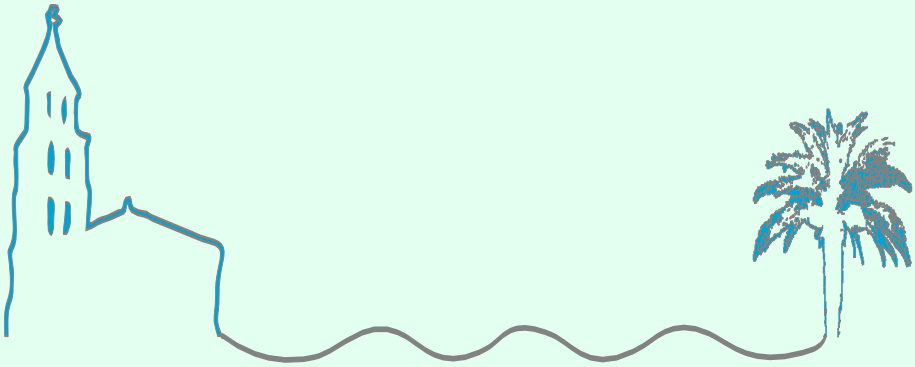

SoftCOM 2016 PhD Forum

Book of Abstracts

Split, September 22-24, 2016

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24th International Conference on Software,
Telecommunications and Computer Networks

SoftCOM 2016

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CONTENTS

SoftCOM 2016 PhD Forum

Foreword

The PhD Forum, hosted for the first time by the 24th *SoftCOM 2016* in Split, Croatia, is an event dedicated to PhD students.

On behalf of the steering committee, it is my pleasure and honor to write this foreword to the PhD Forum's *Book of Abstracts*.

The main motivation for co-locating the PhD Forum to a well-established, IEEE technically co-sponsored conference like *SoftCOM* was twofold. Firstly, we wanted to give PhD students an opportunity to present their doctoral dissertation-related work-in-progress to a diverse and international community of top-researchers. Secondly, we aimed to encourage interaction and networking among PhD students – presenters and their peers in the audience – as well as between PhD students and the main conference audience. In that, as demonstrated by relatively high session attendance and lively discussions, the first *SoftCOM* PhD Forum has fulfilled the steering committee's expectations really well.

To be included in the *SoftCOM* PhD Forum programme, doctoral students were invited to submit a two-page (extended) abstract for review. The submissions were reviewed by the PhD Forum Program & Organizing Committee members, based on relevance to the conference, innovativeness, and quality of (written) presentation. A total of 11 submissions have been accepted, prepared by doctoral students from the University of Zagreb, the University of Split, the Josip Juraj Strossmayer University of Osijek, and the University of Rijeka. The final revised versions of the accepted submissions are now included in this book.

The PhD Forum programme was organized as a poster session, preceded by a set of fast-paced introductory "pitch talks", offering a preview of the posters. The purpose of a pitch talk was to provide a brief outline of one's doctoral research work, with the goal to "set the stage" for further discussion over the upcoming poster session. Each student was given a strictly-timed 2-minutes' slot to present – a difficult task that many of them handled amazingly well. The session chair, Ognjen Dobrijevic, also deserves special mention for expertly moderating the session. Photographs at the end of this book capture some notable moments from the pitch talk session, as well as the discussions regarding the posters. The winner(s) of the best presentation award were determined by the members of the audience in a secret ballot vote. The vote resulted in a tie between Martina Marjanovic from the University of Zagreb and Marina Prvan from the University of Split.

Finally, I would like to thank the *SoftCOM 2016* General Chair, Dinko Begusic, and all the members of the Steering Committee, as well as the Program & Organizing Committee, for great support and the job well done.

Maja Matijašević, University of Zagreb
Steering Committee Chair

Cost-Driven Optimization of Cloud Service Placement Based on Service Resource Usage Profile

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***Abstract*—As cloud computing industry adoption is increasing, service cost management is becoming one of the most important issues from the perspective of cloud users. This work is looking into possibility of using resource usage profile (*RUP*) for cloud service placement optimization. Optimized placement should result in minimized service execution cost, while fulfilling Service Level Agreement (SLA) requirements. We present two application types and discuss how *RUP* can be used for service placement cost optimization.**

Keywords—cloud computing; cost optimisation; quality of service; resource usage profiles; service placement

I. Introduction

Recent RightScale survey [1] reports that cost management was identified as significant challenge by 26% of respondents, and that few companies apply cost optimization techniques, such as optimized service placement [2]. Finding the best service placement is not easily achieved empirically since it requires a lot of time and effort, and causes additional cost.

Research approaches [3][4][5] exist that are dealing with cloud migration profitability and cost optimization. Most of them are based on dynamic redeployment, and require certain execution time. Also, most solutions are implemented from the infrastructure provider perspective, with few of them targeting service providers. The goal of this research is to analyze how *RUP* affects optimal service placement considering cost and SLA requirements. Cloud service models, created based on *RUP*, would be an input to the model-based service placement optimization method (Fig. 1), offering cloud service providers a cost-efficient way to determine the best deployment options for their services.

II. Use Cases and MeasurementS

Service *RUP* contains information about resources consumption for a certain number of concurrent users. The set of resources for this analysis included average CPU and RAM utilization, average network incoming/outgoing byte rates and ingress/egress traffic, average disk read/write byte rates, and used storage. *RUP*s were created by measuring resources consumption under constant load increased for each measurement from one to 150 parallel user requests. We performed measurements of two different application types, selected based on identified typical cloud workload types [6]. The first use case was a video streaming server and the scenario of a short video on-demand access. The second use case was an electronic health record (EHR) system used to retrieve a patient record from the EHR database. Services were hosted on a private cloud infrastructure and deployed on three instance types (Table 1). We collected resources consumption data and SLA parameters - response time, and Service Level Objective (SLO) violations, i.e. the number of requests with response time longer than that defined by the SLA.

III. Use case services resource usage analysis

We present selected graphs (Fig. 2) illustrating the effect an instance type has on the quality of service in case of different *RUP*s. EHR service utilizes more CPU than video streaming service for the same load, and SLA parameters significantly depend on the instance type. Video streaming service has higher egress traffic due to the larger amount of data being transferred to the users. The quality of the video streaming service is almost unaffected by the choice of an instance type.

IV. Conclusion And future work

Performed analysis demonstrates differences between applications in terms of their resource consumption, and the resulting service quality. Service *RUP* might point out extensively used resource types and which instance type should be chosen for optimized cost and quality tradeoff. The final goal of the research is creating the model-based method for optimized service placement driven by cost and service quality.

References

[1] RightScale 2016 State of the Cloud Report, www.rightscale.com

[2] Li, W., Svard, P., Tordsson, J., & Elmroth, E. A general approach to service deployment in cloud environments. In Cloud and Green Computing (CGC), 2012 Second Int. Conf. on (pp. 17-24). IEEE.

[3] Liu, S., Chan, F. T., & Ran, W. "Decision making for the selection of cloud vendor: An improved approach under group decision-making with integrated weights and objective/subjective attributes." *Expert Systems with Applications* 55 (2016): 37-47.

[4] Breitgand, D., Marashini, A., & Tordsson, J. Policy-driven service placement optimization in federated clouds. IBM Research Division, Tech. Rep, 9, 11-15. (2011)

[5] Kang, Y., Zhou, Y., Zheng, Z., & Lyu, M. R. A user experience-based cloud service redeployment mechanism. In *Cloud Computing (CLOUD), 2011 IEEE International Conference on* (pp. 227-234). IEEE.

[6] Leymann, C., Fehling F., Retter, R., Schupeck, W.,& Arbitter, P. "Cloud computing patterns." (2014).

TABLE I. INSTANCE TYPES USED FOR MEASUREMENTS

Instance type	Resources specified by instance type		
	RAM (MB)	*CPU (virtual cores)*	*Storage (GB)*
Small	2048	1	20
Medium	4096	2	40
Large	8192	4	80

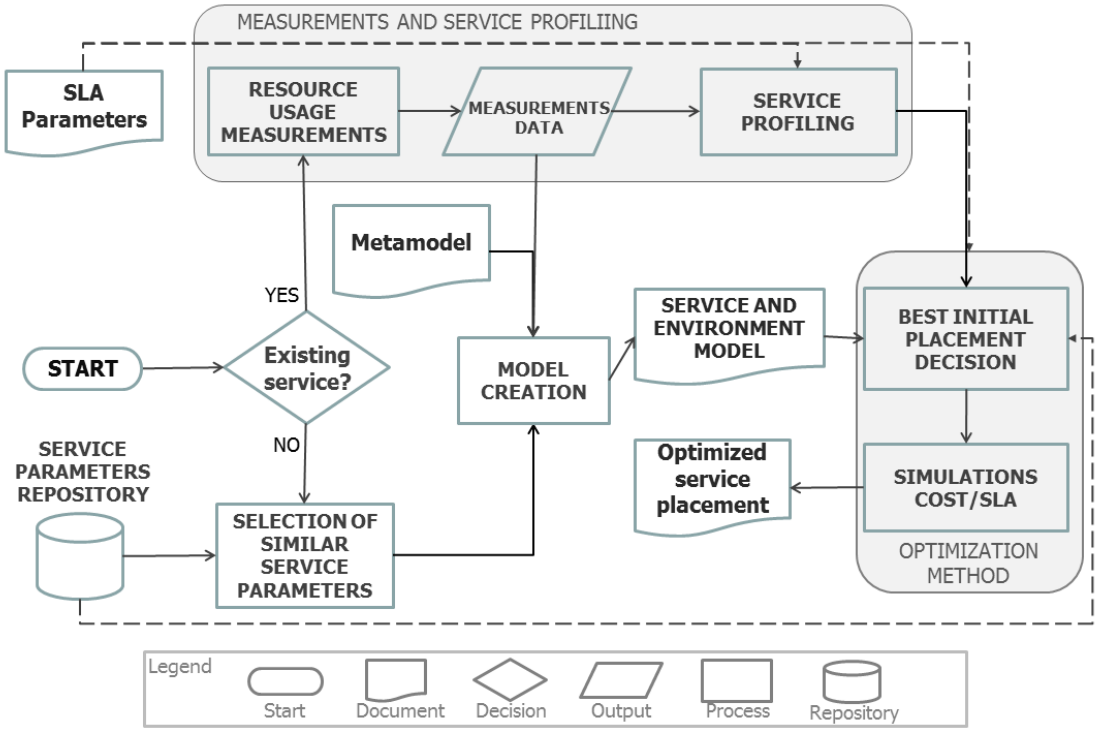

Fig. 1 Proposed model-based method for cost-driven service placement optimization

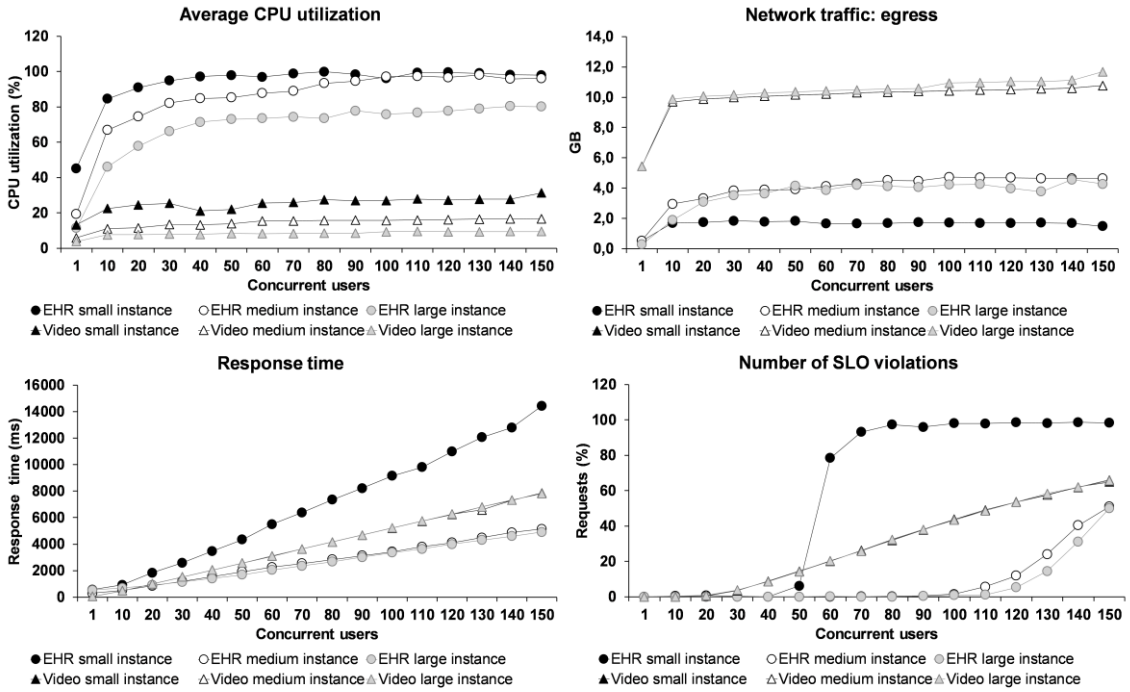

Fig. 2 Resource usage analysis results: a) average CPU utilization, b) network egress traffic, c) number of SLO violations, d) response time

