NEWSLETTER

CONTENT — Excellence in Content Distribution Network Research

December 2008

EDITORIAL

The CONTENT Newsletter is ascertaining itself as a primary means for the CONTENT members to exchange information and publicise their joint research activity, either inside or outside the Network of Excellence. The work carried out in CONTENT is laying the foundation for the first generation of Autonomic Content Networks, covering around 30 joint tasks related to content networking, overlay networking, and content services. The current issue of the Newsletter refeclects this, by including information on recent meetings, School of Audio-visual Topics in Networking (SATIN), joint research work, publications, conferences/workshops, concertation activities, projects, and industry liaison. So, if you want to stay abreast with the latest R&D developments in content distribution networks, do not miss the current issue CONTENT Newsletter, also available at our website, www.ist-content.eu .

ACM SIGMM AWARD

Prof. Ralf Steinmetz of the Technische Universität Darmstadt in Germany receives first ACM SIGMM Award: At this years' ACM International Conference on Multimedia in Vancouver professor Ralf Steinmetz of the Technische Universität Darmstadt was granted the ACM* SIGMM** Award. With the prestigious "ACM Special Interest Group on Multimedia Award for Outstanding Technical Contributions to Multimedia Computing, Communications and Applications" the ACM, the world's largest educational and scientific computing society honoured Ralf Steinmetz' „pioneering work in multimedia communications and the fundamentals of multimedia synchronization". Steinmetz is the very first recipient of this honour. (The same society donates the ACM Turing Award – the „Nobel Prize" for computer science).

Ralf Steinmetz is one of the leading pioneers in his research area, where he has made several fundamental discoveries and new breakthroughs. In the late nineteen eighties, when research in multimedia communications was at its beginning, he already identified "synchronization of media streams" as a key issue of future multimedia communication systems. His pioneering publication on multimedia synchronization in 1990 is one of the most quoted results in multimedia communications literature.

Steinmetz' exceptional contribution covers work in theory as well as practical efforts and many implementations in several system and application environments. For example, his research results on the synchronization of audio and video data are considered in every joint audio and video data presentation today.

Ralf Steinmetz joined the Technische Universität Darmstadt as a full professor in 1996. Prior he worked several years at the IBM European Networking Center in Heidelberg, Germany, as the Technical Leader and Manager of the Multimedia Research and Development Group. Under his guidance, the key components of the first IBM digital TV and video retrieval over LANs were developed. In public they were shown for the first time at CeBIT 1992. Since the very early stages of multimedia communications and computing, Ralf Steinmetz is known as the leading scientist and researcher in this area in Europe and particularly in Germany. Worldwide he enjoys a very high reputation.

MEETINGS

ICT 2008 Event: CONTENT actively participated in the ICT 2008 Event, in Lyon, on 25-27 November 2008. CONTENT members participated in several sessions, including 'Research challenges and users' role in the Future Media Internet', 'Network of the Future', 'Future Internet', 'Dealing with the management challenges posed by the emerging Future Internet', 'ICT for Energy Efficiency' and 'Design and evaluation of new internetworking architectures'. CONTENT NoE jointly with other projects in the Networked Media Unit participated in a networking session at ICT 2008 with the title "Research challenges and users' role in the Future Media Internet". The objective of this session was the discussion of the research challenges in Content Aware Networks, Future Internet of 3D and Immersive Media beyond HD and Networked Search and Retrieval in the Future Media Internet. On November 28th 2008, Prof. Ioannis Stavrakakis gave a presentation in session 'WP 2009-2010: Network of the Future', emphasizing the

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work being done in CONTENT. More information on this presentation can be found in the 'Invited Talks' section.

CONFERENCES / WORKSHOPS

ACM CoNEXT 2008, 9-12 December 2008, Madrid, Spain. The 4th International Conference on emerging Networking EXperiments and Technologies (CoNEXT 2008) was held at UC3M jointly with IMDEA Networks in Leganés in December 2008, involving more than 200 attendees. This is currently a global visibility event, which continues to gain importance in the Internet technologies arena. CONTENT sponsored this conference, offering several student travel grants. This allowed not only an increase in the CONTENT visibility but also an increase of CONTENT experts participation. For more information on this important event, please visit the following url: http://enjambre.it.uc3m.es/conext2008/index.htm.

VICTORY Workshop, 4 December 2008, Stuttgart, Germany. On 04.12.2008 a workshop presenting results from the VICTORY project was held in Stuttgart, Germany. The CONTENT project was represented by Michal Grega from AGH, whose PhD research is related to the research conducted by the VICTORY project. VICTORY (Audio-VIsual ConTent search and retrieval in a distributed P2P repositORY) is a FP6 STREP project which focuses on the search for 3D objects in a distributed P2P overlay. It is at the end of the 2 year of the total of 2.5 years.

During the workshop a tool for sharing and searching of the 3D objects was presented. The tool allows the user to share and search for the 3D models in a structured P2P architecture. It allows performing several types of queries:

- Query by Example (QbE) for 3D models with use of another 3D model
- QbE for 3D models with use of an image
- QbE for 3D models with use of a sketch
- Search with the use of keywords
- Combination of the above

The tool is developed in two versions – for the PC and palmtop environments. The palmtop version has limited functionality due to low processing power of such devices. The project has analyzed two general use cases – for the automotive and gaming industry. In both of these market segments 3D model manipulation is of utmost importance.

