Project Number:	**Project Acronym:**	**Project Title:**
248993	LOLA	Achieving Low-Latency in Wireless Communications

Instrument:	**Thematic Priority**
STREP	The network of the future

Workpackage:
WP6 Standardization and Dissemination

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D6.2 Scientific Publications

Keywords :
Scientific publication, standardization, dissemination, contribution, LTE, LTE-A, M2M, 3GPP, software

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Partners (organisations) contributing to this document :
EURE, TCS, TUV, LIU, AT4, EYU, MTS

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M39	M41

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2010-01-01	39 months

Dissemination level (Project co-funded by the European Commission within the Seventh Framework Programme)		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission	
RE	Restricted to a group defined by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	

Revision History

The following table is a record of the main modifications done to the document since its creation.

Revision	Date	Author (Organisation)	Description
V0.1	2010-08-13	AT4	Creation
V0.2	2010-10-10	EURE	Add publication for ETSI M2M, and IEEE COM
V0.3	2011-06-13	LIU	Updating publications
V0.4	2011-06-23	LIU	Slight changes
V0.5	2011-06-29	LIU	Dissemination activities update
V0.5.1	2011-07-19	AT4	One 3GPP Rel-11 contribution has been added
V0.5.3	2012-05-08	AT4	One national presentation has been added
V0.5.4	2012-06-08	AT4	Three new 3GPP Rel-11 contributions added
V0.6	2012-06-29	LIU	Updates included after comments from Year 2 review
V0.7	2013-03-07	EYU	Updating publications
V0.8	2013-03-28	LIU	Updating publications
V0.9	2013-05-10	AT4 & EURE	Updates of publications and standardization activities
V3.0	2013-06-03	All	Final version of the document

Table of Contents

1. EXECUTIVE SUMMARY

This deliverable is a report covering all standardization contributions and dissemination activities carried out by the FP7 project LOLA within the context of the Work Package 6 (WP6). In particular, this document also includes the details of all the publications (paper, poster, presentation, demonstrations, white paper, flyer) done in the context of LOLA project.

For the duration of the LOLA project, we have provided 10 contributions to standardization activities, 6 publications in international journals, 42 conference papers, 14 presentations on national or international workshops. Detailed information as well as the status of those is given in the document.

Partners from the LOLA consortium have organized or co-organized 4 special sessions on topics concerning the project. This document also provides a short description of the software tools that have been developed within the frame of the LOLA project.

A section of the document describes the networking and interaction activities with other research initiatives.

Brief future plans for the dissemination activities after the end of the project is included in this deliverable.

2. INTRODUCTION

LOLA project Work-Package 6 (WP6) deals with standardization and dissemination issues in order to promote the most relevant innovations and results generated within the consortium. WP6 dissemination and standardization activities are not only focused on providing scientific and technical contributions. Commercial publications and presentations, marketing materials (e.g. flyers, posters) and online advertising have been considered in WP6 as well.

The following figure represents the LOLA PERT chart which illustrates the relation between WP6, highlighted in blue, and the other WPs in LOLA. It can be noted that WP6 receives inputs from WP2, WP4 and WP5 concerning: application scenarios and target architectures, algorithms to lower latency, testbed integration and validation activities.

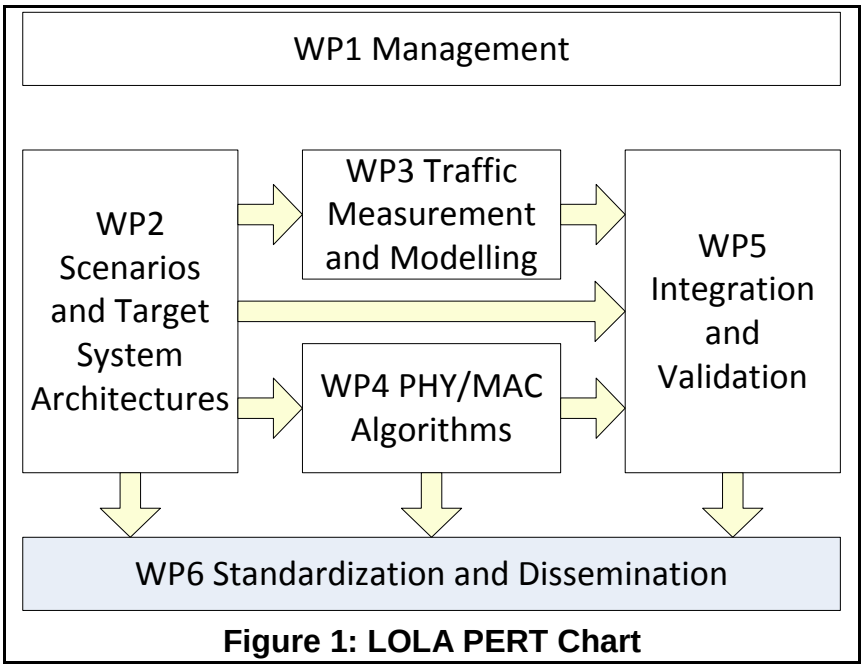

Figure 1: LOLA PERT Chart

As stated in the Description of Work (DoW) document of LOLA, the consortium will disseminate LOLA via the following means:

- Publication in conferences and journals
- Organization of workshops and conference special sessions (covered by D6.3 Project Workshop)
- Inputs to standardization bodies such as the 3rd Generation Partnership Project (3GPP™) and the European Telecommunications Standards Institute (ETSI) Machine-to-Machine (M2M) Technical Committee (TC)
- Dissemination of LOLA generic information and technical results via online advertising (e.g. technical media, websites of LOLA partners, broadcast channels such as Youtube, etc.)
- Networking and interaction with ongoing FP7 research initiatives

- Project branding (e.g. flyers, posters, goodies, etc.)

Activities carried out in LOLA via each of the means presented above are compiled in this deliverable. Section 3 deals with the standardization activities done in LOLA including contributions provided to the 3GPP and the ECC activities on M2M communications. Section 4 provides a detailed description of all publications made at international conferences and journals (e.g. IEEE journals, ICT Mobile Summit conferences, etc.). Various presentations demonstrations of the LOLA project at national and international workshops and summits are described in section 5. Special sessions covering topics related to the project are listed in section 6. In section 7 we give an account of the developed software during the course of the project. Section 8 describes the networking activities and interactions between LOLA and other research initiatives for co-operation. Section 9 details the online advertising activities the LOLA consortium has carried out. Section 10 is focused on providing information about the project branding initiatives done in LOLA. Finally, in section 11 we provide some conclusions and future plans.

3. STANDARDIZATION ACTIVITIES

3.1. Overall description

The LOLA project partners AT4 wireless and Ericsson D.O.O. (as a part of global Ericsson) are members of the 3GPP and are actively following and contributing to the 3GPP LTE and LTE-A standardization process.

AT4 wireless is mostly following activities in the Radio Access Network (RAN) Working Group (WG) 1 (radio layer 1), RAN WG2 (radio layer 2 radio layer 3 radio resource specifications), RAN WG4 (radio performance and protocol aspects) and contributing to RAN WG5 (mobile terminal conformance testing) during most of the LOLA project duration. Additionally, AT4 wireless attended almost all RAN Plenary meetings during the LOLA project duration.

Both AT4 wireless and Ericsson D.O.O. (as a part of global Ericsson) were understood as 3GPP members in a good standing position that could provide contributions on their own behalf but also on behalf of the LOLA consortium (e.g. to provide contributions made by non-member partners).

For the duration of the LOLA project, the LTE Release 8 (Rel-8) standardization process within 3GPP had reached a mature state, where changes in the specification were limited to corrections and bug fixes. All Work Items (WIs) and Study Items (SIs) pertaining to Rel-8 had been closed (except for the TSG RAN WG5) before we could contribute. The LTE and System Architecture Evolution (SAE) enhancements were specified in Release 9 (Rel-9). Throughout 2009, the 3GPP worked on a study which identified a number of LTE improvements in order to meet the IMT-Advanced requirements. In September 2009 the 3GPP partners made a formal submission to the International Telecommunications Union (ITU) proposing that LTE Release 10 (Rel-10) & beyond (LTE-Advanced) should be evaluated as a candidate for IMT-Advanced.

The LOLA consortium has provided 8 contributions to the 3GPP. One of these contributions is related to the work the 3GPP was conducting towards the submission of LTE Rel-10 as IMT-Advanced candidate technology. The main bulk of contributions have been towards the LTE RAN Enhancements for Diverse Data Applications Working Group as described in the sub-sections of section 3.2.

Another standardization body, even if not initially targeted by the consortium, which LOLA has provided contributions to is the European Communications Committee (ECC) of the European Communications Office (ECO). The consortium identified opportunities for participation in the standardization of certain Machine-to-Machine (M2M) topics.

3.2. 3GPP standardization

3.2.1. LTE Rel-8

The LTE Rel-8 was complete and therefore LOLA has not provided any contribution to the standardization process of this release. Rel-8 is considered the baseline over which adaptations are provided in Topology A.

3.2.2. LTE Rel-9

The LTE Rel-9 was almost complete. Only a few Work Items (WI) and Study Items (SI) were still open by the time of the obtaining of the main LOLA results. Rel-9 is also considered the baseline over which adaptations are provided in Topology A. LOLA has not provided any contributions to the standardization process of Rel-9 as most WIs and SIs in this release were already ongoing or complete when LOLA started and therefore the consortium had no time to provide any contribution.

3.2.3. LTE-A Rel-10

The LTE Rel-10 specifications, also known as LTE-A specifications, were still under development when LOLA started. There were yet several WIs and SIs open and some of them were of interest for LOLA. Contributions provided to this release are listed in the following sub-sections.

3.2.3.1. ITU-R Ad Hoc Working Group

Type of contribution: Text proposal

Authors: AT4 wireless

Submission date: 2010-11-17 and 2010-11-19

Status (submitted/accepted/published): Accepted

Specification/standard affected: Document for discussion on '"LTE-Advanced" material for Rec. ITU-R M.[IMT.RSPEC]'. The 3GPP reference is RP-110141 [1].

Relation to LOLA: The ITU-R Ad Hoc WG, in charge of ensuring a proper flow of information and contributions between 3GPP and ITU-R, is currently working towards the initial release of Rec. ITU-R M.[IMT.RSPEC] in March 2011. The ITU-R Ad Hoc developed by TSG RAN#50 (December 2010) an input on the Overview section and the Final Content of the Global Core Specifications (GCS). AT4 wireless, as 3GPP member, used information in the LOLA deliverable D4.1 [2] to provide contributions for this input. Contributions were provided in the form of text proposals related to technical aspects of the LTE-Advanced specifications: descriptions of scheduling modes, network architecture, layer 2 and layer 1 functionalities, physical channels, etc.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/d283415/RP-110141.zip

Details: Some of the contributions from D4.1 were included in the document RP-101174 [3] on November 2010 that was discussed and later revised in RP-101382

during the TSG RAN#50. The document was approved and later updated at TSG RAN#51 as RP-110141.

3.2.4. LTE-A Rel-11

The LTE Rel-11 is intended, among other targets, to provide enhancements to the LTE-A Rel-10 specifications (see the overview document [5]).

3.2.5. LTE RAN Enhancements for Diverse Data Applications Working Group

Type of contribution: Text proposal

Authors: AT4 wireless

Submission date: 2011-07-19

Status (submitted/accepted/published): Accepted

Specification/standard affected: Summary of e-mail discussion [74#33] - LTE: Simulation setup for diverse data applications. The 3GPP reference is R2-114084.zip.

Relation to LOLA: The objective of the document is to come up with agreeable simulation setups and parameters (e.g. traffic characteristics, deployment modelling and mobility modelling) for diverse data applications, as well as a set of agreeable metrics (e.g. UE power consumption, overhead, user experience). The LOLA project is delivering traffic models and traffic traces for a number of applications. These models and traces might be used as inputs to this 3GPP WI.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/298201/R2-114084.zip.

Details: AT4 wireless has added inputs to this document on behalf of the LOLA consortium. These inputs range from questions related to whether traffic models or traces are the preferred option for simulations, the use of separate models/traces for every data application or models/traces grouping different types of applications, need for TCP simulation, need for mobility, performance indicators to be analyzed, etc. The output was the resource R2-114084 containing the summary of e-mail discussion [74#33] on LTE Simulation setup for diverse data applications. The EU FP7 Project LOLA is recognized as a potential source of traffic traces to be used within the WI.

Type of contribution: Text proposal

Authors: AT4 wireless and TUV

Submission date: 2011-10-05 (latest)

Status (submitted/accepted/published): Accepted

Specification/standard affected: 3GPP TR 38.822 RAN Enhancements for Diverse Data Applications via e-mail discussion [75#34] - LTE: Email discussion on traffic statistics of DDA. The 3GPP references are R2-115243.zip and R2-115244.zip.

Relation to LOLA: The objective of the e-mail discussion was to discuss and conclude on packet size and packet inter-arrival CDFs for the traffic scenarios agreed upon in the RAN2#75 meeting, including background traffic, instant messaging,

gaming, etc. AT4 wireless identified a possibility for contribution to this discussion because WP3 had already studied packet size and inter-arrival time distributions for a number of online games.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/298201/R2-115244.zip

Details: AT4 wireless has added inputs to this discussion on behalf of the LOLA consortium.AT4 wireless coordinated the communication with TUV to compile the proper inputs for this discussion which finally covered a set of graphics illustrating CDFs and PDFs for the packet size and inter-arrival time of three online games both for the DL and UL. The outputs were compiled in two resources. The first resource was R2-115243 containing the summary of e-mail discussion [75#34] on traffic statistics of DDA. The second resource was R2-115244 containing including all accepted contributions as text proposal for the TR 36.822. The EU FP7 Project LOLA deliverable D3.3 is included in the reference section of this 3GPP TR.