Quality of Experience Driven Video Encoding Adaptation Strategies for Cloud Gaming under Network Constraints

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***Abstract*— The main objective of this research is to specify video encoding adaptation strategies to optimize end user QoE for cloud gaming under variable system and network conditions. The video encoding adaptation strategies will be based on proposed QoE models for cloud gaming, developed based on empirical user studies examining the impact of network resource availability and objective game characteristics on end user QoE. The research hypothesis is that the novel and context-aware video encoding adaptation strategies can be exploited to improve end user QoE in comparison with state-of-the-art approaches for cloud gaming service adaptation in light of constrained system or network resources.**

Keywords— Cloud gaming, aptation strategies, QoE modelling

I. MOTIVATION

The cloud gaming paradigm is commonly characterized by game content delivered from a server to a client as a video stream, with game controls sent from the client to the server (Fig. 1). The execution of the game logic, rendering of the 3D virtual scene, and video encoding are performed at the server, while the client is responsible for video decoding and capturing of client input. While cloud gaming reduces client hardware requirements and provides other benefits, most such games are traffic intensive and may significantly increase the network requirements necessary to secure a good level of Quality of Experience (QoE). With available system and network resources varying over time, subject to issues such as varying access network conditions or a varying number of players accessing a bottleneck link, there is a need for efficient and dynamic service adaptation strategies on the game server to meet different system and network availability constraints [1]. Given high bandwidth and strict latency requirements, a key challenge faced by cloud game providers lies in configuring the video encoding parameters so as to maximize player QoE while meeting resource availability constraints (Fig. 2). Current developed QoE models [2-4] can for the most part be applied to only one specific game for which they were primarily derived for due to significant differences (in terms of graphics detail, gameplay pace, input rate, etc.) between games that are assigned to the same game category based on present game genre classification. Therefore, there is a need to design an appropriate game taxonomy for cloud gaming based on objective game characteristic that can be later used as a tool when aiming to develop accurate QoE models for derived game categories. Consequently, such a taxonomy could then be used for determining optimal adaptation strategies for classes of games, which could in the future automate the process of deciding on the best encoding adaptation strategy for a particular game, alleviating the need to conduct subjective studies for additionally considered (or newly emerging) games.

This research is supported by the Croatian Science Foundation under the project UIP-2014-09-5605 (Q-MANIC).

II. METHODOLOGY

The research will be conducted in several phases (Fig. 3). In the first phase, a detailed analysis of digital game characteristics will be conducted to identify game aspects which can be used to identify the differences between video streams of different games in cloud gaming. The results of an empirical study performed in the scope of this dissertation [4] indicate that different video adaptation policies should likely be applied for different types of games when aiming to maximize QoE, and that objective video metrics may be used to classify games for the purpose of choosing an appropriate and QoE-driven video codec configuration strategy. The second phase will include user studies to gather empirical data to develop QoE models for digital game categories derived from the proposed game categorization for cloud gaming. The main goal of the user studies is to investigate how and to what extent video encoding parameters affect perceived QoE for each of the game categories under variable system and network conditions. The next phase of the research consists of proposing video encoding adaptation strategies with respect to system and network resource availability and digital game category. The final phase will include validation of the proposed video encoding adaptation strategies. A case study will be designed to demonstrate utilization of the proposed video encoding adaptation strategies to optimize QoE under various service and network resource availability constraints.

REFERENCES

[1] W. Cai et al., A Survey on Cloud Gaming: Future of Computer Games, in IEEE Access , vol.PP, no.99, pp.1-1, 2016.

[2] H. Hong et al., Enabling adaptive cloud gaming in an open-source cloud gaming platform. *IEEE Transactions on Circuits and Systems for Video Technology*, PP(99):1–14, 2015.

[3] I. Slivar et al. The impact of video encoding parameters and game type on QoE for cloud gaming: A case study using the Steam platform. In 7th Intl. Workshop on QoMEX, pages 1–6, May 2015.

[4] I. Slivar et al. "Cloud gaming QoE models for deriving video encoding adaptation strategies", in Proc. of the 7th MMSys, May 2016.

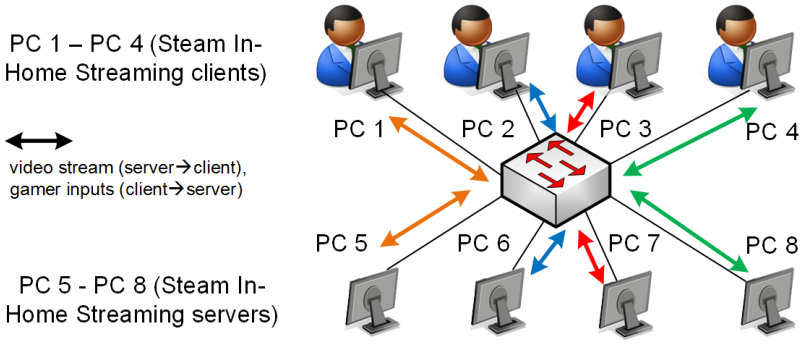

Figure 1 Cloud gaming testbed: multiple simultaneous users using the cloud gaming service

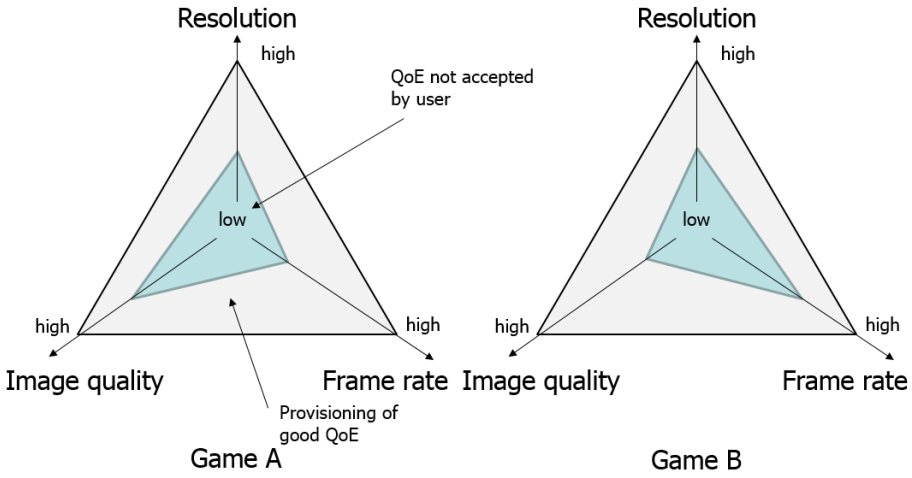

Figure 2 Video encoding adaptation strategies: by manipulating video encoding parameters, we can achieve different QoE levels for different types of games

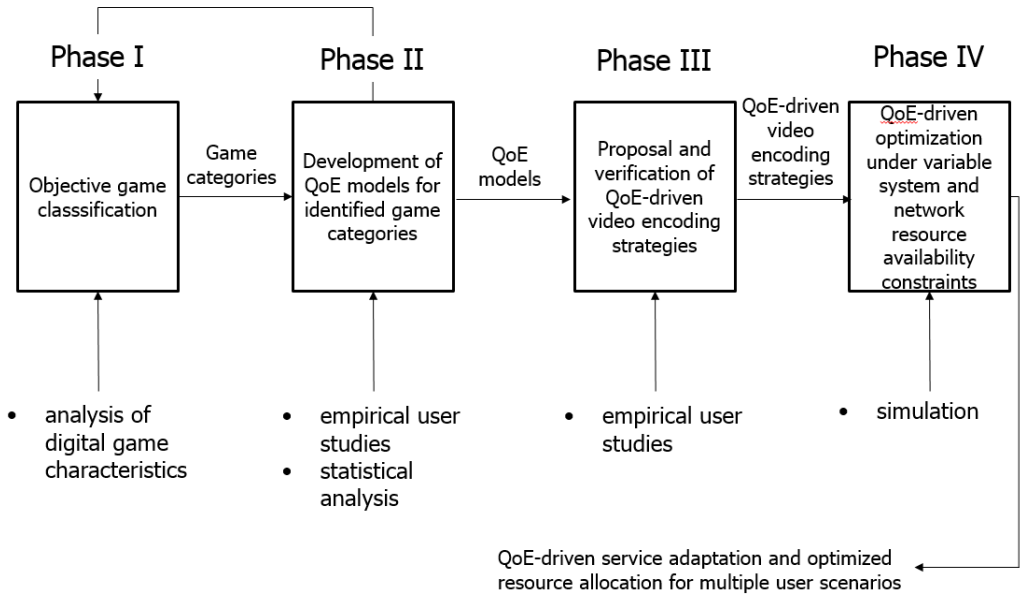

Figure 3 Methodology and plan of research

Cross-Layer Multi-Channel Algorithm for QoS enhancement in Wireless Sensor and Actor Networks

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***Abstract*—Wireless Sensor and Actuator Networks (WSANs) are networks which include both sensing and actuating components. As these networks relay on reliable and timely data delivery the QoS aspect is becoming a very significant factor. This paper presents a hybrid coordination model in WSAN. QoS analysis is performed through experimental validation of a WSAN deployed within the proposed testbed. Also, new algorithm (CLMCA) for improving QoS in the proposed hybrid coordination model is proposed.**

I. Research topic presentation

Wireless Sensor and Actuator Network (WSANs) are wireless networks composed of a large number of sensor and actuator node that are affected by limited processing capabilities and limited communication range [1]. In WSANs besides sensing tasks, acting tasks are present, resulting in the capability of performing actions in real world, rather than just observing [2]. New classes of WSAN applications include industrial process control and monitoring [3] and related applications that demand real-time requirements like bounded end-to-end delay and reliability, which represent a concept of Quality of Service support [4]. Although modern computer networks support QoS differentiation by default, the same cannot be stated for WSANs. Consequently, due to the difference between WSANs and wireless networks such as WSNs, MANETs, VANETs etc. existing standards cannot be easily adopted and implemented to suit the emerging WSAN requirements. This raises the need to propose new communication protocols and standards for WSANs.

In this scope a new WSAN coordination model is proposed for industrial applications: hybrid coordination model. As our previous work in [5] has shown that existing protocols do not exemplify good QoS using the proposed hybrid coordination model, new protocols must be proposed. This paper proposes a new Cross-Layer Multi-Channel Algorithm (CLMCA) that exploits multi-sink topology and multi-channel architecture to improve QoS in the WSAN.

II. Hybrid coordination model in WSAN

The difference between WSANs and WSNs is the fact that WSANs introduce two entirely different coordination; sensor-actor and actor-actor coordination. In certain network architectures coordination can be centralized, while in other architectures it is distributed. Methods of coordination in the WSANs can be divided into sensor-actor coordination and actor-actor coordination.

On the other hand, for new classes of WSAN and industrial application classical coordination models are not suitable. In these application WSAN actors can use query driven model [6], where each actor transmits a query that needs to be processed and a response to the query returned to the actor. The query is sent through the WSAN and is processed at the outskirts of a WSAN, within another network (hybrid network composed of WSAN and classical wired network e.g. LAN). The response is sent back to the actor over WSAN. An important aspect in the proposed configuration as a contributing metrics in the system design are:round-trip-time,*RTT*, and probability of a successful query, *p*, as QoS metrics.

III. CLMCA algorithm

Basic principle of the proposed Cross-Layer Multi-Channel Algorithm is based on three main layers: MAC and Physical layer-represents the lower layers, where the proposed approach continuously monitors the connection with the intermediate node of the network using CSMA-CA method for accessing the medium. It implies checking the MAC layer for ACK packets, for each transmitted packet (CSMA-CA). If an ACK is not received, a cross-layered algorithm runs a dynamic search of neighboring networks (other frequency channels) until it finds a node in range that has submitted a confirmation. Routing layer-refers to a higher layer (a network layer) where the end-to-end confirmation is requested, originating at the network layer of the final destination node (network coordinator). If a network confirmation is not received within a given timeout, the CLMCA will start the channel change procedure. The top layer of the algorithm is planned for future work, that takes into account the QoS metrics on the application layer, and conducts the multi-channel switching operation accordingly. Layered model of the algorithm functionality is shown in Fig. 1.

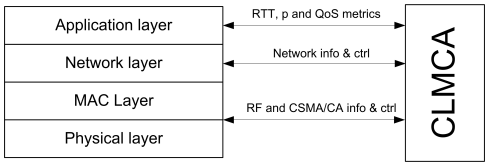

Fig. 1. Graphical representation of the proposed CLMCA algorithm

In our approach, the CLMCA is used for load distribution between the network sinks, in the proposed multi-sink and multi-channel network configuration.

IV. Measurement results

In these measurement two QoS metrics were analysed: **Round Trip Time (*RTT*)** - the time required to receive a response to a sent query, **Query probability (*p*)** - the probability of a successful query-response. Input parameters of the experiment were number of nodes N and maximum time T between consecutive queries (Uniform distribution U(0,T)). The combination of the aforementioned parameters resulted in Cumulative Queries Per Second: $CQPS = \frac{2 \cdot N}{T}$, reflecting on the total number of queries sent within a entire network per second.