Workshop on Video Streaming over MANETs, 18-19 December 2008, Barcelona, Spain. The University of Oslo and the Technical University of Catalunya have co-organized a Workshop on Video Streaming over MANETs (Barcelona, 18/19th of December 2008). The workshop has received contributions both from CONTENT and non CONTENT members (University of Oslo, University of Coimbra, Università degli Studi di Napoli Federico II, Universidad de Ovideo and Technical University of Catalunya). The keynote speech has been delivered by Prof. Thomas Plagemann and later the different contributions have discussed the main issues, challenges and research opportunities in delay-tolerant and delay-sensitive video streaming over Mobile Ad-Hoc Networks. The following is a list of the contributions:

- (Keynote) Thomas Plagemann (University of Oslo) "Delay Tolerant Streaming - Contradiction, Fiction, or Science"
- Sergio Cabrero (Universidad de Ovideo) "An overlay solution to support multimedia services over sparse MANET"
- Francesco Paolo D'Elia (Università degli Studi di Napoli Federico II) "Overlay/Underlay routing issues in Wireless Mesh Networks"
- David Palma (University of Coimbra) "Nature Optimized Deferred Routing Protocol for MANETs - NODRoP"
- Ovidiu Drugan (University of Oslo) "Some Foundations for Topology Aware Service Placement in MANETs"
- Albert Cabellos (Technical University of Catalonia) "Measuring bandwidth over IEEE 802.11 links"
- Pere Barlet-Ros (Technical University of Catalonia) "Load Shedding in Traffic Monitoring"

More information as well as the slides of the workshop can be found at the following url: http://www.cba.upc.edu/workshop_content .

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2nd International Workshop
FUTURE MULTIMEDIA NETWORKING
2009 June 22-23, Coimbra, Portugal
http://fmn2009.dei.uc.pt/

FMN 2009

FMN 2009, 22-23 June 2009, Coimbra, Portugal. The organization of the Second Workshop on Future Multimedia Networking (FMN 2009) on 22-23 June 2009, Coimbra, Portugal, is on-going. FMN 2009 will be the CONTENT open workshop, and will constitute an important event to discuss advanced future multimedia networking issues and research challenges towards Autonomic Content Networks.

The objective of the workshop is to discuss state-of-the-art research and developing activities contributing to aspects of multimedia systems, content networking, and autonomous communication. Topics of interest include:

- Autonomous management in next generation content networks
- Content delivery networks
- Audio-visual systems
- Novel protocol for multimedia services
- Grid networking for multimedia services
- Multimedia in personal, sensor and ad-hoc networks
- Multimedia in peer-to-peer networks
- Quality of service and quality of experience management in content networks
- Management of service oriented architectures
- Seamless mobility of multimedia services
- Novel multimedia architectures/platforms
- Multicast and broadcast multimedia service management
- IP multimedia system operations and management
- Resource reservation for multimedia services
- Multimedia in mobile and broadband wireless access networks
- Experiments/lessons from recent deployments
- Performance evaluation of multimedia services
- Network measurement/monitoring for multimedia services
- Pricing, accounting and billing for multimedia services
- Reliability, availability, serviceability of multimedia services

The submission deadline for FMN 2009 is January 31st, 2009. The workshop proceedings will be published by Springer. For more information, please visit http://fmn2009.dei.uc.pt/

SATIN

Misbehaviour-aware QoS framework for wireless mesh networks
Student: Szymon Szott (AGH)
Supervisors: Marek Natkaniec (AGH), Andrzej R. Pach (AGH), Roberto Canonico (CINI/UoN)

Problem description

Mesh networks rely on the cooperation of all participants. A problem arises if one of the participants misbehaves (i.e., decides not to cooperate with others). A mesh node may decide to misbehave in order to gain certain measurable profits (such as higher throughput). Misbehaviour is always done at the cost of the well-behaved nodes in the network. Therefore, it would be favourable if such actions were at least discouraged, if not made impossible.

In particular, misbehaviour is a threat to networks built with the IEEE 802.11 standard because it provides no incentives to cooperate. Any user can change 802.11 parameters to his/her own advantage. This can be done very easily with the use of the latest madwifi wireless drivers. With these modifications, users can, for example, achieve better network access than their neighbours. Likewise, a vendor of wireless cards might decide on using non-standard parameters to achieve better performance. This makes misbehaviour a real threat to mesh networks.

Papers

In the scope of this work, the following joint papers have been submitted for publication: S. Szott, M. Natkaniec, A. Banchs, "Impact of Misbehaviour on QoS in Wireless Mesh Networks", submitted to IFIP Networking 2009, and S. Szott, M. Natkaniec, R. Canonico, "Detecting Backoff Misbehavior in IEEE 802.11 EDCA", submitted to IEEE Communication Letters.

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The first paper provides simulation results which determine the impact of misbehaviour on QoS provisioning in a multi-hop mesh environment. Two forms of IEEE 802.11 EDCA parameter modification were considered: downgrading forwarded traffic and promoting local traffic. It has been shown that these modifications are a real threat to wireless mesh networks because they both allow easy access to higher throughput and also degrade QoS provisioning. The main conclusion is that, in multihop scenarios, degrading forwarded traffic yields a greater advantage than cheating on medium access parameters.

The second paper analyses several methods for detecting backoff misbehaviour in IEEE 802.11 EDCA networks. Simulation results show varying detection performance depending on traffic class. The most suitable methods for each class have been proposed. Simulation results have shown that the chi-square test is most suitable for high priority traffic while the mean test is most suitable for low priority traffic. These two tests can be considered when implementing a backoff detection mechanism in IEEE 802.11 EDCA networks. The immediate next action in this topic is to implement and evaluate the performance of the proposed detection method in a real-life testbed.

Analysis of IEEE 802.11 EDCA networks in ring topology scenarios with hidden and exposed nodes
Student: Katarzyna Kosek (AGH)
Supervisors: Marek Natkaniec (AGH) and Luca Vollero (CINI/UoN)

In the context of her PhD work, Katarzyna Kosek (AGH) submitted a paper to the Networking 2009 conference. In the paper, she presented a thorough analysis of IEEE 802.11 EDCA networks in ring topology scenarios with hidden and exposed nodes. A generic ring topology is presented in the following figure.

The analysis presented in the paper is not only original but most of all crucial for understanding how the theoretically simple ring topology can be degraded by the presence of hidden and exposed nodes. Configurations with equal and mixed priorities were considered. Additionally, the usefulness of the four-way handshake mechanism was argued. Furthermore, the achieved results were briefly compared with the results obtained for several star and line topology networks.