Type of contribution: Text proposal

Authors: AT4 wireless and TUV

Submission date: 2011-11-02

Status (submitted/accepted/published): Accepted

Specification/standard affected: 3GPP TR 38.822 RAN Enhancements for Diverse Data Applications via e-mail discussion [75b#20] - LTE: Updated TR 36.822 on EDDA. The 3GPP reference is R2-115598.zip.

Relation to LOLA: This e-mail discussion is a continuation of [75#34] presented above. The WI leader was asking previous contributors to provide the mean rate and the average number of packets per second for the traffic statistics in R2-115244.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/298201/R2-115598.zip.

Details: AT4 wireless has added inputs to this discussion on behalf of the LOLA consortium. AT4 wireless coordinated the communication with TUV to compile the proper inputs for this request which finally covered a set of mean rate and packets per second of three online games both for the DL and UL. Resource R2-115598 containing 3GPP TR 36.822 v0.1.0 includes LOLA contributions.

Type of contribution: Text proposal

Authors: AT4 wireless

Submission date: 2012-05-09

Status (submitted/accepted/published): Accepted

Specification/standard affected: 3GPP TR 38.822 RAN Enhancements for Diverse Data Applications via e-mail discussion [77bis#25] LTE/EDDA: Assistance information. The 3GPP reference is R2-122512.zip.

Relation to LOLA: The intention is to clarify whether certain UE assistance information is seen beneficial for network signalling load and resource handling and UE battery consumption, and why. The discussed assistance information includes data/traffic characteristics information, preference for latency/power/DRX and mobility information.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/d353656/R2-122512.zip.

Details: AT4 wireless has added inputs to this discussion on behalf of the LOLA consortium. The input provides views on whether the abovementioned assistance

information is seen beneficial for network signalling load, resource handling and UE battery consumption, and why.

Type of contribution: Text proposal

Authors: AT4 wireless and Eurecom

Submission date: 2012-05-11

Status (submitted/accepted/published): Accepted

Specification/standard affected: 3GPP TR 38.822 RAN Enhancements for Diverse Data Applications via e-mail discussion [77bis#26] LTE/EDDA: L1 uplink control signalling. The 3GPP reference is R2-122251.zip.

Relation to LOLA: The intention is to discuss whether further enhancements to L1 uplink control signalling are needed within the Rel-11 time frame and what possible enhancements could be added.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/d353665/R2-122251.zip.

Details: AT4 wireless has added inputs to this discussion on behalf of the LOLA consortium. AT4 wireless coordinated the communication with Eurecom to compile the proper inputs for this request which finally included a proposal to use of RACH to send some real-time data that requires short latency that cannot be achieved by the existing LTE UL access method. This proposal is being studied within WP4. The WI has finally decided not to provide further RACH enhancements within the Rel-11 time frame but recognizes the LOLA proposal and others as possible ways forward for future releases.

3.2.5.1. Provision of Low-Cost MTC UEs Working Group

Type of contribution: Text proposal

Authors: AT4 wireless and EURE

Submission date: 2011-11-02 (latest)

Status (submitted/accepted/published): Accepted

Specification/standard affected: 3GPP TR 36.888 Study on provision of low-cost Machine-Type Communications (MTC) User Equipments (UEs) based on LTE via a text proposal as output of e-mail discussion [66bis-10] on MTC traffic model. The 3GPP reference is R1-114443.

Relation to LOLA: The objective of e-mail discussion [66bis-10] is to agree on a MTC traffic model and include a corresponding text proposal in TR 36.888. Parameters requested include traffic volume size and inter-arrival time distributions. AT4 wireless identified a possibility for contribution to this discussion because WP3 had already studied packet size and inter-arrival time distributions for a number of MTC applications.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/333947/R1-114443.zip.

Details: AT4 wireless has added inputs to this discussion on behalf of the LOLA consortium.AT4 wireless coordinated the communication with EURE to compile the proper inputs for this request which finally covered a description of some traffic parameters for MTC sensor- and alarm-based traffic applications based on the traffic modelling approach followed in the LOLA project. Resource R1-114443 containing a

Text Proposal for “Traffic model/Characteristics for MTC” includes the output of the e-mail discussion.

3.2.5.2. Enhancement of Minimization of Drive Tests for E-UTRAN and UTRAN

Type of contribution: Text proposal

Authors: AT4 wireless and EURE

Submission date: 2012-05-03

Status (submitted/accepted/published): Accepted

Specification/standard affected: E-mail discussion [77bis#21] Joint/MDT: Scheduled IP Throughput measurement scope. The 3GPP reference is R2-122157.

Relation to LOLA: This e-mail discussion is intended to address whether Scheduled IP Throughput measurements for MDT should be performed per RAB, per QCI, or per UE.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/d353680/R2-122157.zip.

Details: AT4 wireless has added inputs to this discussion on behalf of the LOLA consortium. AT4 wireless provided views on whether IP throughput measurements should be performed per RAB, per QCI, or per UE following same directions as in LOLA WP4 and WP5.

3.3. ECC standardization current status

Even if the ECC was not one of the standardization bodies initially targeted in LOLA the consortium found opportunities to contribute to the standardization of certain features for the M2M communications. Contributions provided are listed below.

3.3.1. ECC Report 153 (1)

Type of contribution: Change request

Authors: AT4 wireless, TCF, EURE and EYU

Submission date: 2010-10-13

Status (submitted/accepted/published): Accepted and published

Specification/standard affected: ECC Report 153.

See http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP153.PDF

Relation to LOLA: The European Communications Committee (ECC) of the European Communications Office (ERO) released a draft of a new ECC Report 153 on numbering and addressing in Machine-to-Machine (M2M) communications for public consultation on July 2010.The authors reviewed this draft and provided contributions to the Annex 2 section on October 2010, where a number of M2M applications, extracted from D2.1 Target application scenarios, were suggested to be included.

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/d185712/

Details: Some of the M2M applications already identified in D2.1 were proposed for this ECC report. The concrete request was to include the following applications in Annex 2: mobile surveillance systems as another type of security and surveillance applications, remote medicine (tele-medicine) including life-support systems and tele-surgery, M2M games which take place contemporarily in different locations and in presence of mobility. The ECC accepted to include the remote medicine and M2M games applications in the Annex 2 of this report. In both cases the report clarifies that the applications will be dealt with in the FP7 IST Project LOLA.

3.3.2. ECC Report 153 (2)

Type of contribution: Change request

Authors: AT4 wireless

Submission date: 2010-09-15

Status (submitted/accepted/published): Accepted and published

Specification/standard/affected: ECC Report 153

Relation to LOLA: The report describes a number of applications where M2M communications seem to be relevant. M2M applications are one of the main targets of LOLA.

BSCW: Not uploaded on the server.

Details: Extensive list of editorial changes

3.4. Future plans

The LOLA consortium developed a specific plan for standardization during year 2, consisting on the identification of the most relevant Rel-10 and Rel-11 3GPP WIs and SIs where LOLA may outcomes may have impact. The plan has been followed and results have been presented in this section. LOLA partners will continue keeping track of the standardization activities within 3GPP and will try to exploit the LOLA test beds to provide future contributions to the 3GPP Rel-12 standardization processes.

No explicit plan has been developed in order to continue providing contributions to the ECC standardization process. The consortium will be passively keeping track of the ongoing standardization activities related to M2M within the ECC in order to find new participation opportunities.

4. PUBLICATIONS IN JOURNALS AND CONFERENCES

In this section we provide a list of publications (papers, articles, book chapters) published or submitted to international and national journals and conferences: IEEE Transactions on Communications, ACM Transactions on Sensor Networks, IEEE International Conference on Communications, ICT Mobile Summit, etc. Only a brief abstract of each publication is added here.

4.1. International journals

4.1.1. Codebook Design and Hybrid Digital/Analog Coding for Parallel Rayleigh Fading Channels

Authors: Shuying Shi, Erik G. Larsson, Mikael Skoglund

Journal: IEEE Trans. Signal Processing

Status (submitted/accepted/published): Published

Relation to LOLA: This paper is a result from the efforts towards Deliverable 4.4 within WP4.

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5934615

Abstract: Low-delay source-channel transmission over parallel fading channels is studied. In this scenario separate source and channel coding is highly suboptimal. A scheme based on hybrid digital/analog joint source-channel coding is therefore proposed, employing scalar quantization and polynomial-based analog bandwidth expansion. Simulations demonstrate substantial performance gains.

Keywords: Hybrid digital/analog transmission, fading channels

Acknowledgments: This paper describes work undertaken in the context of the LOLA project - Achieving LOw-LAtency in Wireless Communications (www.ict-lola.eu). LOLA is supported by the European 7th Framework Programme under grant n° 248993.

References: LOLA consortium, “D4.4 Adaptive Modulation and Coding Scheme for Hybrid Analog/Digital Transmission”, FP7 EU LOLA Project, December 2011.

4.1.2. LTE/LTE-A Discontinuous Reception Modeling for Machine Type Communications

Authors: Kaijie, Zhou; Navid Nikaein; Thrasyvoulos, Spyropoulos

Journal: IEEE Wireless communication letters

Status (submitted/accepted/published): Published

Relation to LOLA: This paper is a result from the efforts towards Deliverable 4.5 within WP4.

URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6376046

Abstract: Machine type communications (MTC) are considered as key applications in LTE/LTE-A networks, for which lowering power consumption is among the primary requirements. In this paper, we model the LTE/LTE-A discontinuous reception (DRX) mechanism for MTC applications based on a Semi-Markov chain model. With our model the power saving factor and wake up latency can be accurately estimated for a given choice of DRX parameters, thus allowing to select the ones presenting the best tradeoff. The proposed model is validated through simulations. We also investigate the effect of different DRX parameters on performance.

Keywords: LTE, DRX, MTC, semi-Markov model

4.1.3. Packet Delay Measurements in Reactive IP Networks

Authors: Philipp Svoboda, Markus Laner, Joachim Fabini, Markus Rupp, and Fabio Ricciato

Journal: IEEE Journal on instrumentation and measurement

Status (submitted/accepted/published): Published

URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6365543

Relation to LOLA: This paper is a result from the efforts towards Deliverable 3.5 in WP3.

Abstract: Discussions of how to measure the performance of computer networks for various applications have been ongoing for over twenty years in the area of network research. The continual increase of data traffic volume has reached a point at which solving any network problem by over-provisioning is not suitable. The quest for alternatives makes it vital to have well-defined metrics for evaluating and sustaining the performance of networks. In this tutorial, we provide a detailed introduction of how delay can be measured in a network, especially considering the so-called stateful, reactive and non-symmetric network setups found in mobile cellular networks today. In this context, the term stateful refers to the different states a user session can assume in such networks. Different states correspond to connection types of different physical 4.1.4.performance, resulting in different levels of performance, e.g., delay. Changes between the states are triggered by central network elements based on the traffic patterns. The network is reactive to user traffic. Different user patterns will result in different states and therefore different performance results. Given the ambiguous definitions of delay, we present the alternative definitions found in literature and standards, highlight the different parameters impacting the delay of a network packet, and help the reader begin by selecting the right definition of his/her problem. We introduce active and passive measurements, discuss the best setup for delay measurements, introduce the need for time synchronized network measurement nodes to obtain one-way delay (OWD) results, and then combine the concepts and present a methodology accompanied by real world measurement examples. Detailed analysis of the results reveals the impact of different network settings and parameters in the network. We close the tutorial with a summary and present a flow chart to guide the reader toward an optimal setup for delay measurement.

4.1.5. Mathematical Framework for Dynamic Resource Allocation in LTE Heterogeneous Networks

Authors: Villa, Tania; Knopp, Raymond; Merz, Ruben (EURECOM)

Journal: IEEE Journal on Selected Areas in Communications: Cognitive Radio Series

Status (submitted/accepted/published): Submitted

Relation to LOLA: This paper is a result from the efforts towards Deliverable 4.3 within WP4.

Abstract: Heterogeneous networks can present strong and extremely challenging interference scenarios due to the difficulty of centralized planning before deployment. However, recent modelling and analytical work has ignored inter-cell interference, focusing on single-cell models, treating it as noise, or having a fixed value.

In this paper, we first present a mathematical framework that can be applied to the analysis of heterogeneous networks, assuming interference and signals from discrete constellations to model practical wireless systems. Our framework takes an information-theoretic approach to derive analytical expressions that represent the long-term throughput of the network. We then consider the problem of variable resource allocation for IR-HARQ schemes under the presence of interference. With our framework, we can alleviate the need for extensive simulations and can flexibly address the development of resource allocation policies with and without constraints on the outage probability. The policies are distributed, applicable for both uplink and downlink scenarios, and based on the dynamic adaptation of the physical dimensions used in each HARQ round. Our results show a significant gain from adapting the resources across the transmission rounds, and we identify specific cases where the dynamic resource allocation provides the highest gain as compared to a fixed allocation scheme.

Keywords: Heterogeneous Networks, resource allocation, rate adaptation, LTE, HARQ, incremental redundancy.

4.1.6. Evaluation of the UTRAN (HSPA) performance in different configurations in the presence of M2M and Online Gaming traffic

Authors: Milica Popovic (MTS), Dejan Drajic (EYU), Srdjan Krco (EYU)

Journal: ETT, Transactions on Emerging Telecommunications Technologies

Status (submitted/accepted/published): Submitted

Relation to LOLA: This paper is a result from the efforts towards Deliverables 3.5 and 5.3 within WP3 and WP5.