Measurements were conducted in a laboratory using previously designed WSAN nodes (see [5]). Maximum number of nodes in the tesbed was 20 and two network sinks are used in multi-sink topology. Nodes were sending queries towards the coordinator in a single-hop manner. The results of the initial protocol LWMesh compared with the proposed CLMCA algorithm are shown in Fig. 2.

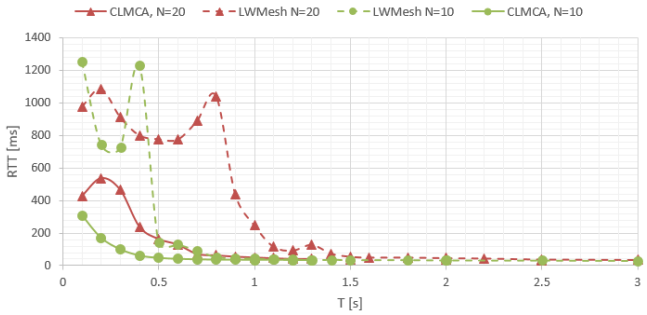

Fig. 2. Probability of a successful query for LWMesh protocol and CLMCA.

As seen in Fig. 2 the proposed CLMCA achieves higher p values for both network configurations (10 and 20 nodes) for various maximum time between consecutive queries (parameter T).

Furthermore, the comparison of the proposed algorithm is performed comparing the Round Trip Time (RTT) parameter. The results are shown in Fig. 3.

It can be concluded that the proposed CLMCA achieves lower values of RTT, reducing query-response time.

The aforementioned improvement can be seen if a diagram of p and *RTT* is plotted against CQPR, representing the WSAN throughput. The results are shown in Fig. 4.

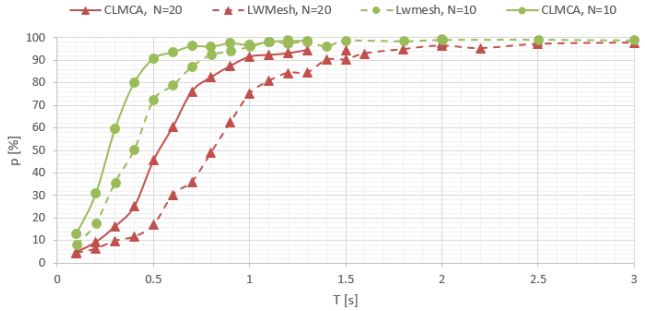

Fig. 3. Round Trip Time of a query for LWMesh protocol and CLMCA.

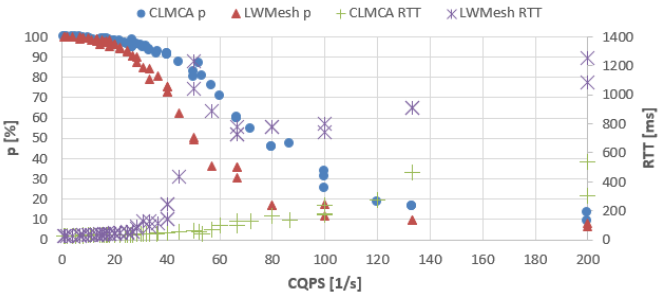

Fig. 4. Probability of a successful query and RTT for LWMesh protocol and CLMCA against CQPS.

It is evident that the CLMCA achieves maximum reduction in *RTT* of 87% and improvement of p for 40pp, for CQPS=57 1/s, resulting in QoS improvement. Future work includes proposing multi-hop communication protocol that takes into account QoS metrics, achieving additional QoS improvement.

References

[1] H. Salarian, K.-W. Chin, and F. Naghdy, "Coordination in wireless sensor actuator networks: A survey," *Journal of Parallel and Distributed Computing*, vol. 72, no. 7, pp. 856 – 867, 2012.

[2] I. F. Akyildiz and I. H. Kasimoglu, "Wireless sensor and actor networks: research challenges," *Ad Hoc Networks*, vol. 2, no. 4, pp. 351 – 367, 2004.

[3] Q. Wang, M. Hempstead, and W. Yang, "A realistic power consumption model for wireless sensor network devices," in *Sensor and Ad Hoc Communications and Networks, 2006. SECON '06. 2006 3rd Annual IEEE Communications Society on*, vol. 1, Sept 2006, pp. 286–295.

[4] J. Chen, M. Daz, L. Llopis, B. Rubio, and J. M. Troya, "A survey on quality of service support in wireless sensor and actor networks: Requirements and challenges in the context of critical infrastructure protection," *Journal of Network and Computer Applications*, vol. 34, no. 4, pp. 1225 – 1239, 2011, advanced Topics in Cloud Computing.

[5] G. Horvat, D. Zagar, and J. Vlaovic, "On the topic of RTT and delivery ratio in query driven wireless sensor networks," in *2015 IEEE Sensors Applications Symposium Proceedings*, April 2015, pp. 293–299.

[6] M. A. Yigitel, O. D. Incel, and C. Ersoy, "Design and implementation of a QoS-aware MAC protocol for wireless multimedia sensor networks," *Computer Communications*, vol. 34, no. 16, pp. 1991 – 2001, 2011. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0140366411001927

Staircase Detection in Camera-Based Assistance Systems for the Blind

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***Abstract* — Assistance systems for the blind and visually impaired based on real-time video processing are still in a preliminary stage. However, increasing computing power of small portable devices opens up a space for research and development of camera-based assistance systems. In this overview, accent is on the problem of staircase detection in such systems. Image and video processing techniques used for automatic staircase detection are presented along with preliminary experimental results.**

Keywords — assistance systems; the blind and visually impaired; video processing; staircase detection

I. Introduction

According to the World Health Organization, there are 285 million people worldwide with some kind of visual impairment while 39 million of them are completely blind [1]. Most of them still use only white cane as an assistive tool for movement and navigation. There are many problems and obstacles that the blind and visually impaired people meet in their movement. By the survey [2], staircase detection belongs to the group of intermediate distance tasks where specific object or obstacle should be detected on distance of few meters from person. This research has aim to develop a video processing method for automatic staircase detection and localization which potentially can be used in assistance system for the blind.

II. Description of the Problem

Camera-based assistance systems for the blind are usually conceived in such a way that the camera is installed on person (head or chest) and connected to a portable device (laptop, mini-PC or smartphone) which is dedicated for video processing (Fig. 1.). The way of informing the blind person about the detected obstacle is out of this research focus but usually is done by using headphones and audible signals.

In order to achieve useful information about detected staircase on time it is necessary to constantly process frames from video captured by camera. Algorithm for staircase detection from those input video frames is the main part of the system and this research topic. It is also important to neutralize negative circumstances like unfocused and blurred input frames caused by capturing in motion and in different lighting conditions.

III. Methodology

For the purpose of staircase detection, some authors use stereo cameras to gain benefits from depth information [3]. Except those benefits, stereo cameras are impractical to use because they need to be mounted on person in motion and are more expensive. As opposed to that, classic monocular cameras used in our research, are cheap and widely available, but require different video processing algorithms.

In research where monocular cameras are used authors usually base their method on finding parallel horizontal lines characteristic for staircase region using Hough transformation [4]. Also, those often include principles of finding the vanishing point [5]. In our research we propose different approach which uses morphological preprocessing (Fig. 2.) and structural analysis of pixel columns at first place (Fig. 3.) [6]. After column analysis, horizontal row analysis is just additional check (Fig. 4.). This research relies fully on the usage of the camera, unlike some others where auxiliary systems are used.

IV. Results

Preliminary results are achieved by testing the algorithm on dataset of video frames in resolution 640×360. Dataset contains frames with staircases in characteristic position in front of the camera, but also the frames without staircases to obtain false positives rate. There were 194 accurate detections in the dataset of 200 frames at average processing speed of 6 fps (Tab. 1.).

V. Conclusion

Except raising the awareness about problems of the blind and visually impaired, this research yields positive results in automatic staircase detection from video sequences. Developed algorithms have potential to be implemented in assistance systems for the blind and even upgraded with other functionalities.

References

[1] World Health Organization, "Visual impairment and blindness." [Online]. http://www.who.int/mediacentre/factsheets/fs282/en/

[2] L. Hakobyan, J. Lumsden, D. O'Sullivan, and H. Bartlett, "Mobile assistive technologies for the visually impaired," *Surv. Ophthalmol.*, vol. 58, no. 6, pp. 513–528, Nov. 2013.

[3] S. Wang, H. Pan, C. Zhang, and Y. Tian, "RGB-D image-based detection of stairs, pedestrian crosswalks and traffic signs," *J. Vis. Commun. Image Represent.*, vol. 25, no. 2, pp. 263–272, Feb. 2014.

[4] S. Shahrabadi, J. M. Rodrigues, and J. H. Du Buf, "Detection of indoor and outdoor stairs," in *Pattern Recognition and Image Analysis*, Springer, 2013, pp. 847–854.

[5] D. C. Hernández and K.-H. Jo, "Stairway segmentation using Gabor Filter and vanishing point," in *2011 International Conference on Mechatronics and Automation (ICMA)*, 2011, pp. 1027–1032.

[6] K. Romic, I. Galic, and T. Galba, "Technology assisting the blind - Video processing based staircase detection," in *ELMAR 2015 57th International Symposium*, Zadar, 2015, pp. 221–224.

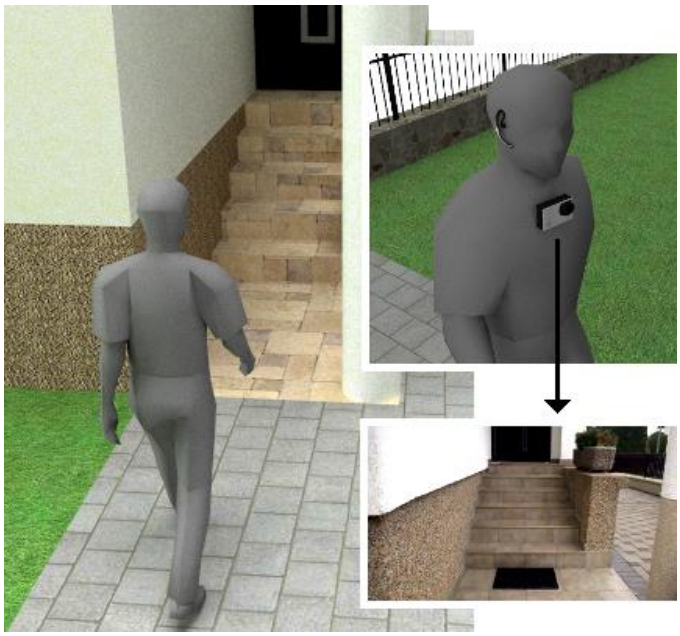

Fig. 1. Person approaching the staircase and input image from camera

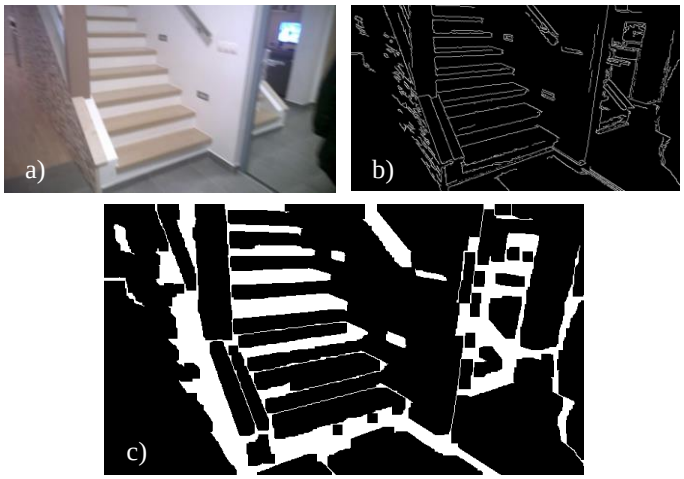

Fig. 2. Preprocessing: a) Input image, b) Canny edge detection, c) Closing operation

Fig. 4. Generated images for row analysis of potential staircase region: a) With staircase, b) Without staircase