The main differences between the compared topologies are as follows:

- The ring topology, in contrary to the star and line topologies, assures fairness if all nodes within a network send traffic with the same priority.
- In general, the overall throughput value of high priority traffic is lowest for ring topology networks.
- Only for the ring topology the order of the EDCA priorities is never swapped.
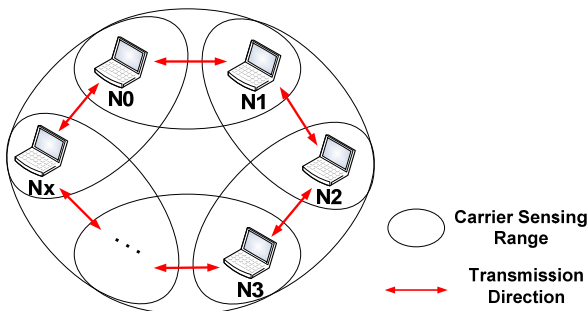
The main similarities are the following:

- For all topologies with mixed priorities, there is significant unfairness in medium access.
- If most nodes send high priority traffic, their overall throughput is lower than for low priority traffic.
- In most cases, turning the RTS/CTS exchange on does not eliminate the unfairness between nodes.
- Considering the values of the overall throughput, it is better to turn the RTS/CTS exchange off for all networks in which low priority traffic is dominant.

Carrier Sensing Range

Transmission Direction

On the basis of the conclusions from the performed simulations, it became obvious that current ad-hoc networks are not able to satisfy QoS requirements of high priority services if hidden and/or exposed nodes appear in a network. As a consequence, a novel MAC layer QoS mechanism must be proposed to deal with this severe problem. Therefore, current work will be focused on finding ways to detect hidden and exposed nodes, optimize the EDCA access parameters, and perform precise MAC layer measurements. These steps are necessary in the process of creating a novel MAC layer protocol which will, ideally, outperform EDCA and will be easy to implement in wireless devices.

JOINT RESEARCH

Routing in Multi-domain Multilayer Networks
Task responsible and organization: Anteneh Beshir (TUDelft)
List of contributing organizations: TUDelft and UPC

The aim of this joint activity is to study inter-domain routing in multilayer networks, with special focus on wavelength-division multiplexing (WDM) optical networks, as the transport means to provide the expected

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bandwidth and quality demands for applications that transport huge volume of data across domains. We compare an inter-domain routing architecture proposed by UPC (after modifying it to achieve wavelength conversion) with others suggested in the literature.

A short scientific mission to UPC for further discussion was carried out by Anteneh from TUDelft in the period 12th – 19th October, 2008. After discussing the specific issues to be dealt with, we have modified the architecture and have been performing comparative simulations. During October to December 2008, work concentrated on the modification of the base architecture in order to achieve wavelength conversion and on simulation. In the near future, a rigorous evaluation of the inter-domain routing model with respect to others suggested in the literature under different scenarios will be carried out.
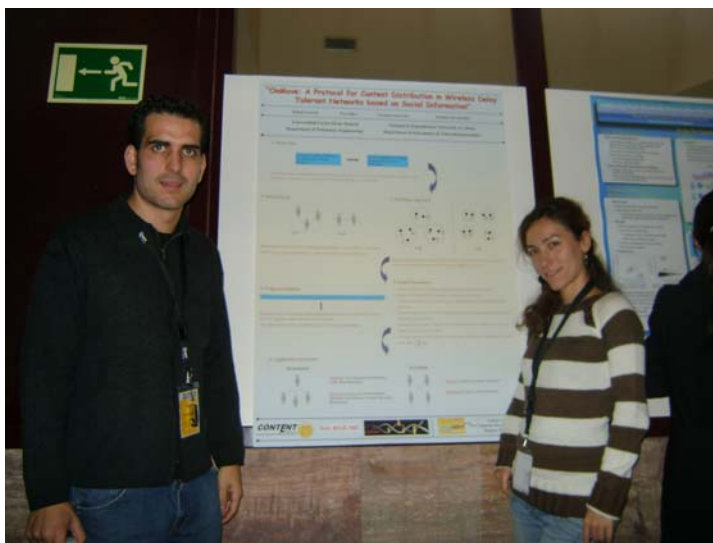
OnMove: A Protocol for Content Distribution in Wireless Delay Tolerant Networks based on Social Information

Rubén Cuevas†, Eva Jaho‡, Carmen Guerrero†, and Ioannis Stavrakakis‡
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UC3M and NKUA have recently initiated joint research in content distribution based on social information. The first ideas and preliminary work were presented in a poster in the ACM CoNEXT 2008 Student Workshop in December 9th 2008 in Leganés Madrid. The Ph.D. students Eva Jaho and Ruben Cuevas presented OnMove, a novel protocol for content distribution in wireless delay tolerant networks populated by handheld devices. To improve content distribution, OnMove exploits social characteristics (social similarities and physical encounters) between individuals. We motivate the problem and describe a content sharing protocol based on a ranking algorithm that exploits the social and networking characteristics of individuals. The core algorithm running on OnMove individuals is a ranking mechanism. The ranking parameters vary depending on the application making OnMove an adaptive protocol. In the next steps, we will extensively investigate the configuration of the ranking algorithm mechanism in several application scenarios and optimize it. We also plan to analyze the social profiles available on the current systems such as FaceBook and how to export them to wireless DTNs. Finally, we will investigate the creation of overlay networks for content distribution in wireless DTNs. This research was also the focus of a short-term scientific mission that took place in the week of Dec 8, 2008 with the visit of the NKUA Ph.D. student Eva Jaho to UC3M for collaboration with Ph.D. student Ruben Cuevas and Prof. Carmen Guerrero.

Objective Video Quality Assessment in Content Distribution Network
Task responsible and organization: Mu Mu (ULANC)
List of contributing organizations: ULANC, AGH and UC

The goal of the task is to design a quality assessment service in the content distribution network to evaluate user satisfaction on the received content. It is essential to address the facet and root cause of video quality degradation in content distribution network. Two approaches namely Artefact Measurement and Artefact Prediction (a. k. a Quality of Delivery) are being taken to explore the task considering the entire lifecycle of the content (capturing, preparing, delivering, receiving and presenting).

From the past and current joint studies within this task, the big picture with respect to Objective Video Quality Assessment in Content Distribution Network has become clear and highly relevant research directions have been identified. In the next period, joint studies will continue and focus on specific technical challenges that have been raised such as integrating artifact measurement with artifact prediction for overall quality assessment. We expect good development and publications in the next period.