Abstract: In this paper, an analysis of the HSPA network performance in the presence of the M2M and Online Gaming traffic using a set of the key performance indicators is described. The evaluation was done in a live network, using a number of mobile phones to generate additional traffic load. One Node B, with different configurations adjusted to the purpose of each test, was used throughout the experiments. The main areas of impact are identified and similar underlying mechanisms later recognized in a live deployment of a large-scale M2M application. The paper describes the key findings of the analysis of five

test cases from the network performance aspect. It further associates perceived network behaviour with the end-user experience in terms of the average delays. At the end, a comparison with the impacts of a live M2M application is given and the main issues highlighted.

Keywords: M2M, Online Gaming, KPI, Accessibility, Latency, HSPA, UTRAN.

4.2. International conferences

4.2.1. Dissecting 3G Uplink Delay by Measuring in an Operational HSPA Network

Title: Dissecting 3G Uplink Delay by Measuring in an Operational HSPA Network

Authors: Markus Laner, Philipp Svoboda, Eduard Hasenleithner, Markus Rupp

Conference: Passive and Active Measurement Conference, PAM 2011

Status (submitted/accepted/published): Published

Relation to LOLA: This work describes the implementation of the measurement scenarios as specified in D3.1 and provides preliminary measurement results similar to those presented in D3.2.

URL: http://pam2011.gatech.edu/papers/pam2011--Laner.pdf

Abstract: Users expect mobile Internet access via 3G technologies to be comparable to wired access in terms of throughput and latency. HSPA achieves this for throughput, whereas delay is significantly higher. In this paper we measure the overall latency introduced by HSUPA and accurately dissect it into contributions of USB-modem (UE), base station (NodeB) and network controller (RNC). We achieve this by combining traces recorded at each interface along the data-path of a public operational UMTS network. The actively generated sample traffic covers real-time applications.

Results show the delay to be strongly dependent on the packet size, with random components depending on synchronization issues. We provide models for latency of single network entities as well as accumulated delay. These findings allow to identify optimum settings in terms of low latency, both for application and network parameters.

Keywords: Latency measurement, HSPA, uplink

Acknowledgements: We would like to thank Sebastian Caban, Robert Langwieser and Michael Fischer for contributing technical expertise. Furthermore, we thank A1 Telekom Austria and ftw for technical assistance and the EU FP7 LoLa Project for financial support.

4.2.2. Optimization of Frame Length in OFDMA Systems Taking into Account the Control Signaling Cost

Title: Optimization of Frame Length in OFDMA Systems Taking into Account the Control Signaling Cost

Authors: Yi Wu, Zhiqiang Tang, and Erik G. Larsson

Conference: IEEE VTC 2011 Spring

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5956516

Abstract: Dynamic OFDMA has been recognized as a promising technique for improving the performance of future wireless cellular systems. However, this potential performance improvement comes at the cost of additional signaling overhead, which can have a non-negligible effect on the system efficiency. In this paper, we propose a new method for optimizing the frame length for the downlink in OFDMA systems. The method maximizes the system efficiency by taking into account both the channel conditions and the amount of signalling overhead needed to deliver scheduling maps to the users. We formulate the frame length optimization problem mathematically. By exploiting the structure of this problem, we develop an algorithm that solves a sequence of dynamic programming problems. Simulation results reveal some insight into fundamental limitations as well as provide guidelines for the design of dynamic OFDMA systems.

Keywords: Optimization of Frame Length, OFDMA, Control Signaling Cost, System Efficiency.

Acknowledgement: This paper describes work undertaken in the context of the LOLA project - Achieving LOw-LAtency in Wireless Communications (www.ict-lola.eu). LOLA is supported by the European 7th Framework Programme under grant n° 248993.

4.2.3. Latency for Real-Time Machine-to-Machine Communication in LTE-Based System

Title: Latency for Real-Time Machine-to-Machine Communication in LTE-Based System Architecture

Authors: Navid Nikaein and Srdjan Krco

Conference/Journal: EW 2011

Status (submitted/accepted/published): Published

LOLA: Low latency analysis for M2M over LTE

URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5898065

Abstract: Machine-to-machine communication has attracted a lot of interest in the mobile communication industry and is under standardization process in 3GPP. Of particular interest is LTE-Advanced support for various M2M service requirements and efficient management and handling of a huge number of machines as mobile subscribers. In addition to the higher throughput, one of the main advantages of LTE/LTE-A in comparison with the previous cellular networks is the reduced transmission latency, which makes this type of networks very attractive for real-time mobile M2M communication scenarios. This paper presents a M2M system architecture based on LTE/LTE-A and highlights the delays associated with each part of the system. Three real-time M2M applications are analyzed and the main latency bottlenecks are identified. Proposals on how the latency can be further reduced are described.

Keywords: Latency, LTE, LTE-A, M2M Communication Scenario, Real-Time Application, System Architecture.

Acknowledgement: LOLA project

4.2.4. Time Synchronization Performance of Desktop Computers

Title: Time Synchronization Performance of Desktop Computers

Authors: Markus Laner, Sebastian Caban, Philipp Svoboda and Markus Rupp

Conference: IEEE Int. Symposium on Precision Clock Synchronization, ISPCS 2011

Status (submitted/accepted/published): Published

LOLA: The time-synchronization mechanism for the measurement setup described in D3.2 is presented.

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6070154

Abstract: Time synchronization is a vital requirement for various applications. Especially the synchronization of desktop computers to the Coordinated Universal Time (UTC) yields numerous use cases, such as distributed measurements. Several solutions address this need, at different levels of price and accuracy. In this work we evaluate on the achievable precision in time synchronization of a desktop PC, for example, assisted by a lowbudget GPS receiver. This is achieved by a novel measurement setup, which is comparing the software synchronized internal clock of the PC to a rubidium frequency standard. Our results show, that the synchronization offsets of the software clocks of all tested PCs have positive mean (time lag) in the order of 10 us. The respective standard deviation is typically an order of magnitude lower. Thereby the unknown interrupt latency is the limiting factor for the accuracy. With this work we show that today (2011) 10 ìs of precision can be achieve at very low cost.

Keywords: Time Synchronization, commodity PC, GPS, pulse per second, NTP

Acknowledgements: The authors would like to thank Armin Disslbacher-Fink for the design of the timestamping unit and Joachim Fabini for the contribution of expertise. Furthermore, we thank the Christian Doppler Laboratory for Wireless Technologies for technical assistance and the EU FP7 Lola Project for financial support.

4.2.5. Low-Latency in Wireless Communication

Title: Low-Latency in Wireless Communication

Authors: Navid NIKAEIN, Raymond KNOPP, Antonio Maria CIPRIANO, Srdjan KRCO, Igor TOMIC, Philipp SVOBODA, Markus LANER, Eric LARSSON, Yi WU, Manuel GARCIA FUERTES, Janie BAÑOS, Nenad ZELJKOVIC, Djordje MAROVIC

Conference: Vitel2011, Slovenia

Status (submitted/accepted/published): Published

LOLA: Description of the overall project progress and achievement

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/273944

Abstract: This paper focus is on access-layer technologies targeting low-latency robust and spectrally-efficient transmission in a set of emerging application scenarios. Two basic types of wireless networks are considered, namely long-term LTE-Advanced cellular networks and medium-range rapidly deployable mesh networks. In cellular networks, research is focused on transmission technologies in support of gaming services which will undoubtedly prove to be a strategic revenue area for operators in the years to come. We also consider machine-to-machine (M2M) applications in mobile environments using sensors connected to public infrastructure (in train, buses, stations, etc.).

Keywords: Latency, LTE, LTE-A, M2M Communication Scenario, Interactive Gaming, Real-Time Application, System Architecture.
Acknowledgement: LOLA project

4.2.6. Robust Joint Optimization of Nonregenerative MIMO Relay Channels with Imperfect CSI

Title: Robust Joint Optimization of Non-regenerative MIMO Relay Channels with Imperfect CSI
Authors: Ebrahim A. Gharavol, Erik G. Larsson
Conference: 45th Annual Asilomar Conference on Signals, Systems, and Computers, 2011
Status (submitted/accepted/published): Published
LOLA: This paper describes work undertaken in the context of the LOLA project
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6190287
Abstract: In this paper we deal with the problem of the joint optimization of the precoders, equalizers and relay beamformer of a multiple-input multiple-output two-way relay channel. Unlike the conventional design procedures, we assume that the Channel State Information (CSI) is not known perfectly. The imperfect CSI is described using the norm bounded error framework.
We use a system-wide Sum Mean Square Error (SMSE) based problem formulation which is constrained using the transmit power of the terminals and the relay node. The problem at hand, from a worst-case design perspective, is a multi-linear, and hence, a non-convex problem which is also semi-infinite in its constraints. We use a generalized version of the Peterson's lemma to handle the semi-infiniteness and reduce the original problem to a single Linear Matrix Inequality (LMI). However, this LMI is not convex, and to resolve this issue we propose an iterative algorithm based on the alternating convex search methodology to solve the aforementioned problem.
Finally simulation results are included to asses the performance of the proposed algorithm.

4.2.7. Robust Joint Optimization of MIMO Two-Way Relay Channels with Imperfect CSI

Title: Robust Joint Optimization of MIMO Two-Way Relay Channels with Imperfect CSI
Authors: Ebrahim A. Gharavol, Erik G. Larsson
Conference: 49th Annual Alerton Conference
Status (submitted/accepted/published): Published
LOLA: This paper describes work undertaken in the context of the LOLA project
URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6120368
Abstract: In this paper, we deal with the problem of joint optimization of the source precoder, the relay beamformer and the destination equalizer in a non-regenerative relay network with only a partial knowledge of the Channel State Information (CSI). We model the partial CSI using a deterministic norm bounded error model, and we use a system-wide mean square error performance measure which is constrained based on the transmit power regulations for both source and relay nodes. Most conventional designs employ the average performance optimization, however, we solve this problem from a worst-case design perspective. The original problem formulation is a semi-infinite tri-linear

optimization problem which is not convex. To solve this problem we extend the existing theories to deal with the constraints which are semi-infinite in different independent complex matrix variables. We show that the equivalent approximate problem is a set of linear matrix inequalities, that can be solved iteratively. Finally simulation results assess the performance of the proposed scheme.

4.2.8. Robust Joint Optimization of MIMO Interfering Relay Channels with Imperfect CSI

Title: Robust Joint Optimization of MIMO Interfering Relay Channels with Imperfect CSI
Authors: Ebrahim A. Gharavol, Erik G. Larsson
Conference: CAMSAP 2011
Status (submitted/accepted/published): Published
LOLA: This paper describes work undertaken in the context of the LOLA project
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6135984
Abstract: In this paper we deal with the problem of the joint optimization of the precoders, equalizers and relay beamformer of a multiple-input multiple-output interfering relay channel.
This network can be regarded as generalized model for both one-way and two-way relay channels with/without direct interfering links. Unlike the conventional design procedures, we assume that the Channel State Information (CSI) is not known perfectly. The imperfect CSI is described using the norm bounded error framework. We use a system-wide Sum Mean Square Error (SMSE) based problem formulation which is constrained using the transmit power of the terminals and the relay node. The problem at hand, from a worst-case design perspective, is a multi-linear, and hence, a non-convex problem which is also semi-infinite in its constraints. We use a generalized version of the Peterson's lemma to handle the semi-infiniteness and reduce the original problem to a single Linear Matrix Inequality (LMI). However, this LMI is not convex, and to resolve this issue we propose an iterative algorithm based on the alternating convex search methodology to solve the aforementioned problem. Finally simulation results, i.e., the convergence of the proposed algorithm and the SMSE properties, are included to asses the performance of the proposed algorithm.

4.2.9. Hash-and-Forward Relaying for Two-Way Relay Channel

Title: Hash-and-Forward Relaying for Two-Way Relay Channel
Authors: E. Yilmaz, R. Knopp
Conference: IEEE International Symposium on Information Theory, Aug. 2011
Status (submitted/accepted/published): Published
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6033760
Abstract: This paper considers a communication network comprised of two nodes, which have no mutual direct communication links, communicating two-way with the aid of a common relay node (RN), also known as separated two-way relay (TWR) channel. We first recall a cut-set outer bound for the set of rates in the context of this network topology assuming full-duplex transmission capabilities. Then, we derive a new achievable rate region based on hash-and-forward (HF) relaying where the RN

does not attempt to decode but instead hashes its received signal, and show that under certain channel conditions it coincides with Shannon's inner-bound for the two-way channel [1]. Moreover, for binary adder TWR channel with additive noise at the nodes and the RN we provide a detailed capacity achieving coding scheme based on structure codes.

Acknowledgement: This work was partially supported by the European Commission's 7th framework programme under grant agreement FP7-248993 also referred to as LOLA.

4.2.10. OpenAirInterface Large-Scale Wireless Emulation Platform and Methodology

Title: OpenAirInterface Large-Scale Wireless Emulation Platform and Methodology
Authors: B. B. Romdhanne, N. Nikaein, R. Knopp, C. Bonnet

Conference/Journal: PM2HW2N 2011

Status (submitted/accepted/published): Published

URL: http://dl.acm.org/citation.cfm?doid=2069087.2069102

Abstract: The OpenAirInterface emulation platform is an integrated tool allowing large-scale networking experimentation applicable to both evolving cellular and adhoc/mesh topologies. The platform in built to represent a realistic system in a controlled and real-time environment, which interacts with the external elements. The platform has a dual objective of performance evaluation of application and protocols as well as their testing and validation.

