what is achieved by Dijkstra algorithm."

6 PARTICIPATION TO EVENTS

This section presents the events which some CONVINCe partners participated in to present project outcomes and results.

6.1 Presenting Demonstrations

6.1.1 Mobile World Congress (MWC)

Convince participated to Mobile World Congress (MWC). MWC is the world's largest exhibition for the global mobile industry. At MWC mobile operators, manufacturers, component providers, service providers and many others within the industry showcase their latest products and offers. The MWC is a yearly event located in Barcelona, Spain. The number of exhibitors is typically over 2000, and annual attendance is generally almost 100 000 people.

In the 2016 event, occurring February 22-25 CONVINCe project results have been showcased. CONVINCe addresses the challenge of reducing the power consumption in IPbased video networks with an end-to-end approach, and at the MWC event CONVINCe project consortium members were involved in demonstrations of two different power consumption saving approaches, being results from CONVINCe project activities. Firstly a power consumption measurement tool for battery powered devices as developed within CONVINCe was presented to selected companies in the exhibition area. The power consumption measurement tool provides possibilities to product developers and software design engineers to measure and analyse the power consumption of battery powered devices. It also enables a correlation between software debug logs with the power consumption allowing software optimizations for minimizing the power consumption of battery powered devices. This power consumption measurement tool is expected to be part of the CONVINCe project test bed.

Secondly the collaborative architectures for power efficient DASH video streaming delivery over cellular mobile networks as developed within CONVINCe project for power consumption savings in mobile terminals was also presented to selected companies in the exhibition area. This solution allows a video streaming client in a mobile terminal to directly interact with mobile network nodes, in order to optimize the video content flow from head end to mobile terminal over a mobile communications network.

6.1.2 Celtic-plus Event 2016

The Celtic-plus Event 2016 in Stockholm was another event that Convince participated and showcased five demonstrations:

- Remote gaming: Energy savings using computational offloading
A working prototype for remote gaming based on GamingAnywhere is shown. The goal is to present a platform for measuring power savings in terminals and compare the consumption to State Of The Art consumption of gaming applications.
- Video streaming: Energy consumption measurements for various types of video encryption
A video is streamed from a server to an Android application. The application displays instantaneous energy consumption figures. The user can choose different security and digital rights settings and see how this affects performance, energy consumption and expected battery lifetime.
- Energy savings using real time energy measurements during software development/debugging
This demonstration shows an energy consumption analysis tool for energy optimization of devices and applications. It enables product developers to quickly understand the energy consumption of the products that they are working on, with the goal of making more sustainable and more energy efficient devices.
- Video processing: Impact on energy consumption in terminals
This demonstration aims at explaining that moving to a better video compression technology takes only a little extra power and that using parallelism for decoding can help to save energy.
- Energy-efficient routing and interface selection mechanism in access and core network
The aim of the demonstration presented in the video is to show how an energy-aware routing approach can reduce the overall energy consumption in access and core networks.

6.1.3 Orange Labs Research Exhibition (Salon de la Recherche)

The tool developed for CONVINCe by Orange has been selected and presented during the Orange Labs Research Exhibition (Salon de la Recherche) 2016 event. This annual event is a major showcase for results from the Orange Group's research laboratories. This year, during three days, more than 2800 internal and external visitors came at the eco-campus Orange Gardens (Chatillon, near Paris) to meet, exchange and share with the researchers of Orange.

The demonstration tool we have presented is an innovative optimization tool to address placement issues (where to deploy equipment) in SDN networks. First, it allows identifying the least cost SDN controller deployment scenario, even in case of multiple controller failures. Thus, it helps network architects to design cost-effective, efficient and reliable SDN networks. Second, it allows to determine and to visualize the maximal energy gain that could be

obtained thanks to a smart load balancing of requests across several geographical distant data centers.

We had the pleasure to meet and to present our work to Peter Herrmann, Director of the Celtic Office, Serge Bodjrenou, from the French Public Authority (DGE, Department of Digital Economy) and Valerie Blavette, from Orange, Celtic-Plus Vice-Chair, who came at our stand (see photo).

6.2 Organizing Workshops/ Presenting Papers

6.2.1 Green Communications Systems

Convince organized a workshop on [green communications systems](#) collocated with ICIN conference in Paris on 2016. This workshop brought a large community of researchers together in green communications area. Convince partners also shared the outcomes of the project in 5 papers presented in the workshop. The detail of these papers are available in Table 1.

6.2.2 Application of Green Techniques to Emerging Communication and Computing Paradigms (GCC)

Convince also will organize an accepted workshop on application of green techniques to emerging communication and computing paradigms ([GCC](#)) collocated with ICC conference in Paris, 2017. Some outcomes of Convince are submitted in 2 papers to present in the workshop.

Other events participated by partners are presented in Table 3.