In the next period AGH will continue development of artefacts measurement scenario. In the nearest future new no-reference metrics for over- and under-exposure will be developed as well as further studies on blockiness metric will be done. In order to strengthen cooperation within CONTENT, Mu Mu from ULANC will visit AGH for a short term scientific mission. The main goal of the visit is to discuss statistical analysis of the

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data obtained in subjective experiments. It is also planned to strengthen cooperation with VQEG group and get involved into new activities. For this purpose one person from AGH will attend next VQEG meeting in San Jose. AGH will cooperate with PTC Era GSM (polish brand of Deutsche Telecom) in order to specify a concrete scenario for video quality assessment and finally validate designed metrics in real environment.

SHORT-TERM SCIENTIFIC MISSIONS

UNIVERSITAT POLITÈCNICA DE CATALUNYA

Loránd Jakab (UPC) has visited CINI-UoN on a short-term scientific mission from the 17th to the 21st November 2008. The main objective of previous work, and of this visit as well, was the definition of the possible threats a P2P network, and especially an infrastructure for Content Delivery, could be subject to. So far, we have collected and studied contributions to the scientific literature on that subject, and submitted apaperto the Computer Networks Special Issue on CDNs, which was rejected by the reviewers, and needs some more work and refinement. We carefully examined implications of reorganizing and, after several upgrades, rewriting that work, but we decided that other, more timely topics should be our top priority and that work will continue as a lower priority objective.

During the stay at UoN, several brainstorming sessions about threats against CDNs (and not only) took place. The most prominent and interesting ones are today posed by botnets whose structures became more and more sophisticated. The existence of P2P botnets, in particular, is one of the most recent examples of how the inherently distributed nature of P2P networks can help a malicious attacker to perform very effective offensive actions, and still keep his identity hidden. We also studied the most recent botnets implemetation, exploiting fast-flux networks. We iterated through several ideas, quickly reviewed related literature, and discussed their feasibility. The most interesting results of these discussions were:

- The improvements and evolution of botnet structures seem to resemble the evolution of the Internet, and respond to an increasing need for effectiveness and availability of malicious tools: starting with a simple centralized content lookup system, and later evolving to distributed, then looking for high availability by using fast flux.. Anticipating the further evolution of those structures would accelerate finding adequate response by the time when they will be actually implemented, thus we should imagine possible scenarios, based on analogies with the evolution of the Internet. Obviously, such a result can be considered as long-term, and requires vision and awareness of the most recent scientific solutions to security problems.

- The newest command and control mechanism and content distribution strategy used by online criminals is based on a technique called fast flux DNS, which is an emerging research field. A few basic studies exist, but a lot still has to be done. Since the effect of using fast-flux can be observed in changes of DNS traffic characteristics, we plan using existing DNS research to be applied to this problem.

- Following up my previous work within CONTENT (modeling the effects of index poisoning in peer-to-peer botnets), we could work on improving the botnet's resilience against this type of attacks, because this may be the logical next step from the botherder's side. We have already identified previous research (S/Kademlia), which could be exploited for this purpose. We will also investigate possible countermeasures for these improvements.

Apart from communicating on email, we agreed on weekly conference calls to discuss advances, discoveries, and questions that came up, exchange new ideas and set next conference's goals. This should ensure constant progress. A long term scientific mission for 2009 is being planned.

INVITED TALKS

On the Internet of the Future
Prof. Ioannis Stavrakakis (NKUA)

Ioannis Stavrakakis was invited to give a presentation titled "The Internet of the Future" in ICT2008, Nov 25-27, 2008, Lyon, in the session WP 09-10: Network of the future, organized by DG INFSO Unit D1. http://ec.europa.eu/information_society/events/cf/item-display.cfm?id=852 . A summary of the talk that reflected own views as well as views expressed by the community at large in previous related forums is provided below.

In general it is believed that there is not sufficiently clear understanding as to what future Internet research should be about. The approaches that have been advocated in this direction can be classified as either evolutionary or revolutionary (or clean slate designs).

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Arguments favoring an evolutionary approach include: the large scale of today's Internet that calls for incremental changes only; the belief that realistic chances of actually deploying something entirely new are very slim; a revolutionary, academic-type of approach would be unlikely to be adopted by component vendors and network providers; ATM was a clean slate design and never made it as such.

Arguments favoring a revolutionary approach include: only long-term research will identify the best solution, as it would not be constrained by current designs; incremental point fixes to Internet architectural problems should not be considered as research to fund, as the industry takes care of them anyway; an evolutionary approach leads to an accumulation of fixes which is itself a problem; evolutionary improvements to the Internet can only be small and typically increase its cost and complexity, without solving its problems.

In view of the issues and challenges that current Internet faces and the changing networking environment, it is widely believed that a new paradigm is needed for designing the network of the future.

Consumers become Content producers and publishers, with the personal self-authored content growth clearly dominating that of the pre-recorded commercial one. Future Internet will mostly be about sharing user-generated. Consequently, the network is increasingly becoming a large distributed database and Content distribution becomes the communications rational. The Future Internet design should move from inter-connecting nodes to inter-connecting information following a Content- rather than connectivity –centric networking approach.

Social networking (MySpace, Facebook, etc) is coming into the picture rather strong, enabling users to create their own profiles and virtual worlds. The social layer is emerging very strong, as person socializing explodes, local communities grow and so do the interactions between physical and social networks. An emerging social control plane could be instrumental in designing the physical plane.

Accommodating the mobile/wireless world by the Post-IP Internet is a necessity, as mobile communication devices are surpassing fixed ones. The wired and wireless networking worlds have been quite   different in their approaches, thus the design emphasis should be different in order to accommodate physical limitations of the mobile radio environment, integrate as core functionality mobility, QoS and security, provide support intermittent and dynamic connectivity, etc.

Telcos - Internet convergence is expected to unlock a new wave of innovation for future services and application scenarios: openness, broad federations of players and do-it-yourself innovative services and knowledge management that will allow people to be the true centre of Information Society. The end-to-end paradigm is changing, also as functionality is being moved inside the network. Future Internet will need to expand its coverage and scope and accommodate a large variety of networked systems, emerging virtual worlds, service creation and competition, and lots more.