Acknowledgement: This paper describes work undertaken in the context of the LOLA and CONECT project. The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement n° 248993 and n°257616.

4.2.11. Measurement Aided Model Designfor WCDMA Link Error Statistics

Title: Measurement Aided Model Designfor WCDMA Link Error Statistics

Authors: Markus Laner, Philipp Svoboda, Markus Rupp
Conference: ICC 2011
Status (submitted/accepted/published): Published

URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5962895

Abstract: Accurate models for error characteristics of radio channels are essential to estimate performance of data transmission. This paper analyzes error-gap and error-burst statistics of the WCDMA dedicated channel (DCH) and provides respective models. We start with an analytical study of the outer-loop power control mechanism (OLPC), which gives directions to this work, revealing that the OLPC strongly influence error behavior. We prove this by large-scale measurements at the Iub-interface of a live UMTS network. Beside statistical evaluation of the measurement data we provide a simple generative hidden Markov model for emulation of DCH

errors. It is able to characterize any arbitrary DCH by only two parameters, with an accuracy below 1%, in terms of Kullback-Leibler divergence. This novel model presents an accurate light-weight alternative to complex tools for simulation of WCDMA DCH connections. It also covers all other communication technologies deploying a similar power control mechanism.

4.2.12. Sensor Network aided Agile Spectrum Access through Low-Latency Multi-Band Communications

Title: Sensor Network aided Agile Spectrum Access through Low-Latency Multi-Band Communications

Authors: C. Bonnet, D. Camara, R. Ghaddab, L. Iacobelliy, F. Kaltenberger, R. Knopp, B. Merciery, N. Nikaein, D. Nussbaum, E. Yilmaz, B. Zayen;
Conference: DCOSS 2011
Status (submitted/accepted/published): Published

URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5982147

Abstract: Dynamic spectrum access supported by a low latency wireless sensor network for spectrum usage monitoring is demonstrated using OpenAirInterface platform. The platform performs secondary communications in bands detected as free, thanks to its multi-band capability. With respect to application scenarios, the main target is to address agile broadband public safety communications. Firstly, this demonstration will highlight the newest hardware platforms offered by OpenAirInterface comprising the ExpressMIMO baseband engine and the AgileRF front-end. The second aspect of the demonstration aims to highlight OpenAirInterface's performance evaluation methodology allowing for scalable emulated real-time deployment of radio networks on generic PC-based computers.

4.2.13. Improved Detection of ACK/NACK Messages in the LTE Uplink Control Channel

Title: Improved Detection of ACK/NACK Messages in the LTE Uplink Control Channel

Authors: Yi Wu, Danyo Danev, and Erik G. Larsson

Conference: IEEE VTC 2012 Spring

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6240179

Abstract: In this paper, we present an improved detector for ACK/NACK message detection in the LTE uplink control channel with imperfect channel state information at the receiver. The detector is based on the generalized likelihood-ratio test (GLRT) paradigm. We derive detection metrics for the cases when the noise variances at the receiver are known and unknown. Noise here may comprise both thermal noise and interference. Simulation results show remarkable performance gains of the GLRT-based detector with unknown noise variances compared to the training-based maximum-likelihood detector with unknown noise variances when the noise variances

in two slots are different. Furthermore, the performance of the GLRT-based detector with unknown noise variances is nearly the same as that of the training-based maximum-likelihood detector with known noise variances.

Keywords: ACK/NACK Messages, LTE, Uplink Control Channel, GLRT Detection.

Acknowledgement: This paper describes work undertaken in the context of the LOLA project - Achieving LOw-LAtency in Wireless Communications (www.ict-lola.eu). LOLA is supported by the European 7th Framework Programme under grant n° 248993.

4.2.14. Contention Based Access for Machine-Type Communications over LTE

Title: Contention Based Access for Machine-Type Communications over LTE

Authors: Kaijie Zhou, Navid Nikaein, Raymond Knopp, Christian Bonnet

Conference: IEEE VTC 2012 Spring

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6240150

Abstract: To enable the efficient and low latency machine-type communications (MTC) over long term evolution (LTE), a contention based access (CBA) method is proposed. With CBA, UEs transmit packets on the randomly selected resource without having any UE specific scheduled resources. To address the problem of collision caused by CBA in high traffic load, eNB exploits the MU-MIMO detection technique to decode radio network temporary identifier (RNTI) of the collided UEs and use this information to perform a regular scheduling in subsequent subframe. The latter is also exploited on the data portion to increase the probability of receiving the packet on the first transmission, even in the case of contention. Detailed low layer signaling enhancement to implement this CBA technique in current LTE specification (Rel. 10) is also presented. Simulation results demonstrate that CBA can significantly outperform the existing uplink channel access methods.

Keywords: MTC, scheduling, MU-MIMO.

DPSM2008

4.2.15. Traffic Generation Application for Simulating Online Games and M2M Applications via Wireless Networks

Title: Traffic Generation Application for Simulating Online Games and M2M Applications via Wireless Networks

Authors: Dejan Drajic, Srdjan Krco, Igor A. Tomic, Philipp Svoboda, Milica Popovic, Navid Nikaein, Nenad Zeljkovic

Conference: WONS 2012

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6152224

Abstract: In this paper we present results of traffic modelling and simulation of multiplayer real-time games and M2M applications using TCP protocol over Telekom Serbia HSPA mobile network, performed within the FP7 LOLA project. In this experimentation, the RTT (Round Trip Time) and cell statistics are analysed. For this purpose, a traffic generation application is developed for Android phones to generate traffic pattern for emerging Machine Type Communication and online multiplayer games in mobile wireless network for different offset of tests. Application is activated by setting the corresponding parameters related to desired test case, i.e. duration of testing, size and frequency of the data packets that the application sends to the server. The main goal of the cell statistic analysis is to evaluate potential impact of additional simulated traffic in view of increasing data-centric users on the performance of mobile wireless radio network.

Keywords: M2M, Traffic modelling, HSPA network, performance evaluation

Acknowledgement: This paper describes work undertaken in the context of the LOLA project - Achieving LOw-LAtency in Wireless Communications (www.ict-lola.eu). The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement n° 248993.

4.2.16. M2M traffic influence on WCDMA/HSPA Network Performance

Title: M2M traffic influence on WCDMA/HSPA Network Performance

Authors: Dejan Drajic, Igor Tomic, Srdjan Krco, Milica Popovic, Nenad Zeljkovic

Conference: 6th KuVS Fachgespräch, 2012

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://www.kuvs-ngsdp.org/_slides/07_M2MTrafficInfluence_Drajic-Popovic.pdf

Abstract: In this paper we present results of experiments done in a live mobile network aiming to analyze influence of the M2M and online gaming traffic on the radio access network. For the purpose of analysis of M2M traffic impact on mobile wireless networks, traffic generation application was developed for Android phones to generate traffic pattern for M2M applications and online multiplayer games. The key performance indicators of a radio cell: accessibility retainability and integrity were analyzed. The experiments were done for two different cells configuration differing in the processor capacity and the number of HS licenses. The main impact of the additional traffic is noticeable on the accessibility of the network.

4.2.17. Impact of Online Applications Traffic on the Performance of HSPA Radio Access Networks

Title: Impact of Online Applications Traffic on the Performance of HSPA Radio Access Networks

Authors: Dejan Drajic, Milica Popovic, Navid Nikaein,Srdjan Krco, Philipp Svoboda, Igor Tomic, Nenad Zeljkovic

Conference: ESIOT 2012, Italy

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/356195

Abstract: In this paper we presented results of the performance evaluation of the WCDMA/HSPA radio access network when loaded with multiplayer real-time games and M2M applications traffic. Evaluation was done in a live network, on one Node B. Traffic, characteristic for the emerging Machine Type Communication and online multiplayer games, was generated by an application running on 10 mobile phones in parallel, all connected to the Node B under test. The focus of the work was on the RTT (Round Trip Time) and radio cell statistics. The main goal of the cell statistics analysis was to evaluate potential impact of the additional traffic on the performance of 3G/HSPA radio access network. It is concluded that system is designed more for continuous traffic patterns with high data rate in general, than for sporadic traffic patterns with very low data rate, like that of M2M or online gaming nodes. Therefore, the cost of signaling and control activity is dominant in comparison to the data rate.

4.2.18. Adaptive Modulation and Coding with Hybrid-ARQ for Latency-Constrained Networks

Title: Adaptive Modulation and Coding with Hybrid-ARQ for Latency-Constrained Networks

Authors: T. Villa, R. Merz, R. Knopp; U. Takyar

Conference: EW 2012, April 18-20, Poznan, Poland

Status (submitted/accepted/published): Published

URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6216897

Abstract: Traffic generated by machine to machine (M2M) communication or online gaming will be a large and integral part of the traffic transported by LTE-advanced and beyond networks. This traffic is characterized by sporadic and low-throughput packet arrivals. It must be scheduled under a latency constraint. Sporadic traffic creates environments where the channel-quality information (CQI) is outdated or unavailable. Fast-fading, the non-stationarity of inter-cell interference and the heterogeneity of Rel-10 networks further exacerbates this issue. However, current LTE-Advanced schedulers and resource allocation schemes are not optimized for these particular scenarios. In this paper, we propose a scheduling and resource allocation mechanism for latency-constrained operation. Our solution significantly improves the spectral efficiency of delay-constrained networks by optimizing a joint hybrid-ARQ and adaptive modulation and coding (AMC) policy that changes the number of dimensions (physical resources) used in each round. With only one bit of feedback, obtained causally from hybrid-ARQ, we achieve a performance close to the ergodic capacity.

4.2.19. Latency Analysis of 3G Network Components

Title: Latency Analysis of 3G Network Components
Authors: M. Laner, P. Svoboda, M. Rupp
Conference: EW 2012, April 18-20, Poznan, Poland
Status (submitted/accepted/published): Published
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6216847
Abstract: Latency in 3G wireless cellular networks is relatively high by design. Hence, optimizing latency will be the key task for improving quality of experience in future mobile networks. This work is a precise dissection of the delay contributions of each element in an operational HSPA cellular network, both in uplink and downlink. The deployed methodology is active probing combined with time-synchronized sensing nodes. The latter enable the tracing of packets on every interfaces along the data-path in a 3G network. Our results show that the major delays are introduced at the user terminal side. Interestingly, each network component shows a higher processing time for data in downlink than in uplink. Further, we assess latency increases carried by the use of legacy network equipment. For reproducibility of the results we provide models for the delay of each HSPA network component. Our findings enable (i) to estimate latencies in existing networks for simulations and network planning and, (ii) to identify reasonable starting points for research on latency reduction in future networks.

4.2.20. Users in Cells: A Data Traffic Analysis

Title: Users in Cells: A Data Traffic Analysis
Authors: M. Laner, P. Svoboda, S. Schwarz, M. Rupp
Conference: WCNC 2012
Status (submitted/accepted/published): Published
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6214330
Abstract: We present a large-scale cell based measurement analysis of the user behavior in a live operational HSDPA network. The motivations are: first, to understand the statistical properties of users in cells for refining network planning procedures; and second, to provide realistic traffic models for simulations of cellular packet-oriented networks. We provide an analysis of mean cell load over daytime, as well as models for short-term cell load in terms of user activity and throughput. Furthermore, an evaluation of user-sessions with respect to duration and mean throughput is given. Our findings lead to four different models reflecting realistic user-traffic load of cellular networks. To verify the concept we present respective simulations which investigate multiuser-scheduling in an LTE-network. They show that conventional simulation settings can lead to an overestimation of performance.

4.2.21. Modeling Randomness in Network Traffic

Title: Modeling Randomness in Network Traffic
Authors: M. Laner, P. Svoboda, M. Rupp
Conference: SIGMETRICS 2012
Status (submitted/accepted/published): Published
URL: http://dl.acm.org/citation.cfm?id=2254809

Abstract: A continuous challenge in the field of network traffic modeling is to map recorded traffic onto parameters of random processes, in order to enable simulations of the respective traffic. A key element thereof is a convenient model which is simple, yet, captures the most relevant statistics. This work aims to find such a model which, more precisely, enables the generation of multiple random processes with arbitrary but jointly characterized distributions, auto-correlation functions and cross-correlations. Hence, we present the definition of a novel class of models, the derivation of a respective closed-form analytical representation and its application on real network traffic.Our modeling approach comprises: (i) generating statistical dependent Gaussian random processes, (ii) introducing auto-correlation to each process with a linear filter and, (iii) transforming them sample-wise by real-valued polynomial functions in order to shape their distributions. This particular structure allows to split the parameter fitting problem into three independent parts, each of which solvable by standard methods. Therefore, it is simple and straightforward to fit the model to measurement data.

4.2.22. A Comparison Between One-Way Delays in Operating HSPA and LTE

Title: A Comparison Between One-Way Delays in Operating HSPA and LTE
Authors: M. Laner, P. Svoboda, P. Romirer-Maierhofer, N. Nikaein, F. Ricciato, M. Rupp
Conference: WinMee 2012
Status (submitted/accepted/published): Published
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6260469

Abstract: The detailed understanding of packet delays in modern wireless networks is crucial to optimize applications and protocols. We conducted high precision latency measurements in operational LTE and HSPA networks, deploying a hybrid approach of active probing and withe-box testing. It allowed us to separately assess the one-way delay contributions of the radio access network and the core network for both technologies. The results show that LTE outperforms HSPA in the case of medium to high data rates. However, due to differences in the radio access procedures, the HSPA uplink connection offers lower delay for specific traffic patterns. A comparison between our measurement results and the requirements for delay sensitive applications exhibits that LTE is not (yet) the generally preferable technology. Hence, further optimizations of the LTE scheduling and resource allocation policies are required to fully exhaust all feasible latency improvements.