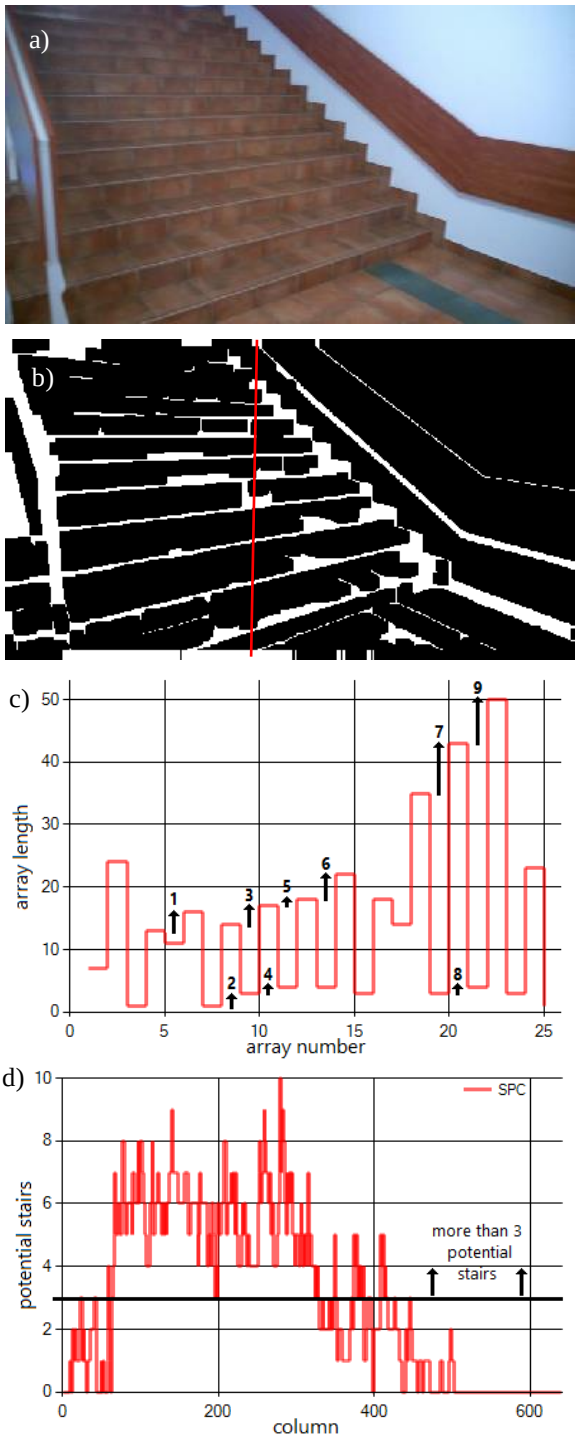

Fig. 3. Column analysis: a) Input image, b) Preprocessed image, c) Black and white pixel array lengths in column, d) Potential stairs per column

Tab. 1. Accuracy results and comparison with similar methods

	Proposed method		Shahrabadi et al. (2D camera)		Wang et al. (3D camera)	
Staircase	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Dataset size	100	100	92	135	106	70
Detected	96	2	76	25	103	0
Accuracy	96%	98%	83%	82%	97%	100%

Towards Cooperative QoE Management Schemes for Multimedia Applications

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***Abstract*— The end-to-end Internet service delivery chain includes many different actors trying to provide the optimal Quality of Experience (QoE) to their users. However, lack of cooperation between multiple actors makes identifying the root cause of QoE impairments, and thus finding a solution, a challenging task. A key goal in the scope of this research is to specify cooperative QoE management schemes between service/cloud and network providers, while taking into account incentives, business models, and potential regulatory issues.**

Keywords—cooperative QoE management; cross-layer; multimedia

I. Motivation and Current Results

In today's Internet, many players are involved in end-to-end service delivery: content providers, cloud providers, network operators, etc. All of them aim to meet users' needs and expectations in terms of both Quality of Service (QoS) and Quality of Experience (QoE) [1]. To achieve that goal, they employ various QoE management strategies. Today, most solutions focus on either application management or network management [2]. Application management solutions implement strategies on the server and client terminal, at an application level, making it possible to adapt the application to network conditions measured by client devices. QoE-driven network management solutions mostly focus on resource allocation decisions that maximize user-perceived quality [3][4]. All of these solutions rely on underlying specific QoE models to calculate QoE based on QoE-relevant factors measured in the network or on client devices.

Due to the widespread encryption of OTT traffic (e.g., YouTube, Netflix, Skype, etc.), it is challenging for network providers to obtain insight into application performance as perceived by end users. Network operators are thus aiming for application-layer monitoring solutions that will enable QoE-driven network management schemes. In our previous studies, we have proposed a solution for YouTube QoE estimation based on the analysis of encrypted network traffic [5]. We have developed a system called YouQ which includes tools for monitoring and analysis of application-layer KPIs and corresponding traffic traces, and the subsequent use of this data for the development of machine learning models for QoE estimation based on traffic features. The system was tested in a laboratory environment (Fig. 1) and the results show that up to 84% QoE classification accuracy could be achieved using only features extracted from encrypted traffic. While these are promising results, the question still remains what potential gains may be achieved if cooperative efforts are established between OTT providers and network operators.

This research is supported by the Croatian Science Foundation under the project UIP-2014-09-5605 (Q-MANIC).

II. Research Challenges and Methodology

Due to a lack of cooperation and information exchange between actors involved in service delivery, it is still challenging to achieve cross-layer QoE management solutions. Future research will focus on resource allocation and service adaptation algorithms targeting different optimization strategies and taking into account multiple stakeholder perspectives. The following challenges will be addressed (Fig. 2):

Incentives for cooperation. QoE-relevant information can be collected all along the service delivery path (Fig. 3). Combining this information has the potential of enhancing and optimizing the service delivery and resource utilization efficiency. From a business oriented point of view, there is a need for business models to define relationships between actors in the service-delivery chain.

Technical solutions. Studies are needed to define functions, information exchange interfaces, and protocols for cooperative QoE management. The Software Defined Networking (SDN) paradigm is a promising solution in this direction.

Regulatory issues. The implications of network neutrality regulation on potential QoE management and control solutions need to be considered.

References

[1] R. Schatz, M. Fiedler and L. Skorin-Kapov. "QoE-based Network and Application Management", in Quality of Experience: Advanced Concepts, Applications and Methods, T-Labs Series in Telecommunication Services, S.Möller and A. Raake (eds.), Springer, March 2014, pp. 411-426.

[2] L. Skorin-Kapov, "Tracking and Managing QoE in the Internet: Towards Cooperative QoE Management Schemes," in NSF/FCC Workshop on Tracking Quality of Experience in the Internet, 2015.

[3] S. Barakovic, L. Skorin-Kapov, "Survey and Challenges of QoE Management Issues in Wireless Networks", Journal of Computer Networks and Communications, Vol. 2013, Article ID 165146, 28 pages

[4] K. Ivesic, L. Skorin-Kapov, M. Matijasevic. "Cross-layer QoE-driven Admission Control and Resource Allocation for Adaptive Multimedia Services in LTE", Journal of Network and Computer Applications, Sept. 2014, vol 46, pp. 336-351.

[5] I. Orsolic, D. Pevec, M. Suznjevic and L. Skorin-Kapov, "YouTube QoE Estimation Based on the Analysis of Encrypted Network Traffic Using Machine Learning", to appear in IEEE GLOBECOM Workshop on QOEMC, 2016, Washington, DC USA, December 2016.

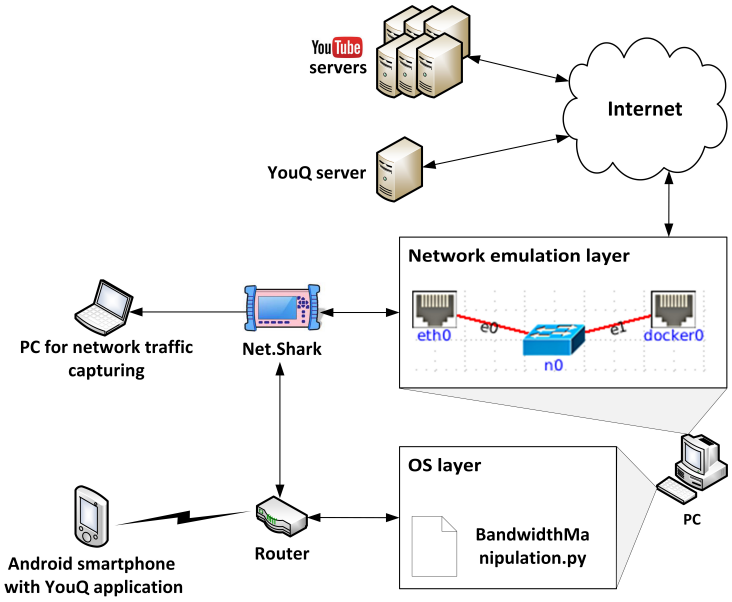

Fig. 1. Testbed for measuring and evaluating YouTube application-layer KPIs

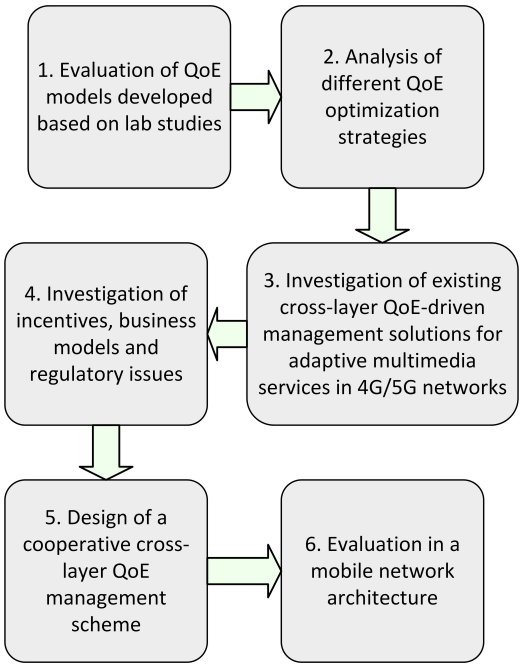

Fig. 2. Research methodology

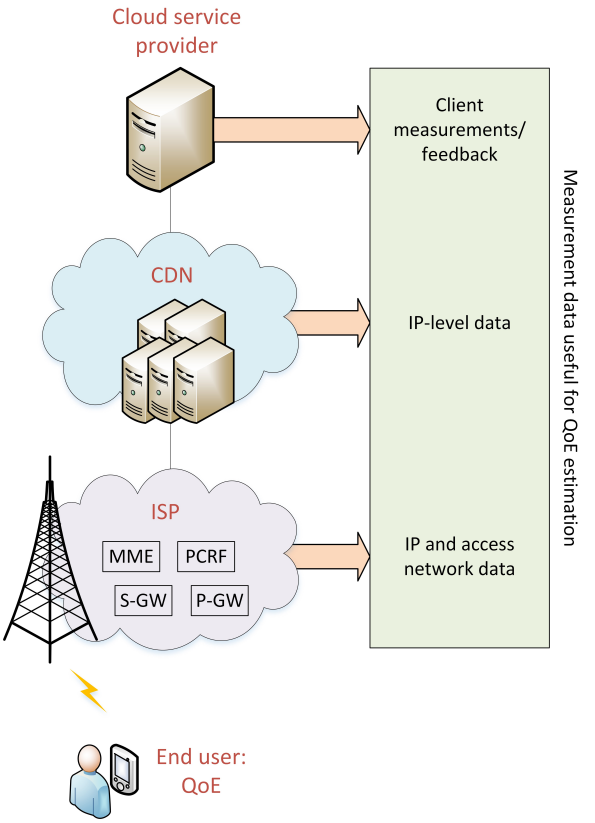

Fig. 3. QoE-relevant information available along the end-to-end service delivery path (adapted from [1])

Generation and Reconstruction of Trigger Signals from High Granularity Calorimeter

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Best Presentation Award

***Abstract*—This research is done in collaboration with CMS group at Ecole Polytechnique, Paris Saclay University. Basic motivation is improvement of CMS detector part which is being replaced with a newly designed one by using a very advanced technology. Doctoral candidate's research work is done inside research group at Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB, Split) and it is involved in the trigger aspect of the project, with the goal to define and implement algorithms for generation of basic objects, so called Trigger Primitive Generation.**

I. Introduction

The Compact Muon Solenoid (CMS) detector (Fig.1) is a general purpose instrument for studying proton to proton collisions at the Large Hadron Collider at CERN (European laboratory for particle physics). It is continuously being improved, from two main reasons: development of new detection technologies and replacing parts of the detector which cannot resist very high levels of radiation [1]. In that context CMS collaboration has decided to replace some parts of the calorimeter and has chosen a very advanced technology, so called "High Granularity Calorimeter" (HGCAL). The CMS detector is a very complex instrument, combining many different technologies and dealing with a huge amount of data [2].

II. Research Topic Presentation

Project is consisting of many different aspects including digital electronics, mechanics and computing problems, some of them with unprecedented complexity, asking for new approaches and ideas. Doctoral candidate's research is done inside research project, specifically as being member of a research group at Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB, Split). This research group is involved in the trigger aspect of the project, with the goal to define and implement algorithms for generation of basic objects, so called Trigger Primitive Generation. The scope of doctoral candidate's PhD work includes analysis of the possible new detector design by modeling the sensors in the tiling plane (Fig.2), implementation of very front end electronics for signal extraction and digitalization, trigger cell selection and mapping algorithms (Fig.3 and Fig.4), summing basic sensor signals to form trigger cells (Fig.5) and reducing the amount of data by making decision of which trigger cells to transmit due to the communication limits (Fig.6). This is the doctoral candidate's research which has been actually done now, with promising preliminary research results. Basic research method used is simulation using Xilinx ISE environment and Verilog HDL. In terms of modeling and visualization of the possible new detector design, doctoral candidate's research included generation of basic sensor cell primitives, their tiling in hexagonal plane [3] as well as development and classification of general architectures for sensor and trigger cells hexagonal geometry. Experimental method has resulted with design of computer program for visualization, which is being used for generation of numerical input data in design groups such as simulation and sensor module development (Fig.7).