With several goals to meet and aspects to accommodate, future Internet is more likely to be a polymorphic one, federating various views on it: as a large distributed database; as a predominately wireless (access) network; as a network of people; as a network is a global virtualized resources. Federation will provide the glue to virtualization and the Polymorphic Internet.

Regarding the enabling communications technologies, several advances are to be made in support of the Future Internet vision. The wireless network should support DSL-like rates, so that the distinction between fixed and mobile/wireless be minimized enabling the concept of a universal high bandwidth connection. Future mobile communication should increase its spectral efficiency, beyond today's limits (10-20 b/s/Hz/Cell, compared to the 0.25 b/s/Hz/Cell currently achieved in GSM). To achieve longer term scalability in the core, advances in current optical switching technologies are needed. Network coding can enhance network operation so that it can go far beyond traditional routing, or store-and-forward, approaches. Information to be treated as a virtual, abstract entity that can be operated upon, rather than as objects to be transported unchanged.

Networking systems consume large amounts of (transmission and dissipated) energy, due to the VLSI technologies, excessive signal processing and excessive higher layer signalling. Energy consumption of Information and Communications Technologies (ICT) equipment is becoming a significant portion of the energy consumption worldwide when one factors in: the electricity consumption of the ICT equipment during its operational lifetime; the energy expended during the ICT equipment manufacturing process, also factoring in the lifetime of the equipment; the energy (that should be) expended during the disposal process. The environmental sensitive Europe has a chance for a pioneering role in this direction.

The largest growth of the Internet is observed in the Asia-Pacific region and the lowest in Europe. Internet growth explodes, but the money is not growing (flat rates), leading to pressure for optimality and efficiency.

Current Internet has been successful, but it faces serious problems or a crisis. Although this is not happening for the first time in Internet's history and, thus, there should be no reason to panic, this time is more alarming and a bigger of a challenge, due to the wide investment of the society on it and expectations from it. Internet has gone out of shape in its effort to accommodate a lot of complexities and peculiarities it has been facing in

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the last years: both its control and data planes have become very complex, making the redesigning of the entire Internet architecture the most promising approach. To be successful in this, we need to understand what is that we should pursue and define a (European) vision that would be clear and possible to articulate even outside the particular research community.

PHD EXAMINATIONS

Student: **Antonio de la Oliva**
Institution: University Carlos III Madrid, Spain
Date: 8 July 2008
Examination board:

- Prof. Ioannis Stavrakakis, National Kapodistrian University of Athens, Greece.
- Prof. Fco. Javier González Castaño, University of Vigo, Spain.
- Prof. Jon Crowcroft, University of Cambridge, UK.
- Prof. Arturo Azcorra, University Carlos III Madrid, Spain.
- Prof. Maria Calderon, Unviersity Carlos III Madrid, Spain.

Thesis title: Control Mechanisms for Mobile Terminals in heterogeneous access technology environments

Abstract: Internet is evolving to become mobile and ubiquitous. As a consequence, there is a trend towards a diversification of the access technologies, as it can be seen with the recent appearance of wireless technologies such as WiFi or UMTS and the future deployment of WiMAX. Following these new opportunities, multi-technology terminals able to connect to the Internet through different technologies are appearing in the market. In this scenario, users start to demand new solutions able to use these new technologies in a transparent way from the user point of view. Foreseeing this demand, the IEEE started developing the specification IEEE 802.21, which enables multi-technology terminals to handover from one technology to another in a transparent way for the user. This specification has not yet being finished, and its deployment requires from the research community to analyze how to integrate it in current networks, how to achieve maximum benefit from its possibilities, and how to configure its parameters.

In this thesis we propose control mechanisms for IP terminals to i) support efficient handovers in multi-technology environments applying the 802.21 framework and ii) allow the use of several interfaces and/or multiple providers by the terminals to improve the failure robustness of their communications. These mechanisms are focused in the terminal, although we also provide details on how to integrate IEEE 802.21 into nowadays operator's networks. The contributions of this thesis are threefold. In the first place the integration of 802.21 into terminals has been studied, focusing on the configuration of the parameters required to decide when to perform a handover in the case when the handover is initiated by the terminal. This analysis has also been done taking into account variables such as the terminal speed and the delay of the links. In the second place, we have studied how to introduce the Network Controlled Handover concept, using 802.21, into the network, including the possibility of the handover being initiated by the network. We have analyzed which are the main benefits of this approach and proposed and validated an implementation of this concept in 802.21. In third place we have analyzed a protocol, REAP, under development in the IETF, which allows terminals to detect and recover from failures in the links used in their communications. We have focused in the analytical characterization of the time required to detect a failure, since this parameter is crucial for the application's behavior. The applications should be able to cope with a failure without being disrupted by it. Through the analytical study performed, the REAP protocol can be properly configured to achieve a target recovery time.

All the proposed mechanisms have been validated through simulation, using several tools such as OPNET, OMNET++ and Matlab.

Student: **Constantinos Vassilakis**
Institution: National and Kapodistrian University of Athens
Date: 18 December 2008
Supervisor: Ioannis Stavrakakis
External examiner: Nikolaos Laoutaris (Telefonica Research)

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Thesis title: Peer-to-Peer Content Distribution

Abstract: Distributing live video stream using a P2P streaming system has the advantage over a point-to-point client/server system of offering more resources to clients by effectively turning each one of them into a secondary server that assists in the distribution of the stream. These additional resources can yield improved scalability and/or resilience, depending on the design of the system. Organizing the nodes into a tree shoots for scalability while meshes on the other hand shoot for resilience to congestion/churn by providing each node with multiple parents from which it can receive the stream in parallel.

Several works focus on overlay construction and coding neglecting the fact that functions well understood in the context of point-to-point video streaming require to be revisited in the context of P2P video streaming since the new setting adds new dimensions beyond our previous understanding. Our approach to the problem is to preserve the inherent advantage offered by the P2P architecture and exploit it to enhance the quality experienced by the end user, by revealing those subtle processes that may affect the overall system performance and require a different design perspective that suits the new distribution environment.