4.2.23. Adaptive Transmission and Multiple-access for Sparse-traffic Sources

Title: Adaptive Transmission and Multiple-access for Sparse-traffic Sources
Authors: Kaijie Zhou, Tania Villa, Navid Nikaein, Raymond Knopp and Ruben Merz
Conference: EUSIPCO 2012
Status (submitted/accepted/published): Published
URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6334303

Abstract:M2M/online gaming are considered as key applications in LTE and LTE-advanced networks. However, for most of these applications whose traffic is sporadic and some of them require very low latency, they are not well supported by the current LTE and LTE-advanced systems due to the large signaling overhead. This paper proposes two methods to address this problem. The first method provides a co-optimization method for AMC and HARQ when CQI is outdated or unavailable and there is a latency constraint. The second method presents a contention based access method to reduce uplink channel access latency. Simulation results show that with these two methods a significant improvement in spectral efficiency can be achieved while greatly reducing latency or maintaining a latency constraint.

4.2.24. Cooperative Communications with HARQ in a Wireless Mesh Network Based on 3GPP LTE

Title: Cooperative Communications with HARQ in a Wireless Mesh Network Based on 3GPP LTE
Authors: A. M. Cipriano, P. Agostini, A. Blad and R. Knopp
Conference: EUSIPCO 2012
Status (submitted/accepted/published): Published
URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6334307

Abstract: This paper presents some results of the FP7 ICT-LOLA (achieving LOw LAtency in wireless communications) project on the design of a clusterized wireless mesh network based on 3GPP LTE. First, we focus on the new MAC/PHY structure proposed. Then, the concept of virtual link is presented for inter-cluster communications combining MAC layer forwarding, hybrid automatic repeat request (HARQ) and cooperative communications with Decode and Forward (DF). The goal of a virtual link is to enable low latency data transfer in inter-cluster communications. The virtual link solution is studied by simulations thanks to OpenAirInterface which integrates LTE MAC and PHY layer procedures, as well as adaptations needed for the LOLA wireless mesh network. Simulation results show that the proposed distributed solution smoothly adapts to the link conditions. A loss in throughput efficiency is the price to be paid in certain configurations for the distributed operation of the virtual link. Nevertheless, the technique helps in reducing the average number of transmissions thus contributing to improve the latency of the system.

4.2.25. Evaluation of Latency-Aware Scheduling Techniques for M2M Traffic over LTE

Title: Evaluation of Latency-Aware Scheduling Techniques for M2M Traffic over LTE
Authors: I.M. Delgado-Luque, F. Blánquez-Casado, M. Garcia Fuertes, G. Gomez, M.C. Aguayo-Torres, J.T. Entrambasaguas and J. Baños
Conference: EUSIPCO 2012
Status (submitted/accepted/published): Published

URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6333920

Abstract: Machine to Machine (M2M) communications are expected to grow dramatically in next years. Scheduling techniques are determinant to achieve high spectral efficiency in wireless systems and to provide QoS guarantees to system users. In this work, several scheduling algorithms are evaluated in order to accommodate delay limited M2M communications over an LTE system. Simulation results show a reduction of mean and 95th percentile packet delay.

4.2.26. Low-latency Transmission of Low-Rate Analog Sources

Title: Low-latency Transmission of Low-Rate Analog Sources
Authors: Ayse Unsal and Raymond Knopp

Conference: EUSIPCO 2012
Status (submitted/accepted/published): Published

URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6334322

Abstract: Asymptotically optimal schemes for both single and dual-source cases with low-latency are addressed in this research. Single-source two-way protocol with non-coherent reception is introduced and its asymptotic behaviour is studied. The protocol consists of a data phase and a control phase which can go on up to N rounds. An upper bound on the distortion is derived for a two-round protocol. It is also extended to the case where there are two highly correlated analog sources one of which is uniformly distributed and the other one with a contaminated uniform distribution in the presence of two-sided feedback. Total energy used by protocol is fixed and the energy used by each source in both phases are derived individually. We have shown that it is possible to achieve the distortion bound of the single source with two highly correlated sources in two rounds.

4.2.27. On ACK/NACK Messages Detection in the LTE PUCCH with Multiple Receive Antennas

Title: On ACK/NACK Messages Detection in the LTE PUCCH with Multiple Receive Antennas
Authors: Yi Wu, Danyo Danev and Erik G. Larsson

Conference: EUSIPCO 2012
Status (submitted/accepted/published): Published

URL:http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6334261

Abstract: In this paper, we study ACK/NACK messages detection in the LTE physical uplink control channel (PUCCH) with multiple receive antennas. The LTE PUCCH is typically characterized by high interference variability due to severe inter-user interferences and slot-level frequency hopping. We present detection methods applicable for the cases when the noise variances at the receiver are known and unknown. Noise here may comprise both thermal noise and interference. The proposed detection technique is based on the generalized likelihood-ratio test (GLRT) paradigm. Simulation results show that GLRT-based detector offers a significant gain over the training-based maximum-likelihood detector when the noise variances in two slots are different and unknown. For the case when the noise variances at the receiver are known, the GLRT-

based detector has nearly the same performance as the training-based maximum-likelihood detector.

4.2.28. Design and Evaluation of Cooperative Broadcast in a Wireless Mesh Network Based on 3GPP LTE

Title: Design and Evaluation of Cooperative Broadcast in a Wireless Mesh Network Based on 3GPP
Authors: Antonio Maria Cipriano and Cécile Gomez

Conference: ISWCS 2012

Status (submitted/accepted/published): Published

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6328391

Abstract: This paper presents results of the Seventh Framework Programme (FP7) LOLA (achieving LOw LAtency in wireless communications) project about the design of a cooperative broadcast (CB) technique based on a decode and forward (DF) protocol, in the context of a clusterized wireless mesh network (WMN) based on 3GPP LTE PHY/MAC layers. The CB technique is compared to a baseline broadcast technique, obtained by packet propagation over a predetermined tree combined with local broadcasts inside the clusters. The novelty of the paper consists in presenting a design of CB which takes into consideration a number of practical issues set by the 3GPP LTE framework, like subframe design or MAC signalling. Moreover, simulation results are presented comparing the two techniques and presenting their advantages and drawbacks.

4.2.29. Hybrid CPU-GPU distributed framework for large scale mobile networks simulation

Title: Hybrid CPU-GPU distributed framework for large scale mobile networks simulation
Authors: Ben Romdhanne, Bilel; Nikaein, Navid; Mohamed Said, Mosli Bouksiaa

Conference: IEEE/ACM DS-RT 2012
Status (submitted/accepted/published): Published

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6365103

Abstract: Most of the existing packet-level simulation tools are designed to perform experiments modeling a small to medium scale networks. The main reason of this limitation is the amount of available computation power and memory in quasi mono-process simulation environment. To enable efficient packet-level simulation for large scale scenario, we introduce a new CPU-GPU co-simulation framework where synchronization and experiment design are performed on CPU and node's logical processes are executed in parallel on GPU according to the master/worker model. The framework is developed using Compute-Unified Device Architecture (CUDA) and denoted as Cunetsim, CUDA network simulator. In addition, we propose a CPU-legacy version which is optimized for multi-core architecture. In this work, we present cunetsim design models, its hardware/software architecture and supporting features. We evaluate the performance of cunetsim (both versions) compared to sinalgo and NS3 using existing benchmark scenario [25]. Evaluation results show that Cunetsim running time remains stable and that it achieves significantly lower computation time than CPU-based simulators for both static

and mobile networks with no degradation in the accuracy of the results. To provide insights into the hardware configuration impact, we realize an experimental study of the simulation performance and correctness which demonstrates the importance of the cores' number for both versions. This detailed study allows us to suggest the most relevant configuration according to the simulated scenario and network.

4.2.30. HSPA radio access performance evaluation for Online games and M2M applications traffic (TCP vs UDP)

Title: HSPA radio access performance evaluation for Online games and M2M applications traffic (TCP vs UDP)

Authors: Dejan Drajic, Milica Popovic, Navid Nikaein, Srdjan Krco, Philipp Svoboda, Igor Tomic, Nenad Zeljkovic

Conference: TELFOR 2012, Serbia

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=6419579

Abstract: In this paper we presented results of the performance evaluation of the live 3G/HSPA radio access network when loaded with multiplayer real-time games and M2M applications traffic. Traffic, for the emerging Machine Type Communication and online multiplayer games, was generated by an application running on 10 mobile phones in parallel using TCP or UDP protocols. In the previous work NodeB processing power and the number of simultaneous HS users were identified as major bottlenecks for system performances. Set of new measurements is conducted with increased processing power and the number of simultaneous HS users. The focus of the work was on the radio cell statistics, i.e. to evaluate potential impact of the additional traffic on the performance of radio access network.

4.2.31. OpenAirInterface traffic generator (OTG): A realistic traffic generation tool for emerging application scenarios

Title: OpenAirInterface traffic generator (OTG): A realistic traffic generation tool for emerging application scenarios

Authors: Hafsaoui, Aymen; Nikaein, Navid; Wang, Lusheng

Conference: IEEE MASCOTS 2012

Status (submitted/accepted/published): Published

LOLA: This paper describes work undertaken in the context of the LOLA project

URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?tp=&arnumber=6298211&tag=1

Abstract: Traffic generation represents one of the main challenge in modeling and simulating the application and network load. In this work, we present a tool, called OpenAirInterface Traffic Generator (OTG), for the generation of realistic application traffic that can be used for testing and evaluating the performance of emerging networking architectures. In addition to the traffic of conventional applications, OTG is capable of accurately emulating the traffic of new application scenarios such as online

gaming and machine-type communication. To highlight the capability and new features of the tool, the one-way delay of OpenArena online gaming application in the presence of the background traffic is analyzed over the LTE network using OpenAirInterface emulation platform.

4.2.32. Analysis and Experimentation with a Realistic Traffic Generation Tool for Emerging Application Scenarios

Title: Analysis and Experimentation with a Realistic Traffic Generation Tool for Emerging Application Scenarios

Authors: Hafsaoui, Aymen; Nikaein, Navid; Bonnet, Christian

Conference: EMUTools - SIMUTools 2013

Status (submitted/accepted/published): Accepted

Abstract: With the emergence of new networks and available applications, emulation of computer networks is an efficient technique for evaluating the performance, transport reliability and application-level protocols. Traffic generation is one of the key challenges in modeling and simulating the application and network load. In this work, we present a tool, called OpenAirInterface Traffic Generator (OTG), for the generation of realistic application traffic that can be used for testing and evaluating the performance of emerging networking architectures. In addition to the traffic of conventional applications, OTG is capable of accurately emulating the traffic of new application scenarios such as machine-type communication (MTC) and online gaming. We aim in this work to present OTG architecture and through experimentations to present main novelties and features of the presented tool. To highlight the capability and new features of the tool, the one-way delay of machine-type communication traffic and the case of M2M aggregated traffic is analyzed over the LTE network using OpenAirInterface in-lab system validation platform. For our delays analysis we will focus on two scenarios with bidirectional and aggregated traffics.

4.2.33. Packet aggregation for Machine Type Communications in LTE with Random Access Channel

Title: Packet aggregation for Machine Type Communications in LTE with Random Access Channel

Authors: Kaijie, Zhou; Navid, Nikaein (EURECOM)

Conference: IEEE WCNC 2013

Status (submitted/accepted/published): Accepted

Abstract: A packet aggregation method is proposed in this paper to lower the packet collision rate when the random access channel is used for machine type communications (MTC) uplink channel access in LTE. With the proposed packet aggregation method, a UE triggers random access when the aggregated packets in the buffer reaches the given threshold. However, this method reduces the packet collision rate at the expense of an extra latency which is used to aggregate certain

amount of packets. Therefore, the tradeoff should carefully be selected between packet loss rate reduction and extra channel access latency. In this paper, we derive the packet loss rate and channel access latency as functions of amount of aggregated packets using a Semi-Markov chain model. With the derived results, the optimal amount of aggregated packets which satisfies the packet loss requirement and keeps the latency as small as possible can be found, which is verified through simulations.
Keywords: LTE, MTC, random access, packet aggregation.

4.2.34. Dynamic Resource Allocation for Machine Type Communications in LTE/LTE-A with Contention-Based Access

Title: Dynamic Resource Allocation for Machine-Type Communications in LTE/LTE-A with Contention-Based Access

Authors: Kaijie, Zhou; Navid, Nikaein; Raymond, Knopp (EURECOM)

Conference: IEEE WCNC 2013

Status (submitted/accepted/published): Accepted

Abstract: In this paper, we propose a dynamic resource allocation method to enable efficient and low-latency machine type communications (MTC) in LTE/LTE-A with the contention based random access (CBA) scheme [9]. In the proposed method, we firstly estimate the probabilities of events caused by a CBA transmission and then calculate the latency with the measured resource unit. We increase the amount of CBA resources until the estimated latency satisfies the application QoS requirement. The simulation results demonstrate that with the proposed resource allocation method for CBA, the uplink channel access latency has been drastically reduced and that it always guarantees the latency requirements. Furthermore, the achievable latency is significantly reduced when compared to the regular scheduling and the standard random access scheme.
Keywords: LTE, MTC, random access, resource allocation, MU-MIMO.