Doctoral candidate's further research is design and implementation of very complex algorithms for trigger object reconstruction, at both software and hardware level. The research topics covered in PhD scope are:

- Modeling of geometrical architecture of hexagonal sensor cells modules, with goal to optimize trigger cells mapping and their tiling in plane and 3D structures, in order to deliver trigger primitives.
- Performance analysis of shower distribution on various cell types.
- Analysis and definition of new basic algorithms properties with respect to algorithms used in current detector design. The taxonomy of currently used algorithms.
- Implementation and verification of designed algorithms in the simulation and hardware test beds. Analysis of measurement results.

III. References

[1] CMS Collaboration, "CMS Technical Design Report for the Muon Endcap GEM Upgrade", CERN-LHCC-2015-012 CMS-TDR-013 30 September 2015. Retieved on 10.09.2016. from: https://cds.cern.ch/record/2021453/files/CMS-TDR-013.pdf

[2] [In Croatian] Puljak I. "Fizika elementarnih čestica i astročestična fizika". Dan e-infrastrukture SRCE, 28. studenog 2012. Retrieved on 10.09.2016. from: http://www.srce.unizg.hr/files/srce/docs/isabella/cro-ngi/Dan_E_INFRA/dan-e-infrastrukture-2012-11-28-6-puljak.pdf

[3] Carr D.B., Olsen A.R., & White D. (1992.) „Hexagon Mosaic Maps for Display of Univariate and Bivariate Geographical Data". Cartography

and Geographic Information Systems, 19:4, pp. 228-236. DOI: http://dx.doi.org/10.1559/152304092783721231

IV. Graphical Appendix

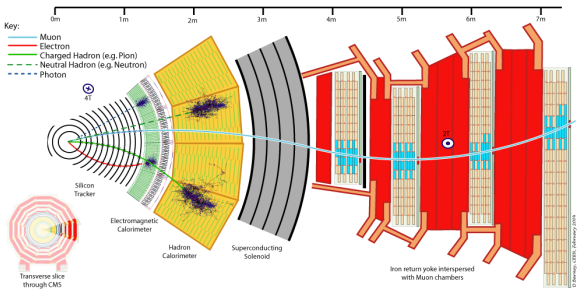

Fig. 1. Cross section view of Compact Muon Solenoid

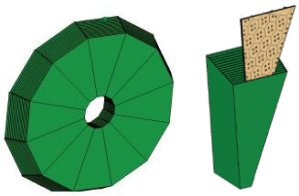

Fig. 2. Detector part to be replaced

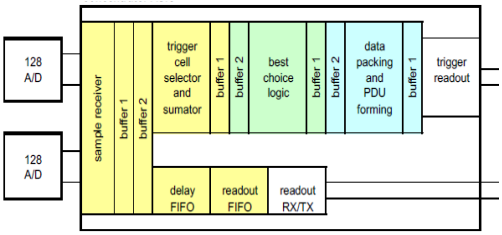

Fig. 3. System structure

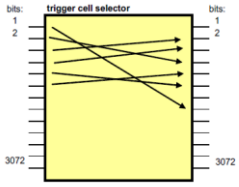

Fig. 4. Sensor cells mapping architecture

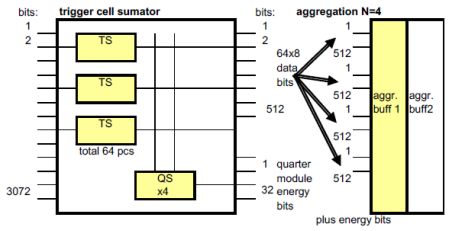

Fig. 5. Sensor cells sumator and aggregation architecture

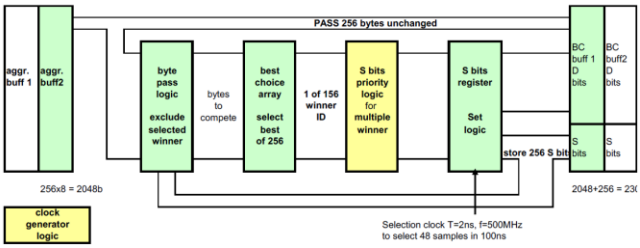

Fig. 6. Architecture for Best Choice selection

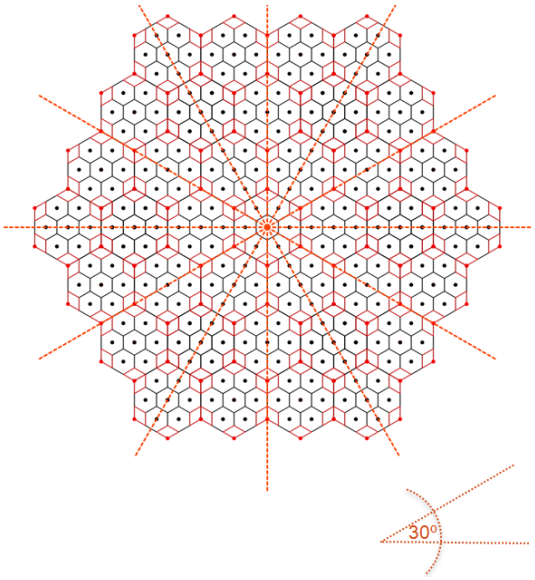

Fig. 7. Output of a program for hexagonal geometry visualization

3D Model Reconstruction Using Multiple Images

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***Abstract* — In computer vision, 3D model of an object can be defined as "digital copy" of a real object. It has many applications in movie industry, game development, virtual reality, medicine and many others. Although, there are many existing solutions for generating geometric 3D model, most of them have flaws and are not fully satisfying. In our research, we are trying to improve existing method for generating accurate 3D model of an object, based on Multi-View Stereo algorithm.**

Keywords — 3D model; reconstruction; Multi-View Stereo;

I. INTRODUCTION

The constant development of technology has led to increasing need for geometric 3D models of an object in all sorts of areas (Fig. 1. and Fig. 2.) such as movie industry, game development industry, virtual environments, medicine and even cultural heritage preservation. Accurate 3D model allows us to inspect details of an object without dealing with an actual object. It also allows us to measure its properties or even reproduce it in different materials.

There are many existing solutions to this problem. However, many of them are often inadequate for a particular problem, can be very time consuming and error-prone. There is a possible solution by using 3D scanners that have excellent accuracy but are very expensive and not convenient for common use because of their large dimensions.

Much cheaper and often, more convenient solution than 3D scanners, is computer software capable of analyzing image sequences as an input and producing accurate 3D model as an output. Cameras are nowadays fairly cheap and reasonably lightweight and in the same time provide great precision. That makes them far better choice for finding solution to our problem.

II. DESCRITPION OF THE PROBLEM

Our goal is to recover the shape and appearance of an object from acquired set of images. To achieve our goal, we only use a set of images of an actual object. As an image is a projection from a 3D scene onto a 2D plane [1], during that process the depth is lost. Therefore, our main goal is to obtain depth accurately from these images. In this process, we are using minimally two images. In order to reconstruct entire object and for acquiring higher accuracy we need a lot more images with high overlap between them. Usually, it is required from twenty to several hundred images.

III. METHODOLOGY

In our research, we are using Multi-View Stereo approach, which consists of following steps [2]: (Fig. 3.)

- Image acquisition (studio conditions, uncontrolled environment, Internet)
- Features detection and matching (SURF, RANSAC) [3], [4]
- Structure and camera trajectory reconstruction [5]
- Dense cloud creation [6]
- Filtration and reconstruction

IV. RESULTS

This is preview of our research, which is still in the beginning and not all steps of constructing 3D model are implemented. So far, we are implementing feature detection and matching as well as camera trajectory reconstruction. Next step is to recover depth and create dense cloud.

Expected results are given in Figure 4 and represent all necessary steps in reconstruction of an accurate 3D model.

V. CONCLUSION

As we mentioned before, generating 3D model from image sequences has its flaws but the best algorithms are capable of competing with 3D scanning technology with their speed and accuracy at much lower cost. Although there are many available algorithms, there is no state-of-the-art algorithm for all applications. Selection of best approach depends on the material properties and lighting of given object.

REFERENCES

[1] J. Xiao, 3D reconstruction is not just a low-level task: retrospect and survey. Citeseer, 2012.
[2] M. Luckner and K. Rzążewska, "3D model reconstruction and evaluation using a collection of points extracted from the series of photographs," 2014, pp. 669–677.
[3] H. Bay, T. Tuytelaars, and L. Van Gool, "Surf: Speeded up robust features," in European conference on computer vision, 2006, pp. 404–417.
[4] M. A. Fischler and R. C. Bolles, "Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography," Commun. ACM, vol. 24, no. 6, pp. 381–395, 1981.
[5] M. Pollefeys, "Visual 3d modeling from images," course/Turorial notes, presented at Siggraph 2002/2001/2000, 2000.
[6] S. M. Seitz, B. Curless, J. Diebel, D. Scharstein, and R. Szeliski, "A comparison and evaluation of multi-view stereo reconstruction algorithms," in 2006 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'06), 2006, vol. 1, pp. 519–528.

Fig. 1. Application of 3D reconstruction in computer games (S. Ilic, Multi-View 3D-Reconstruction)

Fig. 2. Application of 3D reconstruction in cultural heritage (S. Ilic, Multi-View 3D-Reconstruction)

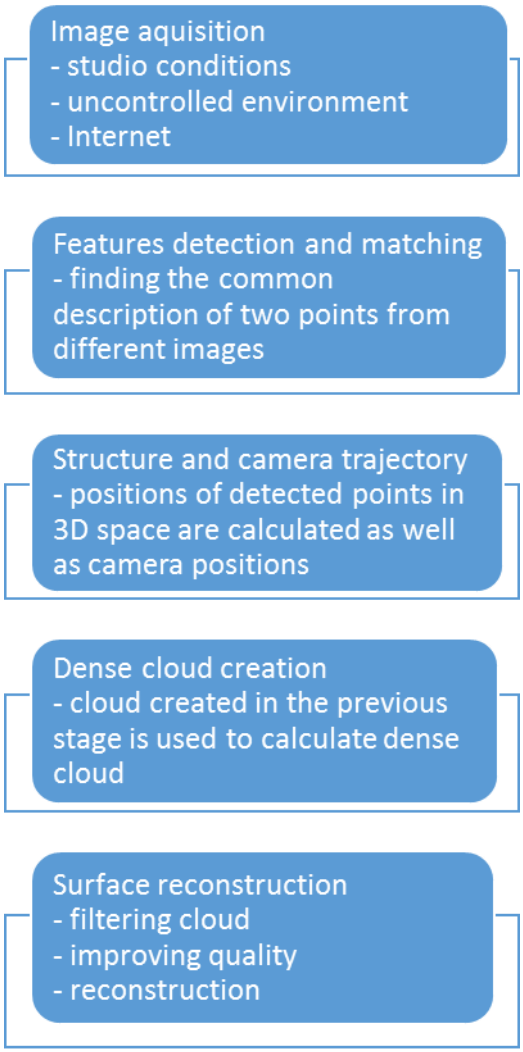

Fig. 3. Multi-View Stereo Reconstruction workflow

a) input images

b) matching points c) camera positions

d) dense cloud e) 3D model

f) Adding texture and color

Fig. 4. Expected results (Model generated using Agisoft PhotoScan)

Extended Abstract: Energy-efficient Mobile Crowd Sensing for the Internet of Things

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Best Presentation Award

***Abstract*—In this paper we address energy-efficient Mobile Crowd Sensing (MCS) in the Internet of Things (IoT) domain where mobile devices continuously collect and share large amounts of sensor data which has to be processed quickly and efficiently.**

The research topic presentation

The IoT is a concept that connects devices and physical objects from the environment in a global network based on the IP protocol, while creating the basis for the development of advanced and self-configuring services which can adapt to user requirements and context. MCS is a novel paradigm which utilizes IoT to observe and measure phenomena over a large geographic area by means of wearable sensors and mobile devices (Fig. 1). The goal is to reduce the amount of collected redundant data in order to optimize the MCS process as well as to control the data transmission process from sensor nodes to a cloud server by means of algorithms for either centralized or decentralized and autonomous decision-making of a mobile device regarding its participation in the sensor data acquisition process and data transmission.