In the first part of this thesis we have examined the impact of the adopted playout policy on the performance of P2P live streaming systems. We argue and demonstrate experimentally that (popular) playout policies which permit the divergence of the playout points of different nodes can deteriorate drastically the performance of P2P live streaming. Consequently, we argue in favor of keeping different playout points "near-in-time", even if this requires sacrificing (dropping) some late frames that could otherwise be rendered (assuming no strict bidirectional interactivity requirements are in place). Such nearly synchronized playout policies create "positive correlation" with respect to the available frames at different playout buffers. Therefore, they increase the number of upstream relay nodes from which a node can pull frames and thus boost the playout quality of both single-parent (tree) and multiple-parent (mesh) systems. On the contrary, diverging playout points reduce the number of upstream parents that can offer a gapless relay of the stream. This is clearly undesirable and should be avoided as it contradicts the fundamental philosophy of P2P systems which is to supplement an original service point with as many additional ones presented by the very own users of the service.

In the second part of this thesis we have taken into consideration the realistic fact that the quality experienced at a peer is highly correlated with the probability of this peer to churn. A novel churn model is introduced which associates the likelihood of churn with the experienced quality. The model produces a lifetime distribution that is in agreement with recent measurement studies. Considering such a model in a P2P environment with node churn, we explore peer selection strategies aiming at improving the stability (reducing node churn) and the offered quality of the system, by taking into consideration the distinct characteristics of a live video streaming service,

Student: **Vittorio Manetti**
Institution: University of Napoli
Date: 19 December 2008
Supervisor: Prof. Giorgio Ventre (CINI/UoN)
Co-supervisor: Prof. Ioannis Stavrakakis
Thesis title: A new paradigm for innovative networked services, the Service Switching

Abstract: The Internet was founded on a simple model in which the routers inside the network are responsible for forwarding packets from source to destination, and application programs run on the hosts connected to the edges of the network. However, the last few years have seen a blurring of the distinction between packet forwarding and application processing. In such a context we propose a new paradigm for modern networked services: the Service Switching.

Composed by nodes capable to host services in addition to the traditional forwarding IP-based mechanism, the Service Switching infrastructure presents as its major feature the ability to implement a service migration mechanism among geographically distributed nodes, in order to make services seamlessly and transparently available to end-users regardless of their current location.

A Service Switch can store and host different services and applications with their respective data providing a secure and differentiated execution environment, and it can coordinate its behavior with other Service Switches in order to develop and provide services in a distributed way, according to optimal resource utilization schemes.

We propose an implementation of the Service Switching infrastructure based on virtualization mechanisms; such a technology allows to create isolated and self-contained virtual computing environments, completely independent from the underlying hardware.

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CONTENT — Excellence in Content Distribution Network Research

December 2008

Student: **Albert Cabellos-Aparicio**
Advisor: Prof. Jordi Domingo-Pascual (Technical University of Catalunya)
Co-Advisor: Dr. Francisco J. Garcia (Agilent)
Institution: Technical University of Catalunya
Date: 16 December 2008
External examiners: Prof. Fernando Boavida (University of Coimbra) and Dr. Fabio Ricciato (Università del Salento), Prof. Giorgio Ventre (UNINA), Prof. Carmen Guerrero (UC3M)
Thesis title: On the Transition to the Mobile Internet

Abstract: The Internet is an evolving system. Recently wireless technologies have opened up the possibility of deploying mobility at the Internet. With mobility end hosts can change its point of attachment while maintaining its network connections. Deploying such functionality at the current Internet architecture is a complex task. Basically, this is because, with mobility, end hosts require two identifiers, one related with its identity and another one related with its location. However the current Internet's end host identifiers (IP addresses) represent both the identity and the routing locator of the node. This issue has raised a debate among the research community: "Which is the optimal layer to deploy mobility?". This thesis analyzes such issue using a technical and a cost-effective point of view. Our analysis suggests that although technically the optimal solution would be a cross-layer deployment, network-layer mobility provides the most cost-effective solution. The proposed network-layer mobility protocol, defined by the IETF, is the Mobile IP technology. Taking this into consideration this thesis analyzes the transition to the Mobile Internet considering the deployment of Mobile IP. Specifically, the main objectives of this thesis are to analyze the transition to the Mobile Internet, identify its potential issues and propose solutions. The analysis is carried out at three different stages of the transition. First at present, by analyzing the Mobile IP technology. Our study shows that one of the key issues of Mobile IP is the performance of the handover.

The thesis presents an analytical model and experimentation to study several metrics related with the handover of the main protocols of Mobile IP. Summarizing, the obtained results show that the Mobile IPv4's handover can support real time applications, but Mobile IPv6's not. A reason for that is the large amount of time that takes to reconfigure IPv6 (in the order of seconds). Furthermore the thesis shows that Fast Handovers for Mobile IPv6, an extension of Mobile IPv6 that improves the handover, effectively enhances the protocol to support delay-sensitive applications. The second stage of the analysis is in the near-future, during the deployment phase of Mobile IP. As shown in this part of the thesis, the main issues during this phase of the transition are the lack of route optimization and low reliability of Mobile IP-based networks. The first issue prevents mobile clients from communicating directly with its peers, and this has a significant impact on the performance of such networks. In order to solve this we propose the fP2P-HN architecture. A P2P-based network of distributed Home Agents that reduces significantly the paths of mobile clients. Our evaluation shows that our proposal is scalable ($O(1)$) and that can reduce significantly the delays of the paths. In order to solve the second issue we propose a novel Home Agent architecture that distributes its operations throughout the network. Our evaluation shows that this increases reliability and reduces the load at the Home Agents. Finally the third stage of our analysis is in the future, were the Internet is Mobile IP-enabled and new architectures can improve its functionalities. Particularly this thesis analyzes the advantages and the complexity of terminals equipped with multiple interfaces. This can provide more aggregate bandwidth, increase the reliability and the area of coverage. However supporting multiple interfaces can be a difficult task. Our analysis reveals that a generic architecture able to deal with these issues can be greatly enhanced if the available bandwidth of the different paths provided by the multiple interfaces can be estimated. Research on bandwidth estimation has focused mainly on periodic probing processes and wired networks, however very little research has been conducted considering wireless links (a typical scenario of mobility). Therefore this thesis focuses on analyzing the existing methodologies and tools in the presence of wireless links, taking the IEEE 802.11 standard as a reference. Our study shows that periodic probing processes target the achievable throughput instead of the available bandwidth. This metric is related with the fair share of the network. Additionally, measurements using periodic probing processes present a bias. This affects the first packets of the process that are served faster than the remaining ones. This bias appears due to the random nature of wireless networks and may impact the measurements. Taking this into consideration this thesis explores poisson-probing process to estimate the available bandwidth in wireless and wired scenarios. In particular our research has lead us to design three different tools that can operate in a wide range of scenarios. Furthermore, our study in poisson probing processes reveals that they are useful to estimate the available bandwidth in wireless links and can produce lighter (less intrusive) and faster tools