4.2.35. Distortion bounds and a Protocol for One-Shot Transmission of Correlated Random Variables on a Non-Coherent Multiple-Access Channel

Title: Distortion bounds and a Protocol for One-Shot Transmission of Correlated Random Variables on a Non-Coherent Multiple-Access Channel

Authors: Ayse Unsal, Raymond Knopp (EURECOM)

Conference: IEEE SCC 2013

Status (submitted/accepted/published): Accepted

Abstract: Bounds on the distortion derived in [1] are adapted to the case where two continuous random variables are sent over a multiple access channel with phase shifts using the help of two feedback channels. The first source is defined to be uniformly distributed and the second source is defined as the sum of the first source and an auxiliary random variable which is also uniform. Additionally, using the same definition of the two sources, the two-round protocol introduced in [2] is studied in

detail and a comparison is made in order to discuss the tightness of the information-theoretic bounds.

4.2.36. Distributed Sensing and Transmission of Sporadic Random Samples

Title: Distributed Sensing and Transmission of Sporadic Random Samples

Authors: Ayse Unsal, Raymond Knopp (EURECOM)

Conference: IEEE ISIT 2013

Status (submitted/accepted/published): Submitted

Abstract: This work considers distributed sensing and transmission of sporadic random samples. Lower bounds are derived for the reconstruction error of a single normally or uniformly distributed vector imperfectly measured by a network of sensors and transmitted with finite energy to a common receiver via an additive white Gaussian noise asynchronous multiple-access channel. Transmission makes use of a perfect causal feedback link to the encoder connected to each sensor. A retransmission protocol inspired by the classical scheme in [1] applied to the transmission of single and bi-variate analog samples analyzed in [2] and [3] is extended to the more general network scenario, for which asymptotic upper-bounds on the reconstruction error are provided. Both the upper and lower-bounds show that collaboration can be achieved through energy accumulation under certain circumstances.

4.2.37. Dynamic Resource Allocation in Heterogeneous Networks

Title: Dynamic Resource Allocation in Heterogeneous Networks

Authors: Villa, Ruben Merz, Raymond Knopp (EURECOM)

Conference: IEEE GLOBECOM 2013

Status (submitted/accepted/published): Submitted

Abstract: LTE systems do not suffer from intra-cell interference, but they are affected by interference coming from adjacent cells. However, most of the research on resource allocation and repetition protocols has not paid attention to the interference case.

In this paper, we consider the problem of dynamic resource allocation for IR-HARQ schemes under the presence of interference. We consider resource allocation by means of rate and physical dimensions adaptation in each HARQ round. We provide a mathematical framework that can be applied for the analysis of heterogeneous networks. Rather than performing extensive simulations, we take an information theoretic approach to derive analytical expressions that represent the long-term throughput of the network and we consider distributed resource allocation policies. Our policies are applicable for both the uplink and downlink channels.

4.2.38. Performance Evaluation of cooperation-based techniques for M2M traffic over LTE

Title: Performance Evaluation of cooperation-based techniques for M2M traffic over LTE

Authors: Isabel M. Delgado-Luque, Francisco Blánquez-Casado, Francisco Javier Martín-Vega, Manuel Garcia Fuertes, Gerardo Gomez, Mari Carmen Aguayo-Torres, J. Tomás Entrambasaguas, Janie Baños

Conference: IEEE PIMRC'13

Status (submitted/accepted/published): Submitted

Abstract: Long Term Evolution (LTE) and its evolved version, LTE-Advanced (LTE-A), are the standards developed by 3GPP to avoid the limitations associated to 3G networks. Efforts have been put on the improvement of system performance in terms of data rates. Coordinated Multipoint (CoMP) and inter cell interference avoidance techniques have been widely studied in order to do that. However, not only is the increase in data rate important, but also latency reduction is a crucial factor to be considered for some applications. For instance, Machine-to-Machine (M2M) communications is nowadays one of the most promising applications, which are very sensitive to delay. In this work, we evaluate one of the most promising CoMP techniques, i.e. non-precoded Joint Transmission (non-precoded JT) and one of the most widely studied inter-cell interference avoidance technique, i.e. Partial Frequency Reuse (PFR). The objective is to determine whether, in addition to increase the data rates, they also reduce the latency. Simulation results show that PFR presents a greater reduction in the mean packet delay than this associated to non-precoded JT.

4.2.39. Simple Traffic Modeling Framework for Machine Type Communication

Title: Simple Traffic Modeling Framework for Machine Type Communication
Authors: Markus Laner, Philipp Svoboda, Navid Nikaein, Markus Rupp, Kaijie Zhou, Dejan Drajic and Milica Popovic
Conference: ISWCS 2013
Status (submitted/accepted/published): Submitted
Abstract: Machine-to-machine (M2M) or Machine-type Communication (MTC) is expected to become a significant share in future wireless networks. It exhibits considerably different traffic patterns than human-type communications, thus, claims for new traffic models and MTC simulation scenarios. For example, one cell shall serve up to 30 000 MTC devices, a number reaching limits in traffic emulation. This work evaluates known and proposes novel traffic models for MTC. In particular, the feasibility of source traffic modeling approaches (i.e., modeling each device as autonomous entity) for a massive amount of machines is examined. We introduce Coupled Markov Modulated Poisson Processes (CMMPP), a framework demonstrating the feasibility of source traffic modeling for MTC. Compared to aggregated MTC traffic models, such as proposed by 3GPP TR37.868, the CMMPP allows for enhanced accuracy.

4.2.40. Benchmarking End-to-End Delay Performance of Reactive Mobile Networks

Title: Benchmarking End-to-End Delay Performance of Reactive Mobile Networks
Authors: Markus Laner, Philipp Svoboda and Markus Rupp
Conference: IMC 2013
Status (submitted/accepted/published): Submitted
Abstract: Modern mobile communication networks handle user traffic in terms of data streams rather than single packets. Resources are allocated per stream as a reaction to its history. In particular, the network's delay figure depends on the entire traffic pattern injected by the user. This work aims to find a comprehensive measure for the delay behavior of both reactive and non-reactive networks; to (i) benchmark networks, (ii) unveil hidden network parameters and (iii) determine the delay of arbitrary streams. We define reactive networks and specify requirements for appropriate latency measurements which ensure statistical significance. External influences are found to be suppressed on timescales of 1–15 minutes; hence, such intervals are recommended for investigations on the impact of traffic patterns on latency. Based on this, a novel measurement methodology is introduced which enables the fast assessment of the delay performance of arbitrary communication links for a multitude of traffic patterns. The results are condensed to a handful of typical classes by simultaneously minimizing the loss of information. Those classes enable (i) an intuitive representation of the network's latency behaviour and (ii) fair benchmarking. We demonstrate the practicability of the approach by assessing three network technologies: WLAN (non-reactive), LTE (semi-reactive) and HSPA (reactive). The analysis shows that the proposed method works very well for all three technologies; outperforming standard methods which a priori assume non-reactiveness of the network under test.

4.2.41. Coordinator-Master-Worker Model For Efficient Large Scale Network Simulation

Title: Coordinator-Master-Worker Model For Efficient Large Scale Network Simulation
Authors: Ben Romdhanne, Bilel; Nikaein, Navid; Bonnet, Christian
Conference: Simutools 2013.
Status (submitted/accepted/published): Accepted
Abstract: In this work, we propose a coordinator-master-worker (CMW) model for medium to extra-large scale network simulation. The model supports distributed and parallel simulation for a heterogeneous computing node architecture with both multicore CPUs and GPUs. The model aims at maximizing the hardware usage rate while reducing the overall management overhead. In the CMW model, the coordinator is the top-level simulation CPU process that performs an initial partitioning of the simulation into multiple instances and is responsible for load balancing and synchronization services among all the active masters. The master is also a CPU process and provides event scheduling, synchronization, and communication services to the workers. It manages workers operating potentially on different computing resources within the same shared memory context and communicates with the coordinator and others masters through the messages passing interface. The worker is the elementary actor of CMW model that performs the simulation routines and interacts with the input and output data, and can be a CPU or a GPU thread. Compared to existing master-worker models, the CMW is natively parallel and GPU

compliant, and can be extended to support additional computing resources. The performance gain of the model is evaluated through different benchmarking scenarios using low-cost publicly available GPU platforms. The results have been shown that the speedup up to 3000 times can be achieved compared to a sequential execution and up to 6 times compared to a mono-GPU MW-based simulation. The hardware activities rate of the CMW services for both CPU and GPU are analyzed in detail.

4.2.42. Hybrid scheduling for event-driven simulation over heterogeneous computers

Title: Hybrid scheduling for event-driven simulation over heterogeneous computers
Authors: Ben Romdhanne, Bilel; Mosli Bousiaa, Mohamed Said; Nikaein, Navid; Bonnet, Christian
Conference: ACM SIGSIM PADS 2013.
Status (submitted/accepted/published): Accepted
Abstract: In this work we propose a new scheduling approach designed from scratch to maximize heterogeneous computers usage and the event processing flow at the same time. The scheduler is built based on three fundamental concepts which introduces a new vision of discrete event simulation: 1) events are clustered according to their potential time parallelism on one hand and to their potential process and data similarity on the other hand. 2) events meta-data is enhanced with additional descriptor which simplifies and accelerates the scheduling decision. 3) the simulation is hybrid time-event driven rather than time- or event-driven. The concretization of our approach is denoted the H-scheduler which uses several processes to manage the event flow. Furthermore we propose a dynamic scheduling optimization which aims to further maximize the event flow. The combination of those features allows the H-scheduler to provide the highest efficiency rate compared to the majority of GPU and CPU schedulers. In particular it goes beyond the default Cunetsim Scheduler by 90% in average while it keeps a significant lead on existing simulators.

4.3. Book chapters

4.3.1. M2M Traffic and Models

Title: M2M Traffic and Models

Authors: Markus Laner, Navid Nikaein, Dejan Drajic, Philipp Svoboda, Milica Popovic, Srdjan Krco

Book title: Machine-To-Machine Communications - Architectures, Technology, Standards, and Applications

Edited by: Vojislav B. Mišić and Jelena Mišić

Publisher: CRC Press, Boca Raton, FL, USA

Status: Expected publishing time in August 2013

4.3.2. Traffic modelling for M2M communication

Title: Traffic modelling for M2M communications",

Authors: Markus Laner, Navid Nikaein, Dejan Drajic, Philipp Svoboda, Milica Popovic, Srdjan Krco

Book Title: Machine-to-machine (M2M) communications, architecture, performance and applications.

Edited by : Mischa Dohler and Carles Anton (CTTC)

Publisher: Woodhead Publishing on

Status: invited and accepted, 2013

5. PRESENTATIONS, POSTERS AND FLYERS

5.1. International workshops/summits

5.1.1. RAS CLUSTER Meeting 2010

Type of material presented: Presentation
Authors: Raymond Knopp
Event reference: RAS Showcase
Date: 2010-06-16—2010-06-18
LOLA: Project presentation
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/211958
Details: LOLA Achievement

5.1.2. ETSI M2M Workshop 2010

Type of material presented: Poster
Authors: LOLA Consortium
Event reference: ETSI M2M Workshop
Date: 2010-10-19 — 2010-10-20
LOLA: Explanation of LOLA's real-time M2M scenarios, latency analysis, and potential latency reductions through appropriate MAC/PHY adaptations.
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/185101
Details: Many M2M applications will run over wireless or broadband wireless technologies. Latency is an important requirement in many M2M applications. Both the core network and the access network impact the overall end-to-end latency.

LOLA is an FP7 ICT European Project that has recently started. The purpose of LOLA is to provide significant technological advances in terms of minimizing end-to-end latency in wireless systems for two types of networks based on OFDMA: 4G cellular networks (mostly based on LTE or LTE-A) and rapidly deployable wireless mesh networks.

LOLA project has performed an analysis of M2M application scenarios and has identified the ones where low latency is a key requirement or may compromise the application. In LOLA low-latency application scenarios are classified into three main areas: gaming, M2M applications and human remote control, alarm and event detection. Some of the M2M scenarios considered are: auto pilot (car-to-car communications); sensor-based alarm or event detection; on-line interaction for life support systems; M2M games (bicycle race); and team tracking.

The results of the initial analysis will be presented including a description and motivation for each application and a rough latency budget. LOLA will also perform theoretical traffic modelling and measurements, which will be presented.