Hitherto, an opportunistic MCS application for air quality monitoring [1] has been implemented based on the publish/subscribe messaging paradigm which proved to be suitable for the development of IoT services [2]. The CloUd-based PUblish/Subscribe middleware (CUPUS) was used in the air quality campaign Sense ZG Air (Fig. 2) where volunteers carrying smartphones and mobile sensors (Fig. 3) were contributing sensed data to the application server [3]. In order to reduce the energy consumption on mobile sensors and devices, as well as to optimize the amount of data transmitted over the network to the cloud, we have implemented the Quality of Service Manager (QoS Manager) component (Fig. 4) responsible for context-aware and energy-efficient sensor data acquisition [4]. QoS Manager obviates redundant sensor activity while satisfying sensing coverage requirements and sensing quality, and consequently reduces the overall energy consumption of an MCS application. Furthermore, we have analytically modelled the total energy savings for different application requirements and geographical sensor distribution scenarios when using the QoS Manager under the assumption that users are unevenly distributed in observed areas according to a power law distribution (i.e. Zipf distribution) [5] (Fig. 5). The model was evaluated using a real data set. The results show that in certain cases it is possible to reduce the overall energy consumption between 50% and 90% when using the proposed data collection method while retaining the sensing quality and satisfying sensing coverage requirements in the observed area (Fig. 6). The energy savings model is further generalized in [6] by including variable data requirements within cells of interest and the proposed solution for data acquisition is compared to existing protocols from the scientific literature. As future work during the doctoral research we plan to model mobile crowd sensing paradigm and environment with respect to the characteristics of data source in a geographic area, the properties of the observed phenomena and requirements for the sensing data in the observed area, as well as, to develop algorithms for decentralized and autonomous decision of moving objects on the collection of sensor data that would allow further savings in terms of energy consumption.

Acknowledgment

This work has been supported in part by the Croatian Science Foundation under the project number 8065 (Human-centric Communications in Smart Networks).

References

[1] A. Antonić, K. Rožanković, M. Marjanović, K. Pripužić, and I. Podnar Žarko, "A mobile crowdsensing ecosystem enabled by a cloud-based publish/subscribe middleware," in *Proc. of FiCloud-2014*, Aug. 2014.

[2] A. Antonić, M. Marjanović, K. Pripužić, and I. P. Žarko, "A mobile crowd sensing ecosystem enabled by cupus: Cloud-based publish/subscribe middleware for the internet of things," *Future Generation Computer Systems*, vol. 56, pp. 607 – 622, 2016.

[3] A. Antonić, V. Bilas, M. Marjanović, M. Matijašević, D. Oletić, M. Pavelić, I. Podnar Žarko, K. Pripužic, and L. Skorin-Kapov, "Urban crowd sensing demonstrator: Sense the zagreb air," in *Proceedings of the 22th International Conference on Software, Telecommunications and Computer Networks (SoftCOM 2014)*, 2014.

[4] I. Podnar Žarko, A. Antonić, M. Marjanović, K. Pripužic, and L. Skorin-Kapov, "The openiot approach to sensor mobility with quality-driven data acquisition," *Workshop on Interoperability and Open-Source Solutions for the Internet of Things, LNCS vol. 9001*, 2015.

[5] L. Skorin-Kapov, K. Pripužić, M. Marjanović, A. Antonić, and I. Podnar Žarko, "Energy efficient and quality-driven continuous sensor management for mobile IoT applications," in *Proc. of IEEE CollaborateCom 2014*. IEEE, Oct 2014.

[6] M. Marjanović, L. Skorin-Kapov, K. Pripužić, A. Antonić, and I. Podnar Žarko, "Energy-aware and quality-driven sensor management for green mobile crowd sensing," *Journal of Network and Computer Applications*, vol. 59, pp. 95 – 108, 2016.

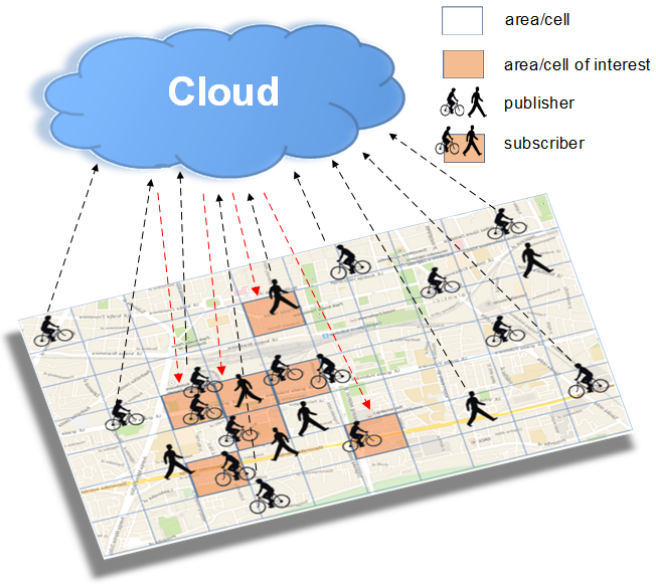

Fig. 1. An environment for MCS

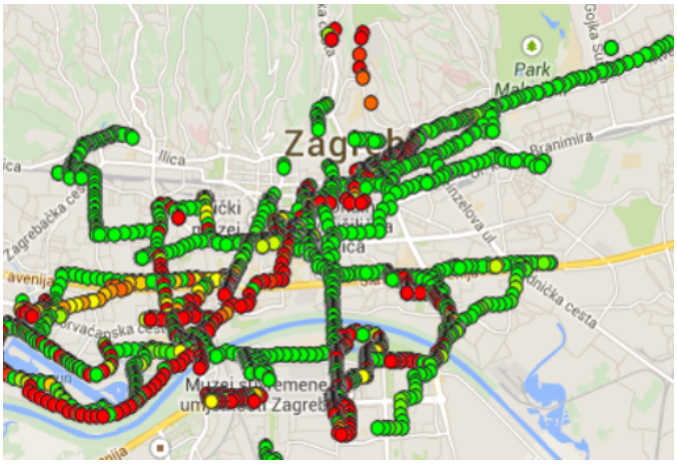

Fig. 2. Data collected during the ”Sense ZG Air” campaign

Fig. 3. Sensor and mobile application for air quality monitoring

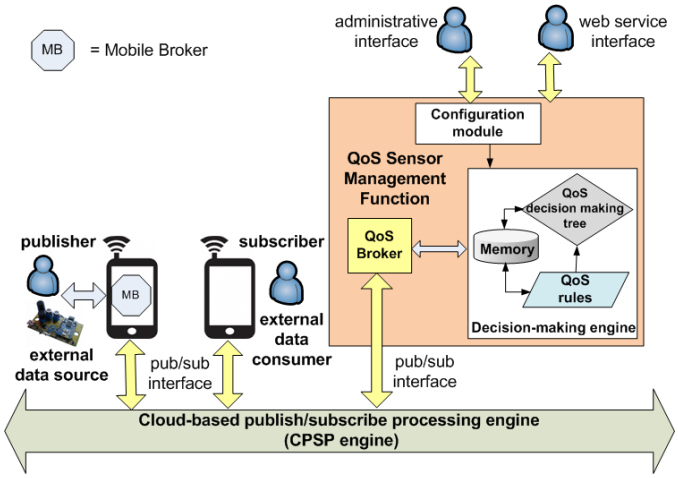

Fig. 4. The CUPUS architecture enhanced with a QoS sensor management function

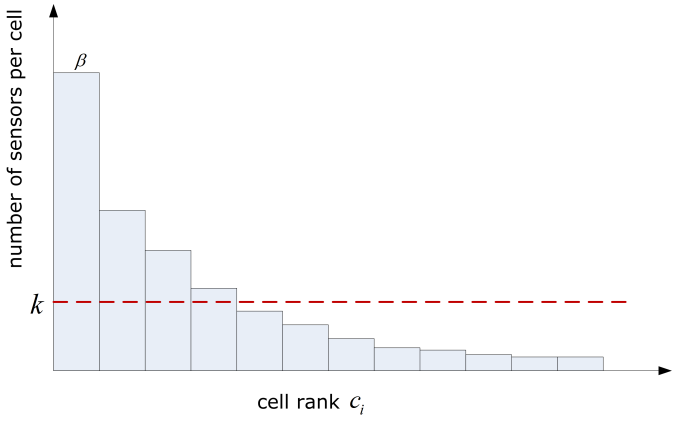

Fig. 5. Example mobile sensor distribution across different cells. Value k refers to the number of required unique sensors publishing data needed to meet the sensing coverage requirements of a given application.

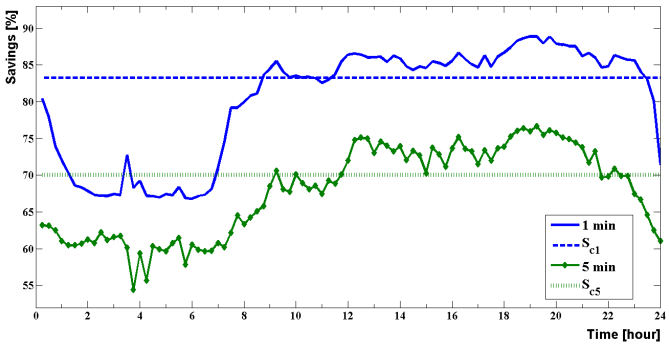

Fig. 6. Cumulative comparison of energy savings during a 24 hour period when data is published either every minute or every 5 minutes

I-codes and flashing display: User-friendly method for secure wireless sensor network bootstrapping

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***Abstract*—The Internet of things (IoT) is a new ubiquitous-computing paradigm which seeks to enhance the traditional Internet by creating intelligent interconnections of diverse objects in the physical world. System in healthcare, smart homes and cities include a large number of interconnected devices such as wireless sensor nodes. Wireless sensor networks generally encompass a large number of wireless devices that lack traditional user interfaces (like keyboards, keypads, and displays), and often have limited computing and energy resources. At the same time one of the big challenges is the initial configuration of these resource constrained wireless devices for the secure communication. In this article a novel multichannel key deployment scheme for wireless sensor networks that only require presence of a light source device, such as a multi-touch screen (tablet or smartphone device), is presented. The main reason for using touchscreens lies in the fact that they are ubiquitous in our everyday lives, be it on smartphones, tablets, laptops, desktop monitors, and different appliances, they can be found just everywhere. The scheme for secure network bootstrapping employs public key cryptography and assumes a strong attacker that is capable of reading the contents of the flashing screen at any moment.**

I. RESARCH TOPIC

The problem of bootstrapping a secure communication between wireless sensor nodes (a.k.a. secure wireless sensor network bootstrapping/initialization) presents a great challenge [1], especially for devices that lack traditional user interfaces. Many existing proposals for secure network bootstrapping assume that the networks nodes already share a secret key [2], or assume that that the attacker will not be present during the key deployment. However, these approaches can lead to compromising the security of the whole wireless sensor network. In works [3,4] a network bootstrapping scheme named LIRA in which the visible light communication (VLC) is used to transfer secret keys to the network devices, and then the radio channel is used to confirm their correct reception is presented (Fig. 1.). The LIRA solution is based on secret key cryptography, and therefore, it is suitable for highly CPU-constrained devices/nodes. Although light signal is harder to intercept than a radio signal, it would still be possible to eavesdrop data (secret keys in the LIRA) transmitted using a flashing screen with collocated suitable sensitive photodetectors (e.g., a video camera). A more dedicated adversary could also observe the electromagnetic radiation generated by flashing screen, thus potentially compromising the content shown on the screen (the secret keys). Therefore, this mechanism for secure network bootstrapping employs public key cryptography and assumes a much stronger adversary that is capable of reading the contents of the flashing screen at any moment. In this scheme, the VLC is used in combination with security primitive *integrity codes* (*I-codes*) [4,5]. Unlike similar approaches in [6] where the VLC is used for transmission of short authentication string (SAS), in this scheme the VLC is used only to synchronize specially crafted (*I-coded*) radio messages and to ease the process of loading the group size into interface limited wireless sensors (Fig. 2.). We also study in detail the behavior of *I-codes* in realistic environment in condition of non-malicious interference (low and high interference) from other wireless devices operating within our frequency spectrum (Fig. 3., Fig. 4.). This represents an important practical consideration that has not been explored yet, and that contributes to a better understanding of security and robustness of the proposed solutions. The main motivation to use I-codes for transmission of public messages rather than using approaches in which user verifies public messages by means of the VLC [6] is to design a solution that minimizes participation by non-specialist users.

REFERENCES

[1] K. Chelli, "Security Issues in Wireless Sensor Networks: Attacks and Countermeasures." *Proceedings of the World Congress on Engineering*. Vol. 1. 2015.

[2] A. Perrig, R. Szewczyk, J. Tygar, V. Wen, and D. E. Culler, "SPINS: Security protocols for sensor networks." *Wireless networks* 8, no. 5 (2002): 521-534.

[3] T. Kovacevic, T. Perkovic, M. Cagalj. LIRA: A New Key Deployment Scheme For Wireless Body Area Networks. SoftCOM 2013, Primosten, Croatia

[4] T. Kovacevic, T. Perkovic, M. Cagalj, "Flashing displays: User-friendly solution for bootstrapping secure associations between multiple constrained wireless devices." Security and Communication Networks, Volume 9, Issue 10, July 2016, Pages 1050–1071

[5] Mario. Cagalj, S. Capkun, R. Rengaswamy, I. Tsigkogiannis, M. Srivastava and J.P. Hubaux, "Integrity (I) codes: Message Integrity Protection and Authentication over Insecure Channels" IEEE Symposium on Security and Privacy, Oakland, California, USA, 2006.