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PUBLICATIONS / SCIENTIFIC EDITORIAL WORK

FMN 2008 Best Papers Awards (correction) – Due to a mistake in the October Newsletter, the correct list of papers which received the best paper award (ex-aequo) at FMN 2008 - First IEEE Future Multimedia Networking Workshop, Cardiff, UK, 17-18 September2008, is given below:

- Benny Fallica (TUDelft); Yue Lu (TUDelft); Fernando Kuipers (TUDelft); Robert Kooij (TNO ICT, NL); Piet Van Mieghem (TUDelft), "On the Quality of Experience of SopCast".
- Isaias Martinez-Yelmo (UC3M); Alex Bikfalvi, (IMDEA Networks); Carmen Guerrero (UC3M); Rubén Cuevas Rumín (UC3M); Andreas Mauthe (ULANC); "Enabling Global Multimedia Distributed Services based on Hierarchical DHT Overlay Networks".

Software evolution in decentralised environments
Andreas Mauthe (ULANC), Gareth Thyson (ULANC), Sebastian Kaune (TUD)

The heterogeneous and large-scale nature of complex decentralised systems creates significant issues when deploying new functionality and adapting node behaviour. This problem centres on the difficulty in disseminating functionality and subsequently selecting which nodes should adopt it. In traditional client-server models this is not a concern as it is easy for a centralised point of control to introduce new functionality and dictate that particular clients incorporate it. However, within decentralised systems it is the nodes themselves that manage behaviour and therefore it is important to ensure that each node operates in the optimal manner for its environment. As a collaboration between ULANC and TUD an investigation has been performed into the potential of using a combination of peer-to-peer technology and reflective software engineering to perform autonomic evolution and adaptation in a totally decentralised manner. The approach exploits the similarities between peer-to-peer networking and biological ecosystems. Within an ecosystem exists a number of autonomous organisms attempting to self-optimise. Those that possess effective characteristics survive and reproduce whilst those that do not, become extinct. This is an efficient and self-organising process that can offer a number of advantages for decentralised computing systems. Using the designed approach, functionality is encapsulated in reflective components that are considered first class entities in the system. Functionality that is well suited to nodes that it is hosted on gets autonomously propagated whilst ill-suiting functionality becomes extinct. By this, a self-managed infrastructure is created that supports the deployment of functionality following the evolutionary theory of natural selection. Simulations show that effective functionality quickly spreads to nodes that consider it optimal whilst functionality existing in ill-suited environments becomes extinct. This process therefore allows any user to deploy any body of adaptive functionality without the need to handle either its distribution or the selection of suitable peers for its operation. The figure shows the percentage of nodes that gain the optimal functionality for their particular environment; the black line shows the optimisation levels with 10 components competing whilst the red line shows optimisation levels with 50 components competing. It can be seen that a high degree of optimisation occurs soon after the deployment of the functionality in the network. This approach offers further benefits that include autonomic configuration generation, self-evaluative test-beds and the decentralised detection of malicious peer-to-peer services. This work was recently published at ACM/IFIP/USENIX Middleware's Workshop on Adaptive and Reflective Middleware.
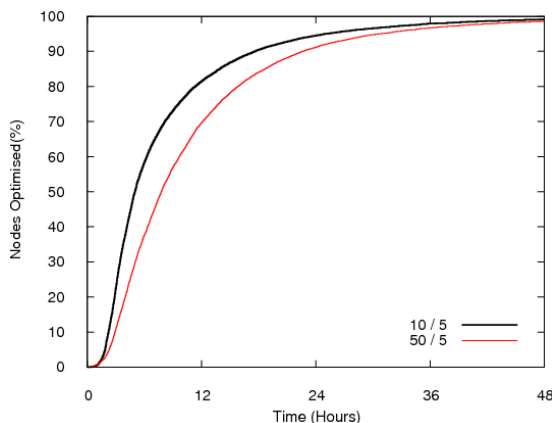
Analytical Model for Mesh-based P2PVoD
Yue Lu, Jan-David Mol, Fernando Kuipers, and Piet Van Mieghem (TUDelft)

Recently, there has been a growing interest in academic and commercial environments for Video-on-Demand (VoD) using Peer-to-Peer (P2P) technology. Unlike centralized solutions for VoD services, P2P technology lets the clients distribute video content among themselves. In this research, we proposed an analytical model for P2PVoD and we compared that model to a realistic P2PVoD simulator. With our model, parameters that affect the system performance can be observed, and the system stability can be investigated. Our model leads to design rules for achieving a good and stable system performance. This work is, to our knowledge, the first analytical work to model mesh-based P2PVoD.

In December 2008, this work was presented at the IEEE International Symposium on Multimedia (ISM2008), Berkeley, California, USA.

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Computer Networks special issue

The publication COMNET's special issue on Content distribution infrastructures for community networks is expected to occur during the first quarter of 2009, according to the following schedule:

- Reception of camera-ready versions - 20 January 2009
- Dispatch for publication - 26 February 2009
- Publication – 14 March 2009 (vol 53, no. 4).