5.1.3. 18th Telecommunications Forum TELFOR 2010

Type of material presented: Presentation
Author: Katarina Šekeljić
Event reference: http://www.telfor.rs/
Date: 2010-11-23—2010-11-25
LOLA: Visibility
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/356103
Details: A general presentation of FP7 projects LOLA, SENSEI and EXALTED

5.1.4. Future Network & Mobile Summit 2011

Type of material presented: Poster+Demo (common Booth with ICT FP7 SAMURAI project)
Title: Achieving Low Latency in Wireless Communication
Authors: Raymond Knopp and Navid Nikaein
Event reference: http://www.futurenetworksummit.eu/2011/
Date: 2011-06-15—2011-06-17
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/279527
Abstract: The demonstration highlight advances in dynamic Carrier Aggregation schemes (PHY/MAC), MU-MIMO schemes (PHY) and access layer technologies targeting low-latency transmission.
Keywords: Latency, LTE, LTE-A, M2M Communication Scenario, Interactive Gaming, Real-Time Application, System Architecture.
Acknowledgement: LOLA project

5.1.5. RAS Cluster meeting 2011

Type of material presented: Presentation
Authors: Raymond Knopp, Antonio Cipriano
Event reference: RAS Cluster meeting, Brussels
Date: 2011-10-06—2011-10-07
LOLA: Visibility
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/211985
Details: A general presentation of LOLA

5.1.6. 6th ACM Workshop on Performance Monitoring and Measurement of Heterogeneous Wireless and Wired Networks

Type of material presented: Poster/Demo
Title: OpenAirInterface Large-Scale Wireless Emulation Platform and Methodology
Authors: Bilel Ben Romdhanne, Navid Nikaein, Raymond KNOPP and Christian Bonnet
Event reference: http://paradise.site.uottawa.ca/PM2HW2N2011
Date: 2011-10-31—2011-11-04
LOLA: Description of the OpenAirInterface emulation platform
URL: http://dl.acm.org/citation.cfm?doid=2069087.2069102

5.1.7. SIGMETRICS/Performance 2012

Type of material presented: Poster
Title: Modelling Randomness in Network Traffic
Authors: Markus Laner, Philipp Svoboda and Markus Rupp
Event reference: **http://www.sigmetrics.org/sigmetrics2012**
Date: 2012-06-15 — 2012-06-15
LOLA: Presentation of results obtained within WP3.
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/386684

5.1.8. Future Network & Mobile Summit 2012

Type of material presented: Poster+Demo (common Booth with ICT FP7 SAMURAI project)
Title: Large System LTE/LTE-A Emulation Platform
Authors: Raymond Knopp and Navid Nikaein
Event reference: **http://www.futurenetworksummit.eu/2012**
Date: 2012-07-04 — 2012-07-06
LOLA: Presentation of the OpenAirInterface LTE/LTE-A Large Scale Emulator
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/360267
Abstract: The demonstration highlight advances in dynamic Carrier Aggregation schemes (PHY/MAC), MU-MIMO schemes (PHY) and access layer technologies targeting low-latency transmission. How to achieve low-latency for a large scale system in LTE/LTE-A in view of emerging applications (M2M and online gaming)
Details: Through interaction with the researchers, the delegate will also understand how these schemes will impact the future of LTE. We intend to prepare posters that can also be used as tutorial style (for non experts) still without trading on the technology complexity and quality.

5.1.9. 20th Telecommunications Forum TELFOR 2012

Type of material presented: Presentation
Author: Milica Popović
Event reference: http://www.telfor.rs/
Date: 2012-11-20—2012-11-22
LOLA: Visibility
Details: A general presentation of FP7 project LOLA

5.1.10. FOKUS FUSECO Forum 2012

Type of material presented: Presentation
Title: M2M simulations and real applications in HSPA network – impact on network performance and service
Authors: Milica Popović
Event reference: **http://www.fokus.fraunhofer.de/en/fokus_events/ngni/fuseco_forum_2012/**
Date: 2012-11-15—2012-11-16
LOLA: Presentation of LOLA simulation results and real M2M deployment
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/377887
Details: Simulations performed within the LOLA project for applications with critical latency, Online Gaming and M2M. Real M2M application deployment with significant network performance degradation as observed during simulations.

5.1.11. EMUTools 2013

Type of material presented: Poster
Title: OpenAirInterface in-lab system validation tool
Event reference: http://simutools.org/2013/index.php?n=Workshops.Emutools
Date: 2013-03-05—2013-03-07
LOLA: Participation as chair of the EMUTools workshop
BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/360267
Details: Presentation of the baseline OpenAirInterface emulator.

5.1.12. SIMUTools 2013

Type of material presented: Poster
Title: Scalability demonstration of a Large Scale GPU-based Network Simulator
Event reference: http://www.simutools.org/2013/
Date: 2013-03-05—2013-03-07

LOLA: Participation as local chair of the workshop

Abstract: Large scale simulation is a challenging issue of the network research area. In particular, simulating one large space where a big number of nodes are in continuous interaction remains complex even if we consider distributed and parallel solutions. In this perspective; GPU appears as a promising hardware providing an important number of independent computing resources. Nevertheless its usage requires a new software design. In that context, Cunetsim is a distributed GPU-based framework which aims to combine the power of GPUs with the flexibility of distributed solution in order to increase the scalability while reducing the complexity. In this work, we aim to demonstrate the efficiency and the scalability of that framework on one hand and its robustness in terms of event handling on the other hand; therefore we propose a validation scenario including 1.5 millions nodes where we generate up to 10 billions events; we conduct the simulation using one workstation which includes three GPUs.

5.1.13. PADS 2013

Type of material presented: Poster

Title: Event-flow stability demonstration for a hybrid GPU-CPU scheduling in large scale network

Event reference: http://www.acm-sigsim-pads.org/

Date: 2013-05-019—2013-05-22

Abstract: Efficient simulation is a challenging issue when targeting large-scale networking experimentation. In particular, simulating a large-to-extra-large number of nodes interacting continuously with each other remains complex even if we consider distributed and parallel solutions. In this perspective, the GPU appears as a promising hardware providing an important number of independent computing resources. Nevertheless, the usage of such resources calls for a new simulation framework and software design. In this context, Cunetsim, a distributed hybrid CPU-GPU simulation framework, is proposed with the aim of combining efficient parallel processing capabilities of GPUs with the flexibility of CPU in order to increase the simulation scalability and efficiency. In this work we aim to demonstrate the event flow stability achieved by the parallel and hybrid scheduling of Cunetsim when targeting a heterogeneous computing node architecture. The validation scenario will be a wireless adhoc sensor networks with up to 1.5 millions nodes generating 10 billions events.

5.2. National workshops/summits

5.2.1. World Telecommunication Day 2012

Type of material presented: Presentation

Author: Mr. Torrecilla (AT4 wireless LOLA Team)

Event reference: World Telecommunication Day 2012, Inacap, Santiago (Chile)

Date: 2012-05-03

Relation to LOLA: Visibility

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/349723

Details: AT4 wireless gave a presentation titled "Evolución hacia 4G" about the Evolution towards 4G in the World Telecommunication Day meeting held in the Instituto Nacional de Capacitación (Inacap), Santiago (Chile). The presentation included a reference to LOLA project, highlighting its main objectives and outcomes. AT4 wireless and several University Directors from Latin America participated in this meeting mainly oriented to students.

5.3. Demonstrations

5.3.1. OpenAirInterface Emulation Platform at Alcatel-Lucent Bell-labs

Author: Navid Nikaein

Event: Alcatel Lucent, 2011 Bell Labs Open Days in France

Date: May 13, 2011

Location: Bell Labs Research Center Villarceaux, France

Relation to LOLA: Show case large emulation platform and methodology (testbed 1)

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/356252

Details: Demo on potential on OAI and research avenues. Topic: Autonomous interference management for LTE small cells

5.3.2. OpenAirInterface Emulation Platform at Alcatel-Lucent Bell-labs

Author: Navid Nikaein

Event: Alcatel Lucent, 2012 Bell Labs Open Days in France

Date: May 25, 2012

Location: Bell Labs Research Center Villarceaux, France

Relation to LOLA: Show case large emulation platform and methodology (testbed 1)

BSCW: https://bscw.eurecom.fr/bscw/bscw.cgi/356286

Details: Demo on realistic mobility and traffic models and emulation platform

6. SPECIAL SESSIONS

6.1. Machine-to-Machine Inter-networking

Special session name: Machine-to-Machine Inter-networking
Organizer: S. Krco
Conference: WONS 2012
Date: 2012-01-11
URL: http://wons2012.tlc.polito.it/cfp.html
Program: http://wons2012.tlc.polito.it/program.html
Description: Strategic and technical challenges (architecture design, access layer, mobility, networking, security, services), role/interest of the industry, integration in future networks (vehicular networks, Psycho-Physical Systems, LTE-A).

6.2. Latency Aspects in Cellular and Ad-hoc Networks

Special session name: Latency Aspects in Cellular and Ad-hoc Networks
Organizers: M. Rupp, P. Svoboda, D. Danev
Conference: EUSIPCO 2012
Date: 2012-08-29
URL: http://www.eusipco2012.org/program_special_sessions.php
Program: http://www.eusipco2012.org/program_final_technical_program.php
Description: Latency in wireless communications is crucial in many modern applications. The importance of providing technological advances in terms of minimizing end-to-end latency is undisputed. The purpose of this SS is to bring forward some of the latest achievements in this field. Some of the topics covered are the following:

- Latency improvements in M2M communications
- Adaptive modulation and coding techniques
- Hybrid ARQ techniques
- Hybrid Analog/Digital transmission
- Scheduling policies in cellular networks
- Simulation tools for measuring of latency
- Measuring and modelling of traffic in wireless networks

6.3. M2M (Machine-to-Machine) and IoT (Internet of Things) Evolution

Special session name: M2M (Machine-to-Machine) and IoT (Internet of Things) Evolution

Organizers: S. Krco, D. Drajic

Conference: TELFOR 2012

Date: 2012-11-20

URL: http://www.telfor.rs

Program: http://www.telfor.rs/files/Program%20TELFOR%202012.pdf

Description: During the Telfor 2012 conference (20.-22.11.2012. Belgrade, Serbia http://www.telfor.rs/) special session dedicated to M2M and IoT evolution is organized by Ericsson d.o.o. The scope of the session was presentation of ongoing FP7 projects in Serbia related to M2M and IoT work. On the session are given overview of the LOLA, EXALTED, HOBNET, SmartSantander, IoT6 and CitySense projects, and the papers related to LOLA and EXALTED projects.

6.4. ICC Workshop: Beyond LTE-A

Special session name: Beyond LTE-A

Organizers: M. Rupp, A. Lozano, C. Papadias

Partners: LOLA, HIATUS, NFN SISE

Conference: ICC 2013

Date: 2013-06-09

URL: http://www.lteb.net

Program: http://www.lteb.net/wp-content/uploads/2013/02/IEEE-International-Conference-on-Communications-2013.pdf/

Description: While existing standards of LTE-A already allow very high data rates for few users in a cell, there are still open questions that need to be addressed in future systems. For sure energy, capacity, and efficiency are key elements in future cellular systems as they directly affect the OPEX of such systems. Low latency also remains a crucial element to drive some applications. With further advances in high speed trains it becomes important to further enhance the support for high-speed users, beyond what is possible with LTE-A. Only through sophisticated coordination schemes we can expect to significantly increase multi-user efficiency. However, the required feedback data load as well as response time needs to be kept low in order to become a realistic concept. While Machine to Machine (M2M) communication is already part of the existing standard, the classical cellular system is not able to communicate with hundreds or even thousands of machines in a single cell. Device-to-device (D2D) communication is a promising technique to increase the efficiency of cellular communication systems. It is of significant interest to devise D2D communication schemes that underlay conventional LTE networks in an energy-efficient and interference-aware manner.

7. DEVELOPED SOFTWARE

In this section we describe and provide references to the specially developed software packages created during the project.

7.1. Smart phone App for traffic generation

Developers: EYU, MTS, TuV

Link: https://bscw.eurecom.fr/bscw/bscw.cgi/2755351

Brief description: Based on parameters provided as the results of modeling in LOLA, Traffic Generation Application is developed with goal to implement modeled parameters, like different distributions of packet sizes and inter-arrival packet times, and to fulfill needed requirements, like TCP or UDP transmission of packets, multi-connection (few parallel TCP or UDP sessions), in order to perform reliable and realistic emulation of observed applications in real Telekom mobile network.

The application is particularly developed for the purpose of traffic generation in mobile wireless network for different types of tests in LOLA project.

Application is written for Android phones. Actually there are two applications, one being application for mobile phones, and another one for server side, that should be installed on the server towards which the application from mobile phone will send packets through the mobile network. More about application can be found in [6].

Application availability: Traffic generation Application is available upon request. Please contact Ericsson Serbia about further information.

7.2. Traffic simulator at TuV

Developer: TuV

Link: https://bscw.eurecom.fr/bscw/bscw.cgi/198669

Brief description: This software is a command line tool written in PERL programming language, which allows for the exchange of data traffic between server and client instances at remote machines. The data is exchanged in form of UDP packets. Custom traffic patterns can be specified by input files, the exact format of which is provided in companion documents available at the link specified above. The tool enables detection of erroneous transmission, logging of packet exchange statistics, packet segmentation of datagrams with maximum size of infinity continuous replay of input files and transmission at arbitrary port numbers.

7.3. Timing synchronization for desktop PCs

Developer: TuV

Link: https://bscw.eurecom.fr/bscw/bscw.cgi/198639,
http://www.nt.tuwien.ac.at/about-us/staff/markus-laner

Brief description: This software is a command line tool written in C programming language, which enables the accurate synchronization of the software clock of Linux PCs to an external source (such as a GPS receiver). It works on the basis of the LinuxPPS tool which enables accurate timestamping of voltage pulses at the PC's serial interface (RS232). Further, coarse synchronization to UTC is performed via the NTP framework. The tool includes a clock servo which steers the timing behaviour of the software clock. The resulting accuracy is assessed and documented in companion documents provided at the links specified above. Further capabilities are online accuracy estimation and logging.

7.4. Traffic simulator included by OTG/OpenAirInterface

Developers: TuV, EURE

Link: http://www.openairinterface.org/

Brief description: This tool is a module of the OpenAirInterface written in C programming language, which allows for the generation of random traffic patterns which are characterized by random processes of packet size and packet inter-arrival time with given probability density functions, auto-correlation functions and cross-correlation function. The respective modelling approach is commonly deployed for Video, Online-gaming and VoiP traffic patterns. The tool is optimized for low computational complexity.