Table 3 - Events partners participated in

Row	Event Name	Location	Involved Partners	Conducted Activities
1	ICC Conference 2015	UK, London	Lund University	Presentation of a paper (Towards optimal content replication and request routing in content delivery networks), participation in panel discussions related to green computing, and demonstration conducted by industrial participants
2	OMNeT++ Summit 2015	Zurich, Switzerland	Lund University	Presentation of a paper (paper title: A Simulation Package for Energy Consumption of Content Delivery Networks (CDNs)), participation in a panel discussion focused on the implementation challenges of our proposed simulation package in OMNeT++
3	SNCNW 2015	Karlstad University, Sweden	Lund University	Presentation of a poster paper (poster title: Energy Efficient Distribution of Video Contents)
4	IEEE CAMAD 2016	Toronto, Canada	Lund University	Presentation of a paper(paper title: A Study on Energy Used to Deliver H.264/AVC and H.265/HEVC Video Content)
5	ICIN 2016 1ST WORKSHOP ON GREEN	Paris, France	Lund University	Presentation of paper (paper title: Cross-layer energy optimization for dynamic video streaming over Wi-Fi)

	COMMUNICATIONS SYSTEMS			
6	IFIP WMNC 2016	Colmar, France	Lund University	Presentation of paper (paper title: Resource management for OFDMA based next generation 802.11 WLANs)
7	Keynote speech in PDP'15	Turku, Finland	VTT	REPLICA — Addressing the performance and programmability problems of CMPs with a high throughput architecture and strong model of computation
8	Asonam 2015	Paris	IMT	To present the accepted paper entitled "Characterization of Cross-posting Activity for Professional Users Across Major OSNs". Discussion with other people working in the domain to see potential collaboration.
9	ICC Conference 2015	London	IMT	To present the accepted paper entitled "Link Prediction for New Users in Social Networks". See the potential of organizing a workshop in ICC'16.
10	Sigcomm 2015	London	IMT	Discussion with people in domains of networking and CDNs for future collaboration.
11	EUCNC 2015	Paris	IMT	Discussion with relevant projects people and evaluate the possibility to disseminate CONVINCe in the next edition of this European conferences as a poster or stand.
12	ICIN 2016	Paris	IMT	Organizing the workshop on Green Communications Systems
13	GlobeCom 2016	Washington, USA	IMT	Presentation of a paper entitled "Video Content Delivery Enhancement in CDNs based on Users' Social Information"
14	SNCNW 2015	Karlstad University, Sweden	BTH	Presentation of a paper (paper title: On the Performance of Uplink Transmission in Cognitive Radio Mesh Networks)
15	EUCNC 2015	Paris	BTH	Presentation of a poster paper (poster title: On Prioritized Uplink Transmission in Cognitive Radio Mesh Networks)
16	3rd International Symposium on Energy Challenges and Mechanics'15	Scotland, United Kingdom	BTH	Presentation of an invited talk (title: CONVINCe: Greening of Video Distribution Networks)
17	COMM 2016: The 11th International Conference on Communications	Bucharest, Romania	BTH	Presentation of an invited talk (title: Dealing with QoE and Power Consumption in Video Distribution Netw) and a paper (title: On Energy Consumption in Mobile Multimedia Networks with OpenFlow Switch)
18	SustainCom 2016	Atlanta, GA, USA	BTH	Presentation of a paper (title: QoE-Aware Sustainable Throughput for Energy-Efficient Video Streaming)

19	CIE'45	Metz, France	OL	Presentation of the paper Energy saving in content-oriented networks
20	DRCN 2016	Paris	OL	Presentation of the paper Optimal Placement of Controllers in a Resilient SDN Architecture
21	INFORMS Telecom 2016	Boca Raton, Florida, United State	OL	Presentation of our work on the Optimal Traffic Routing and VNF deployment for Service Function Chaining in SDN
22	Networks 2016	Montreal	OL	Presentation of the papers (paper1: Estimates of the economic impact of energy savings in the E2E chain for Video on Demand and Over The Top services, Paper2:Energy-Efficient Load Balancing in SDN-based Data-Center Network)
23	ICIN 2016	Paris	CEA, ER, Harmonic, BTH	Presenting the five papers published on ICIN workshop
24	Salon de la recherche	Paris	CEA, Orange	Visit demos and discuss topics related to routing and energy efficiency in 5G networks. Presenting the tool developed for Convince by Orange.
25	CELTIC-plus event	Stockholm	CEA, Harmonic, ER	Presenting the demonstrations
26	Mobile World Congress	Barcelona	Sony	Showcased the project results

7 CONCLUSIONS

This report summarizes the final state of the publication activities of CONVINCe. It includes two main parts. The first one is about accepted scientific papers in conferences and journals. The second part shows the participation of CONVINCe partners in relevant events to present their results or discuss about topics addressed by the CONVINCe project.