[6] T. Perkovic, M. Cagalj, T. Mastelic, N. Saxena, D. Begusic, "Secure Initialization of Multiple Constrained Wireless Devices for an Unaided User" IEEE Transactions on Mobile Computing, February 2012

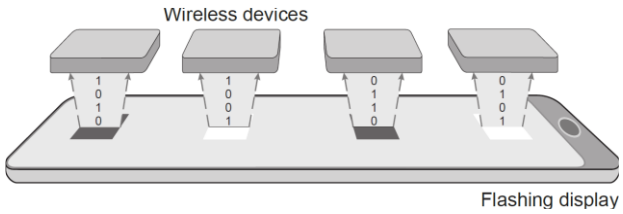

Fig. 1. *Blinking screen: transmission of messages using the VLC [4]*

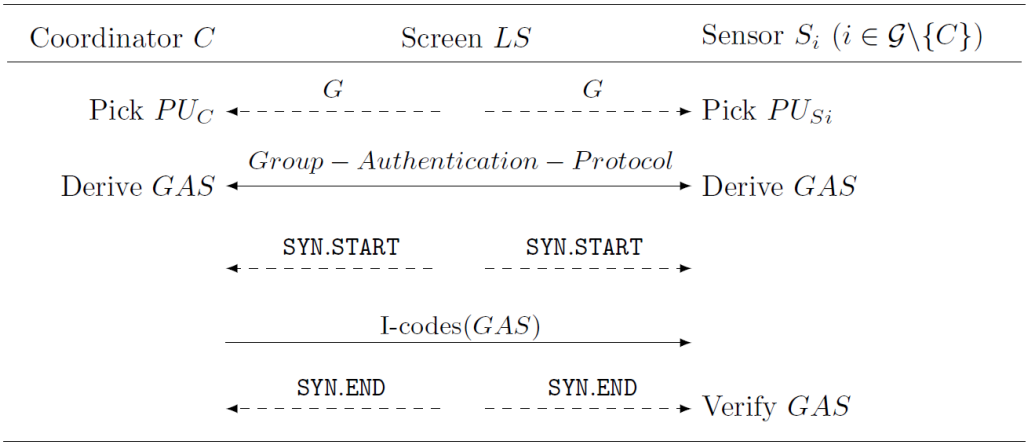

Fig. 2. *Public-key cryptography based key deployment scheme [4]*

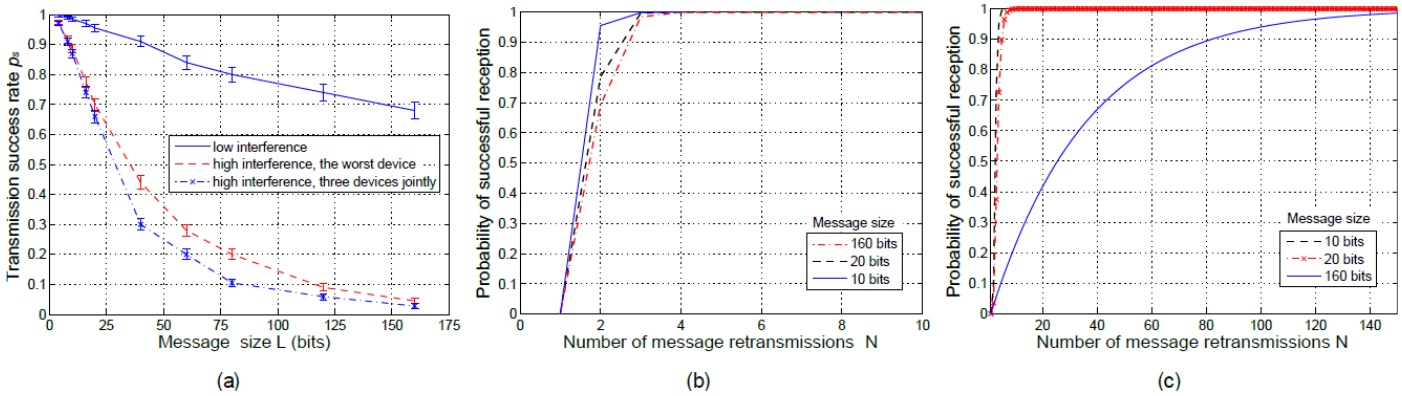

Fig. 3. *(a) Transmission success ratio p_s as a function of the transmitted message size fot the case of low and high interference; (b) Probability that a message is sucessfully received under conditions of low interference; (c) Probability that a message is sucessfully received under conditions of high interference [4]*

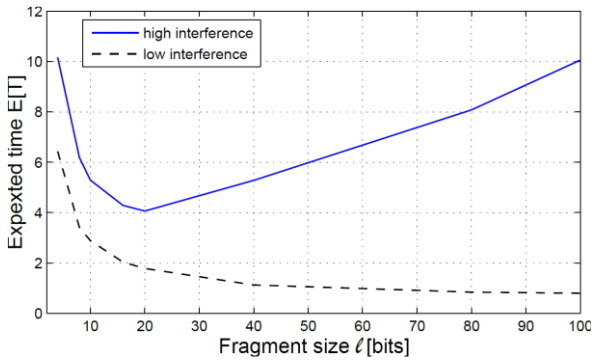

Fig. 4. *The expected time in seconds required to successfully transmit a message as a function of the fragment size in bits under conditions of low and high interference [4]*

Software structure evolution and relation to subgraph defectiveness

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***Abstract*—In this paper, we use a network analysis approach to represent software structure. With that, we can analyse the relation of structure evolution and defectiveness of subgraphs present in the software structure.**

THE RESEARCH TOPIC PRESENTATION

One fraction within the network structure analysis is identification of significant network substructures aiming to uncover structural design principles in complex networks. Network motifs, proposed by [6], are patterns of interconnections in complex networks with an occurrence that is statistically higher than in random networks. It is identified that motifs could be useful for characterizing universal classes of different complex network structures in different scientific fields such as medicine, sociology, electrical engineering. There are numerous structural abstractions we can use to analyse complex software systems such as software modules, classes, files, packages, system units. Mostly, the empirical studies studying behaviour of complex software system chose abstraction that is equivalent to the basic building system element of the system they observe. Moreover, using different metrics on these basic analysis units further complicates the ability to generalise empirical observations. Empirical studies on software defect prediction lack generalisation property, [5].

The fault distributions across system modules has been investigated by many authors. The first systematic study was established by [3] that was motivated by numerous earlier studies, in particular [1]. All these studies identified the uneven distribution of software fault over the system modules. All of these studies empirically observed existence of the Pareto principle of uneven distribution of software faults over the system modules. Studies on the analytic model for fault distributions over the system modules have resulted with less consistent results in terms of best fit particular analytical distribution to empirical data of faults over the system modules [2], [4].

In our previous study, we analyzed the software structure evolution by representing software as network graph and analyzed changes in subgraph frequencies over versions of the system evolution. We found that software structure of the system developed in system versions continuously evolve and identified a correlation between system defectiveness and frequency of some software network subgraphs. In this paper, we aim to extend this study to analyze the relation of structure evolution and defectiveness of subgraphs present in the software structure.

We analysed two Java projects that contained 25 versions. Structural analysis was applied based on subgraph types that are representing primitive 3 node communication patterns within the graph structure. We have shown that software programs have similar behaviors in terms of average subgraph type defectiveness and distributions of average subgraph frequencies coming from the same population. We found that subgraph defectiveness is a good predictor of number of defects in system version. New insights obtained with this approach may be useful in better fault prevention by providing software architects with new architecture design guidelines or by providing software quality personnel with a set of risky subgraphs so they may better plan verification and thus be more effective in defect detection activities. In our further work we aim to investigate how different subgraphs influence other metrics of the software. Also, analysing software written in other languages could be interesting. Seeing if software evolution, in terms of subgraphs, in other languages tends to evolve in the same way and if same subgraphs are also present.

ACKNOWLEDGMENTS

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REFERENCES

[1] E. Adams. Optimizing Preventive Service of Software Products. *IBM Research J.*, vol.28, no.1, pages 214, 1984.
[2] G. Concas, M. Marchesi, A. Murgia, R. Tonelli, and I. Turnu, "On the Distribution of Bugs in the Eclipse System," *IEEE Trans. Softw. Eng.*, vol. 37, no. 6, pp. 872–877, Nov./Dec. 2011.
[3] N. E. Fenton, N. Ohlsson, "Quantitative Analysis of Faults and Failures in a Complex Software System," *IEEE Trans. Softw. Eng.*, vol. 26, no. 8 , pp. 797–814, Aug. 2000.
[4] T. Galinac Grbac, D. Huljenić, "On the probability distribution of faults in complex software systems," *Information and Software Technology*, vol. 58, pp. 250–258, Apr. 2015.
[5] T. Hall, S. Beecham, D. Bowes, D. Gray, and S. Counsell. *A systematic literature review on fault prediction performance in software engineering*. IEEE Trans. Softw. Eng., 38(6):1276, 1304, Nov. 2012.
[6] R. Milo, S. Shen-Orr, S. Itzkovitz, et al. *Network motifs: simple building blocks of complex networks*. Science 2002; 298:824–27.

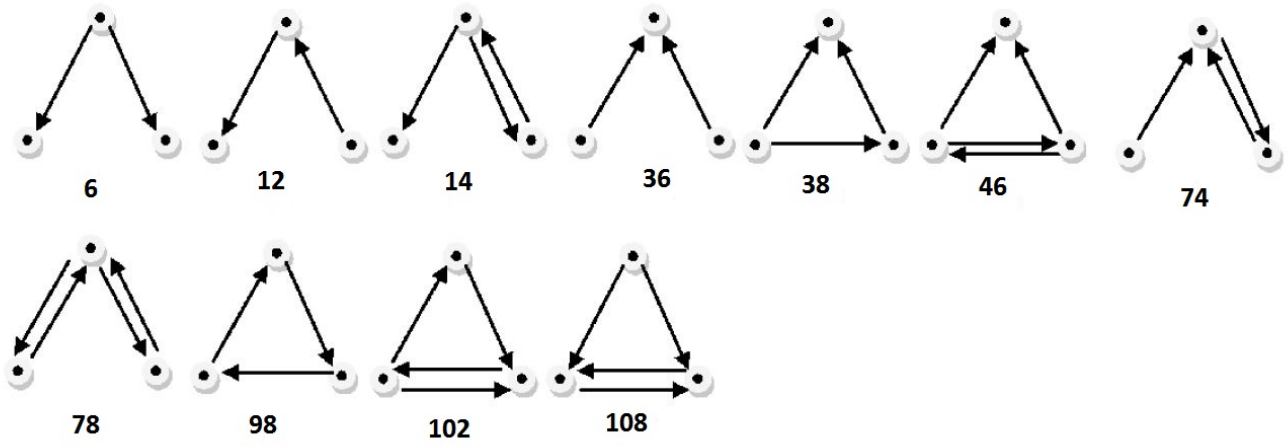

Fig. 1: All types of three node subgraphs

```
class Point {
      int row, column;
}
class Chessmen {
      Point pos;
      int iGetValue();
}
class Move {
      Point start_pos;
      Point end_pos;
      bool bIsAllowedMove();
}
class Pawn : public Chessmen {
      Move *moves;
      int iGetValue();
}
```

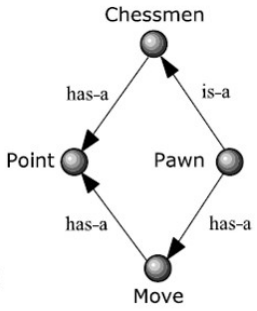

Fig. 2: Code to graph example

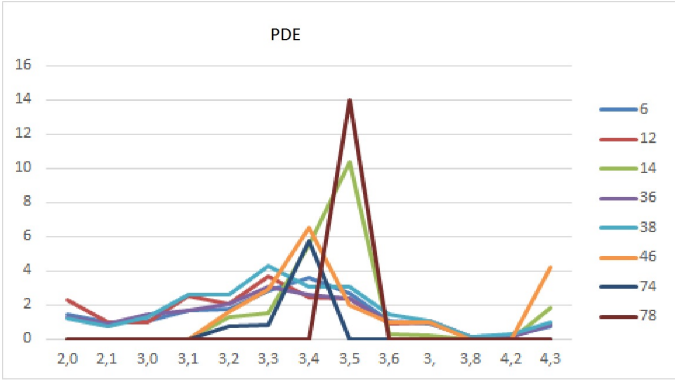

Fig. 4: Frequency and defects ratio over versions in PDE project

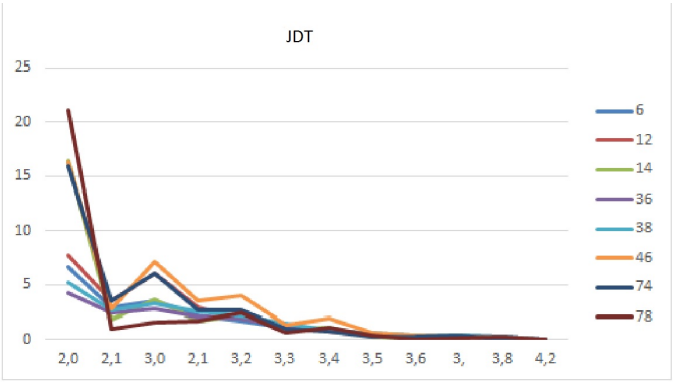

Fig. 3: Frequency and defects ratio over versions in JDT project

The climate forecasting model of power system hourly load curves

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***Abstract*— The climate forecasting model of power system hourly load curves is based on loads and climate data from the past. Analysis of the processes affecting the load curve can be decomposed into several components. They are as follows: base, week, climate and stochastic loads component, respectively. The climate component is consisted of several climate variables such are wind speed and direction, temperature, cloudiness and rainfall. Influence each of them on forecasting of power system load curve is given. The result of forecasting are 24 hourly loads of the following day.**

Keywords—climate model; forecasting; power system load curve; wind speed and direction, temperature, cloudiness, rainfall

I. INTRODUCTION

The problem of as more accurate forecasting load curve for a day or more ahead is of great importance in the electricity market. The main feature of here described climate forecasting model of power system hourly load curves, unlike some other market models, is ease of use and accuracy of forecasting. After the initialization of the forecasting model it is necessary enter into the model only realized load curve of the previous day and forecasted meteorological data.