7.5. OpenAirInterface developement

Developer: EURE

Link: http://www.openairinterface.org/

SVN Read only: http://svn.eurecom.fr/openair4G/trunk

SVN READ/WRITE: http://svn.eurecom.fr/openairwebsvn/openair4G/trunk (RW)

Twiki: https://twiki.eurecom.fr/twiki/bin/view/OpenAirInterface/WebHome

Brief description: OpenAirInterface is an open-source platform for experimentation in wireless systems with a strong focus on cellular technologies such as LTE and LTE-Advanced. The platform comprises both hardware and software components and can be used for simulation/emulation as well as real-time experimentation. It comprises the entire protocol stack from the physical to the networking layer. The objective of this platform is to fill the gap between the simulation and real experimentation by providing the baselines for protocol validation, performance evaluation and pre-deployment system test.

8. NETWORKING AND INTERACTION WITH OTHER RESEARCH INITIATIVES

The FP7 EXALTED is an IP type of project addressing M2M and LTE. It has been identified as a project of particular interest for collaboration due to the overlapping scope. This was also confirmed at the first LOLA project annual review and included in the reviewers' recommendation list. The initial interaction between the projects has been established at the ETSI M2M workshop in Sophia Antipolis (September, 2010). Further interactions were continued mainly through Ericsson as a partner active in both projects.

While the focus of the LOLA project is on LTE latency in the case of M2M applications, the EXALTED project has a larger focus, targeting all layers of LTE communications as well as capillary networks. Analysis and definition of the M2M traffic models is of interest for both projects. While in the LOLA project this is one of the core activities, for the EXALTED project the traffic models are one of the inputs to the architecture of the so called LTE-M (M2M adaptation of LTE). Having in mind that LOLA project started 9 months earlier, we were able to provide information about the M2M traffic models as an input to the EXALTED work on LTE-M architecture during 2011. Joint preparation of Transactions on Emerging Telecommunications Technologies (ETT) Journal Special Issue on Machine-to-Machine: An Emerging Communication Paradigm is under way and is planned to be published in 2013.

More interaction activities in brief are:

- We have participated at the Future Networks 8th FP7 RAS Cluster and Concertation Meeting, Brussels 6-7 October 2011.
- Jointly with the CONECT project an OAI Training at EURECOM has been held at Sophia Antipolis on 7-8 July 2011.
- A summer school was organized together with the FP7 projects EXALTED, SmartSantander, HOBNET and IOT-6. It was the 7th event in the series "senZations summer school". A range of advanced topics from wireless sensor networks to M2M to Internet of Things and their applications are covered. The summer school was held during the period 3-7 September 2012 in Mecavnik, Serbia.
- During the consortium meeting at TCF in May 2012, T. Lestable from FP7 EXALTED presented the project. The presentation was followed by an extended discussion on possible future interactions between the two projects.
- We have participated in the Future Networks 10th FP7 RAS Cluster and Concertation Meeting, Brussels 10-11th October 2012.
- During February 20-22, 2012, an OAI training has been held in conjunction with @cropolis winter school at Sophia Antipolis. There were four OAI training sessions and presentations from the LOLA project and CONECT project.

- The results of the LOLA project have been made available for the com4innov platform, a French national project, and in particular the Android TG-App traffic generator has been delivered. The results concerning latency reduction for M2M in LTE have been presented to the OrangeLab at Sophia Antipolis.
- There has been a tight collaboration with the European projects CONNECT, SAMURAI, newcom+ and newcom#.

9. ONLINE ADVERTISING

9.1. Specialized online media dissemination

The official LOLA website is the main online dissemination channel of the project. It can be found at http://www.ict-lola.eu All publications and public deliverables can be retrieved from the website.

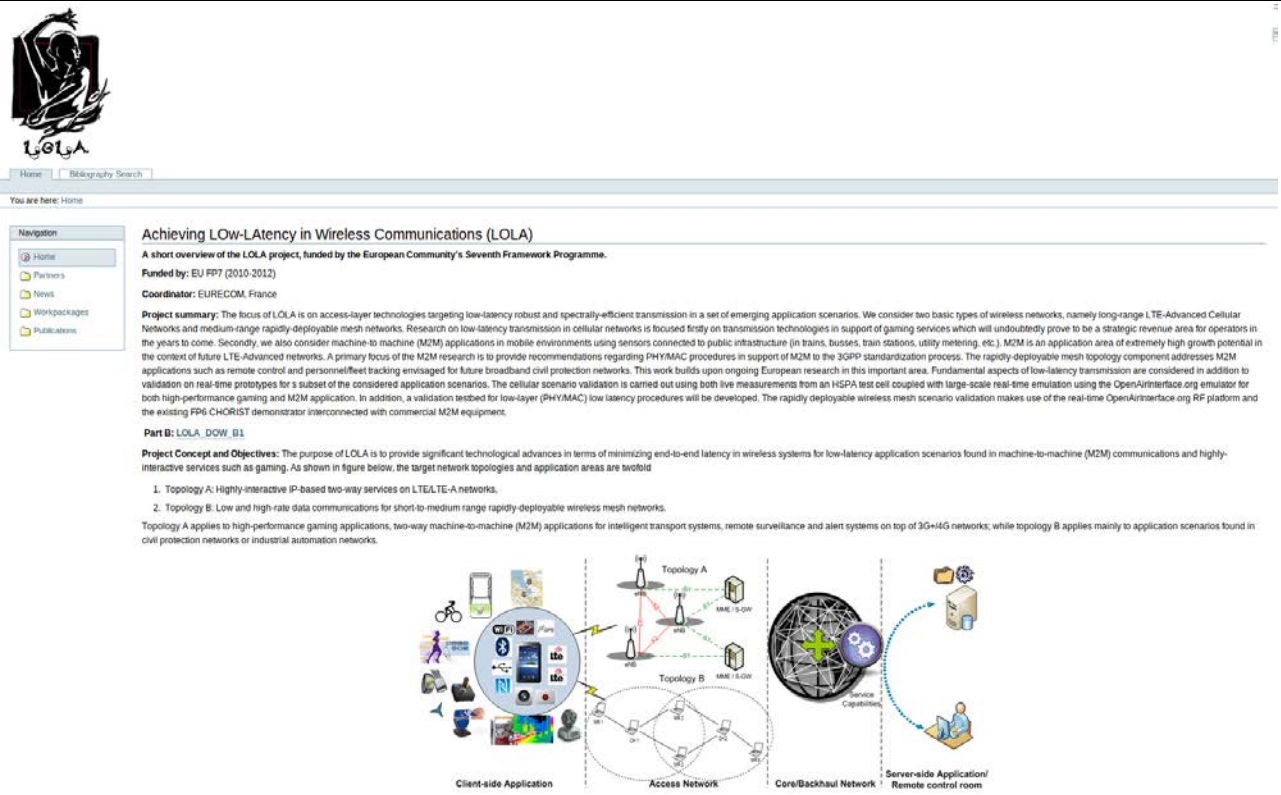

Figure 2: LOLA official website

9.2. LOLA project and partners' websites

The LOLA partner AT4 wireless disseminates information about LOLA via its website in both English and Spanish languages, where the objectives, partners and other relevant project data are published, as well as a link to the official LOLA website. Link to AT4 wireless website:

http://www.at4wireless.com/corporate/rd-activities/lola.html

The other partners refer to the LOLA project on their research activities web-pages.

Figure 3: LOLA in the AT4 wireless website

10. PROJECT BRANDING

The project logo is given here. More presentation templates, flyers and posters can be found on the BSCW server

https://bscw.eurecom.fr/bscw/bscw.cgi/137041

Figure 4: LOLA Project logo

11. CONCLUSIONS AND FUTURE PLANS

In this document the dissemination activities of the LOLA project have been presented. In total 6 papers in international scientific journals have been published, accepted or submitted. In addition to that 42 contributions to various international conferences have been achieved. Presentation of the project's results has been performed at 14 workshops/summits. As part of the dissemination activities the project partners have been part of the organization of 4 workshops concerning topics related to the LOLA project. Four different software applications has been developed during the course of the project

The project's website has served as a channel for spreading the project results. We plan to keep this website alive and updated in the future. This will assure the long-term accessibility to these results. All project non-confidential deliverables will be publicly available through that website. The software packages developed will be continuously updated in the near future. We intend to continue the cooperation between the project's partners on topics considered in the project.

The industrial partners AT4 and EYU will continue following the standardization activities within 3GPP and the M2M related activities within the ECC. Exploitation of the LOLA test beds is foreseen to provide future contributions.

In particular the following manuscripts are in preparation phase:

Title: Latency analysis for M2M and Online Gaming traffic in an HSPA network
Authors: Popović, Milica; Drajić, Dejan; Svoboda, Philipp; Nikaein, Navid; Krčo, Srdjan; Laner, Markus
Journal: to be selected

Status (submitted/accepted/published): in preparation

Relation to LOLA: This paper is a result from the efforts towards Deliverable 5.3 within WP5.

Subject: Analysis of latency per different parts of the network with sufficient resources for supporting these types of traffic, analysis of TCP and UDP case, conclusions concerning the relation between the traffic pattern (time between packets and packet length) and latency

Keywords: M2M, Online Gaming, HSPA network, Latency, RTT

Title: The impact of HSPA core network features on latency for M2M and OG-like traffic patterns
Authors: Popović, Milica; Drajić, Dejan; Svoboda, Philipp; Nikaein, Navid; Krčo, Srdjan

Conference: to be selected

Status (submitted/accepted/published): in preparation

LOLA: This paper is a result from the efforts towards Deliverable 3.5 within WP3.

Subject: Analysis of the latency in the core network using different APNs, i.e. proxy server, Service Aware feature, different GGSNs and firewalls.

Keywords: M2M, Online Gaming, HSPA network, Latency, RTT, APN

12. ACRONYMS

Acronym	Defined as
3GPP	3rd Generation Partnership Project
ENB	Enhanced Node B
ETSI	European Telecommunications Standards Institute
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GMSC	Gateway MSC
GW	Gateway
LTE	Long Term Evolution
LTE-A	LTE-Advanced
MAC	Medium Access Control
M2M	Machine-To-Machine
MME	Mobility Management Entity
MSC	Mobile Switching Centre
PHY	PHYsical (layer)
RAN	Radio Access Network
SAE	System Architecture Evolution
UE	User Equipment
UTRA	Universal Terrestrial Radio Access

13. REFERENCES

[1] 3GPP TSG RAN Meeting #51, RP-110141. ""LTE-Advanced" material for Rec. ITU-R M. [IMT.RSPEC]". Kansas City (USA), March 15-18, 2011.

[2] LOLA Project (Achieving Low-Latency in Wireless Communications), "D4.1 Specification of PHY/MAC Adaptations for the Target Architectures v1.0". November, 2010.

[3] 3GPP TSG RAN Meeting #50, RP-101174. ""LTE-Advanced" material for Rec. ITU-R M. [IMT.RSPEC]". Istanbul (Turkey), December 7-10, 2010.

[4] Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT), ECC Report 153, "Numbering and Addressing in Machine-to-Machine (M2M) Communications". November, 2010.

[5] 3GPP, "Overview of 3GPP Release 11", V0.0.4, September 2010.

[6] LOLA Project (Achieving Low-Latency in Wireless Communications)," D3.5 Traffic Models for M2M and Online Gaming Network Traffic". February, 2013.

ANNEX A PROCEDURES FOR THE PUBLICATIONS ACCORDING TO CONSORTIUM AGREEMENT AND GRANT AGREEMENT

A.1 Dissemination

Prior notice of any planned publication shall be made 30 days before the publication - including sufficient information concerning the planned dissemination activity and the data envisaged to be disseminated.

Any objection to the planned publication shall be made in accordance with the GA in writing to the Coordinator and to any Party concerned within 21 days after receipt of the notice. If no objection is made within the time limit stated above, the publication is permitted.

All publications or any other dissemination relating to foreground shall include the following statement to indicate that said foreground was generated with the assistance of financial support from the Community:

The research leading to these results has received funding from the [European Community's] [European Atomic Energy Community's] Seventh Framework Programme ([FP7/2007-2013] [FP7/2007-2011]) under grant agreement n° [248993].

An objection is justified if

a) the objecting Party's legitimate academic or commercial interests in relation to its foreground or background are compromised by the publication; or

b) the protection of the objecting Party's Foreground or Background or Confidential Information is adversely affected.

The objection has to include a precise request for necessary modifications.

If an objection has been raised the involved Parties shall discuss how to overcome the justified grounds for the objection on a timely basis (for example by amendment to the planned publication and/or by protecting information before publication) and the objecting Party shall not unreasonably continue the opposition if appropriate actions are performed following the discussion.

However, none of the Parties may withhold its consent to publication or communication upon the expiry of a period of three (3) calendar months following the first submission of the proposed publication/communication.

For the avoidance of doubt, a Party shall not publish Foreground or Background or Confidential Information of another Party, even if such Foreground or Background or Confidential Information is amalgamated with the Party's Foreground, without the other Party's prior written approval. For the avoidance of doubt, the mere absence of an objection according to 8.3.1 is not considered as an approval.

Any dissemination activity shall be reported in the plan for the use and dissemination of foreground, including sufficient details/references to enable the Commission to trace the activity. With regard to scientific publications relating to foreground published before or after the final report, such details/references and an abstract of the publication must be provided to the Commission at the latest two months following publication. Furthermore, an electronic copy of the published version or the final manuscript accepted for publication shall also be provided to the Commission at the same time for the purpose set out in Article II.12.2 if this does not infringe any rights of third parties.