The many submissions we received were evenly spread over different areas and showed how relevant and timely the topic of this special issue is. Out of sixty-five submitted papers, nine were selected considering their quality and relevance for the topic of the special issue. The articles selected for this special issue can be grouped into three different research themes: i) articles dealing with different issues related to application domains such as peer to peer streaming; ii) articles presenting analysis and measurements of content distribution networks; and iii) articles presenting research into overlay network design and new concepts for content network overlays.

The editors of this special issue are Prof. Roberto Canonico (CINI-UoN), Prof. Carmen Guerrero (UC3M) and Prof. Andreas Mauthe (ULANC).

COOPERATION WITH OTHER INSTITUTIONS

Access Network Synthesis Game in Next Generation Networks

The National & Kapodistrian University of Athens (NKUA) – a CONTENT and an E-NEXT partner - and the University of Cyprus – an E-NEXT partner - initiated new joint research in 2008, exploiting the mutual understanding built in the past in the context of the E-NEXT NoE activities. This research brought together two new Ph.D. students from the two Universities that collaborated under the supervision of Prof. A. Pitsillides (U. Cyprus) and Prof. I. Stavrakakis and Post-Doc Dr. G. Koukoutsidis from NKUA: Josephina Antoniou (U. Cyprus) and Eva Jaho (NKUA).

In next generation communication networks, multiple access networks will coexist on a common service platform. In cases where network resource planning indicates that individual access network resources are insufficient to meet service demands, these networks can cooperate and combine their resources to form a unified network that satisfies these demands. Using Game Theory as the theoretical framework, this research introduces and studies the Network Synthesis game, in which individual access networks with insufficient resources form coalitions in order to satisfy service demands.

The formation of stable coalitions in the core of the game has been investigated, in both cases where payoffs are transferable or are attributed in proportion to the contribution of each member of the coalition. We study the stability of coalitions according to the core and inner core concepts. When payoffs are transferable, this leads to trivial solutions of minimal-sized coalitions. When payoffs are non-transferable, the proportional payoff allocation case is considered and the notion of a "by-least winning" coalition is employed. In all cases, when access networks have more than one preferences for coalitions, the game results in a coordination game with conflicting preferences. We show that there exists at least one coalition which satisfies service requirements and in which all its members attain their highest possible payoff. When there are multiple stable coalitions, we introduce the concept of stability under uncertainty of formation, to single out coalitions which are more likely to be formed.

We have also examined the behaviour of different indices that can be used to represent the relative power of each network in the game, such as Shapley-Shubik, Banzhaf and Holler-Packel indices. In game theory, power indices are used to measure the influence of a player on the formation of coalitions and thus on the game itself. Payoff allocations based on power indices are appropriate in case of a common pool of resources. Using the knowledge attained from the coalition game analysis we propose a new index, called the Popularity Power Index, which associates the popularity of each access network to the number of stable coalitions it participates in. This new index aims to achieve fairness, in the sense that it considers only the stable coalitions that would be formed if payoffs were assigned proportionally to the players' contributions, considered as a fair manner.

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This research has led to the following article which has been submitted for journal publication: Josephina Antoniou (UCY), Ioannis Koukoutsidis (NKUA), Eva Jaho (NKUA), Andreas Pitsillides (UCY), Ioannis Stavrakakis (NKUA), "Access Network Synthesis Game in Next Generation Networks", University of Cyprus(UCY) and National & Kapodistrian University of Athens(NKUA), submitted for journal publication.

INDUSTRY LIAISON

Local Industry Workshop @ TUDelft

15 October 2008, TNO ICT, Brassersplein 2, Delft, The Netherlands

About 40 persons from KPN, TNO, IBM, Ericsson Netherlands, Government, and Dutch universities attended the workshop. Attendance from TUDelft: Dr. Doerr (new assistant professor in NAS), Yue Lu (PhD student, TUDelft/NAS), António Madureira (PhD student TUDelft/NAS), Prof. Nico Baken (KPN/TUDelft), and Ing. Edgar van Boven (KPN/TUDelft). On this occasion, several presentations were made by TUDelft:

- "To peer or not to peer, that's the question", Yue Lu
- "Trans-sector innovation from a modelling perspective", António Madureira
- "Trans-sector innovation framework", Edgar van Boven

Due to the success of the event, there will be a new local industry workshop organized next year. In addition, there are attempts to formalize the links with the Dutch telecommunications industry. In particular, TUDelft/NAS is currently working on establishing a new "knowledge center" with the industrial partners KPN and TNO.

dagen @ ifi

30 October 2008, UiO, Oslo, Norway

The Mayor of Oslo opened on the morning of the 30th of October 2008 the fifth edition of dagen@ifi, which is Norways leading full day ICT event at the University of Oslo. This event brings together the main Norwegian ICT companies, like Accenture, ABB, Capgemeni, Computas, FAST, Nokia, Opera Software, StatoilHydro, Tandberg, etc. with academic researchers and computer science students from Norway and other parts of Europe. The program is a combination of talks, stands, and demos.

The CONTENT NoE was actively represented through live demonstration of future P2P based content distribution solutions at a stand. The CONTENT PhD students Jarle Søberg and Piotr Srebreny presented during the entire day the P2P demo and also other technical aspects of CONTENT. In this context they had many in depth discussions on content distribution issues and also explained to students and representatives from Companies like Bekk Consulting, Computas, Ciber Norge og Ergo Group CONTENT research challenges and recent results. They also distributed the CONTENT leavelets. The outcome of this dissemination activity is that many companies are now aware of the NoE CONTENT and its aim and they know that they might use CONTENT if they are working with multimedia issues in the future.

CONTENT Industry Advisory Board

Leading European industrial companies and R&D centres, including service providers and/or broadcasters can be part of the CONTENT Industry Advisory Board, which follows the activities of the consortium, access their public results, provide input and general advice (including on technology transfer matters) and establish bilateral agreements and exploration of PhD students internship opportunities. Industry Advisory Board members can also exploit opportunities to carry out joint research with CONTENT members through joint participation in national or international projects, whenever possible: Integrated Projects, STREPS and Joint industry-funded research projects. Regarding SMEs, CONTENT interacts with them at national level, by organising Local Industry Workshops and/or Technology Days for local industry in several countries.