II. THE CLIMATE FORECASTING MODEL

A. Decomposing load curve on components

Load $Y(d,i)$ of hour i and day d in climate forecasting model is consisted of the following components

$$Y(d,i) = B(d,i) + S(d,i) + W(d,i) + \xi(d,i) \quad (1)$$

where $Y(d,i)$, $B(d,i)$, $S(d,i)$, $W(d,i)$, $\xi(d,i)$ are realized load, base, week, climate and stochastic loads component in hour i of day d, respectively.

The main part of hourly load is the base load component that is changing depending on the connection of new customers and changes of existing customers consumption. The effect of different consumption on certain days of the week is included in week load component. Climate load component represents the information about the load dependence on the climate conditions. Stochastic load component includes stochastic fluctuations of the loads.

1) Base load component: The method of exponential smoothing is used to calculate base load component. Coefficient of exponential smoothing is determined empirically for each system.

2) Week load component: This load component is determined by seven values related to a particular day of the week.

3) Climate load component: This component is the sum of linear functions adequatelly transformed values of climate variables such as temperature, wind speed and direction, cloudiness, rainfall and so on. In addition to these, another temperature variable is introduced in the model that connects the neighboring hours. In this way the average temperature of the last n hours is taken into account. This takes into account the effect of the accumulation of heat in the building walls which further increases the accuracy. This second temperature variable and hourly resolution of all climate variables are the main contribution of this research with regard to [2].

B. Results of simulation

The main findings are: 1) temperature is the crucial variable for the load model forecasting, 2) wind speed/direction and cloudiness variables are not necessary to obtain good modeling results and 3) rainfall variable has no significant correlation to the load modeling forecast. The main feature of this forecasting model, unlike some other market models, is user friendly platform and forecasting accuracy. It is enough to install the program and provide a realized daily load data and the weather forecast for the next day. Usage of small number of climate variables assumes less expensive forecast, since the collection of actual and forecasted data of each climatic variables requires higher costs. The simulation results are shown on following figures.

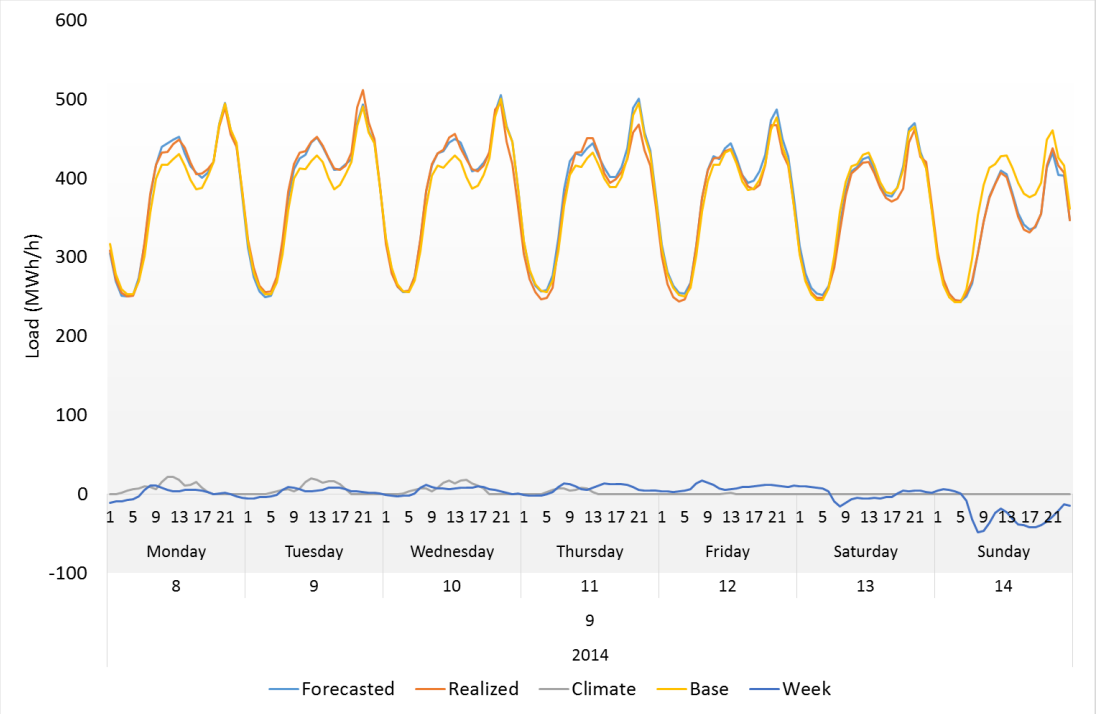


Fig. 1. Forecasted and realized load curves with forecasted load components when the only climate variable is temperature.

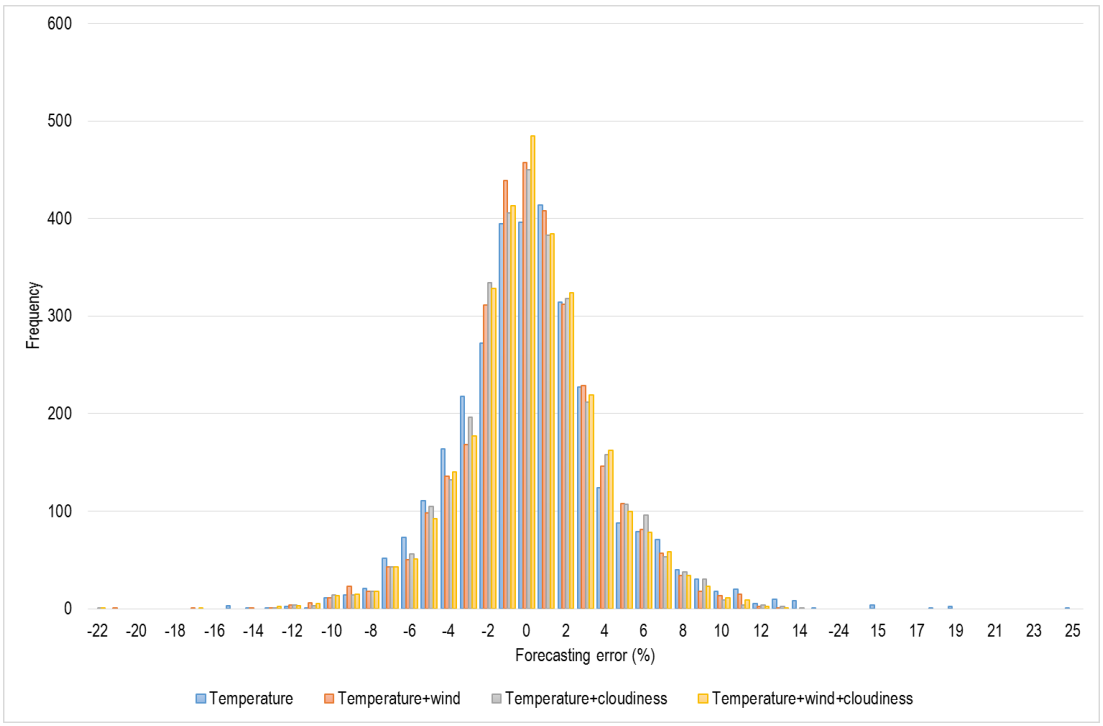


Fig. 2. Forecasting error frequency distribution

REFERENCES

[1] M. Skok, D. Vidovic, T. Baricevic, D. Pesut, H. Keko, "Planning the load curve of customers within the power supply which is performed as a public service", EIHP, 2015

[2] D. Pesut, "A method of predicting the daily load diagram in the power system", Master's thesis, Zagreb, 1981

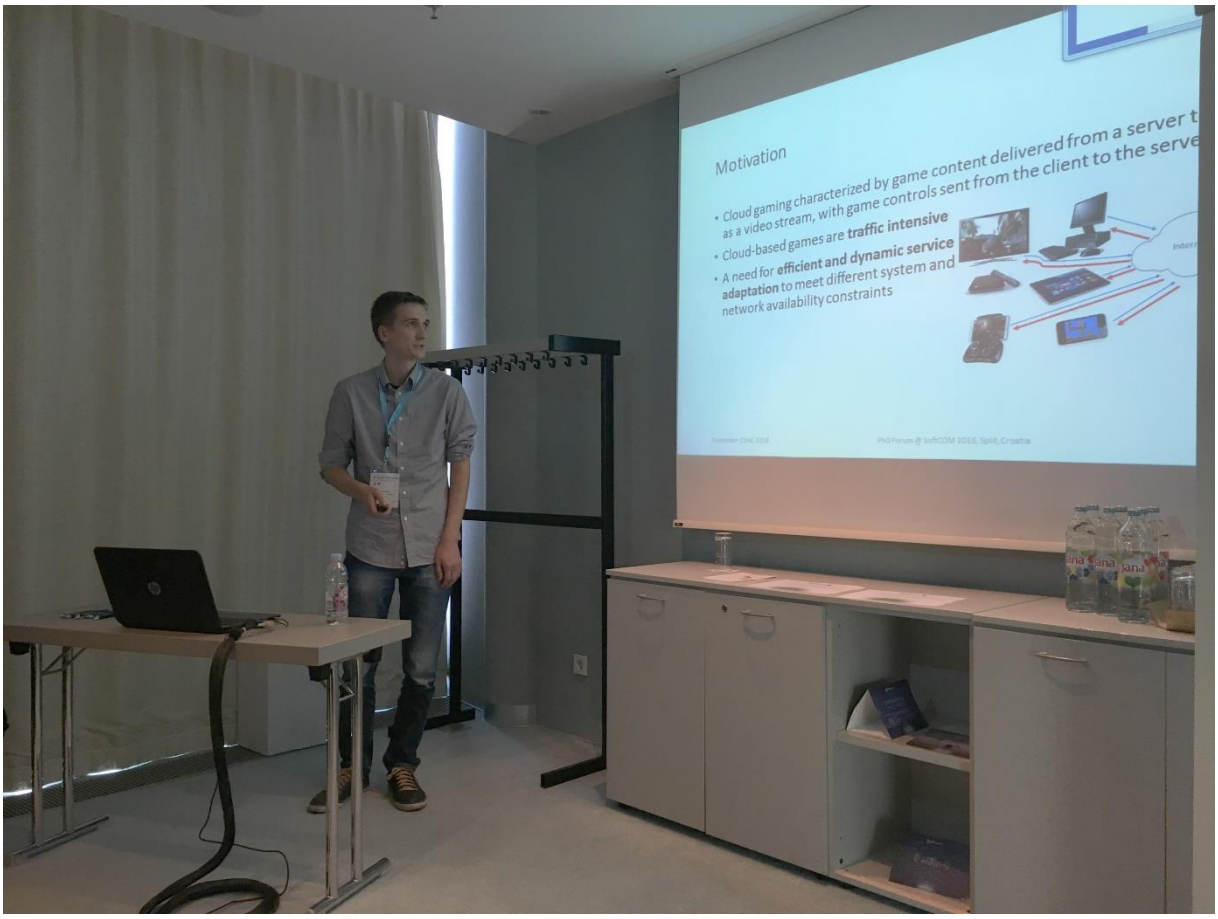
[3] "Mathematical models for short-term forecasting of hourly consumption of electricity for distribution areas", FER, 2011

[4] G.H. Golub, C.F. Van Loan, "Matrix Computations", fourth edition, The Johns Hopkins University Press, Baltimore, USA, 2013

Author index

Photos from the PhD Forum

Welcome and opening address



Pitch talk presentations

Pitch talk presentations

Pitch talk presentations

Poster session

Poster session

Poster session

Poster session

Poster session

Awards ceremony

Awards ceremony