

BIHTEL 2016

XI International Symposium on Telecommunications

# **Book of Abstracts**

24<sup>th</sup> – 26<sup>th</sup> October 2016

Sarajevo, Bosnia and Herzegovina

BIHTEL 2016

XI International Symposium on Telecommunications

Book of Abstracts

IEEE Catalog Number: CFP1622U-USB

ISBN: 978-1-5090-2901-3

© 2016 IEEE

Personal use of this material is permitted. Permission from IEEE must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collective works, for resale or redistribution to servers or lists, or reuse of any copyrighted component of this work in other works.

**Organized by:**



**Faculty of Electrical Engineering  
University of Sarajevo**



## Technical Co-sponsors





## Conference Partners

### Conference Gold Partner

BH Telecom



### Conference Silver Partner

Comtrade d.d.



### Conference Bronze Partner

Rohde & Schwarz







# Contents

- Welcome Message**.....11
- Preface**.....12
- Conference Information** .....14
- Conference Committees** .....15
  - Conference Co-Chairs .....15
  - Technical Program Co-Chairs.....15
  - Conference Treasurer .....15
  - Publication Chair .....15
  - Local Arrangements Chairs.....15
  - Technical Program Committee (International Program Committee).....15
  - Reviewers .....17
- Hosting City** .....20
  - Sarajevo.....20
  - Time Zone.....21
  - Climate.....21
  - Population .....21
  - Important Phone Numbers .....22
  - Electricity.....22
  - Water Supply .....22
  - Currency .....22
  - Public Transport.....22
  - Taxis .....23
  - How to get to BIHTEL 2016 Venue .....23
  - Where to shop.....23
    - Souvenirs .....23
    - Shopping Centers.....23
    - Useful Websites .....24
- Accommodations** .....25
- Locations**.....26
- Conference Program** .....28
  - Social Events .....28
  - Registration.....28
- Sessions**.....32

Sessions on Monday, 24 <sup>th</sup> October, 2016 .....	32
Sessions on Tuesday, 25 <sup>th</sup> October, 2016 .....	37
Sessions on Wednesday, 26 <sup>th</sup> October, 2016 .....	40
Keynote Speakers .....	41
Book of Abstracts .....	43
Keynotes .....	44
SESSION 1 .....	47
SESSION 2 .....	55
SESSION 3 .....	61
SESSION 4 .....	68
SESSION 5 .....	76
SESSION 6 .....	83
<b>BIHTEL 2016 Notes</b> .....	<b>90</b>

## Welcome Message

Dear guests, dear participants,

It is our great pleasure to welcome you to the 11th International Symposium BIHTEL 2016. Welcome to Sarajevo, welcome to Bosnia and Herzegovina.

The BIHTEL 2016 symposium takes place in Sarajevo, from the 24th to the 26th of October 2016. BIHTEL 2016 is organized by the Faculty of Electrical Engineering University of Sarajevo in co-operation with BH Telecom, and other sponsors. We are very proud that BIHTEL 2016 symposium takes place under technical co-sponsorship of IEEE Region 8, IEEE Bosnia and Herzegovina Section, IEEE Bosnia and Herzegovina Section Chapter of the Communications Society.

The BIHTEL 2016 is held in Sarajevo, a beautiful city with long and sometimes troubled history. It was site of the assassination that sparked World War I, while seventy years later it becomes the host city of the 1984 Winter Olympics. Today Sarajevo is recovering and adjusting to a post-war reality, is major centre of culture and economic development in Bosnia and Herzegovina. The travel guide series Lonely Planet has named Sarajevo as the 43th best city in the world, and in December 2009 listed Sarajevo as one of the top ten cities to visit in 2010. One when you visit Sarajevo, it becomes the city you yearn for, the city you wish to return to. The scientific program of this year BIHTEL symposium is divided into 6 sessions that cover 10 research topics. After the reviewing process, Review Committee has selected 32 submitted papers for oral presentation. These research papers were written by 108 authors. Participants come from the 5 countries.

This year The International Program Committee invites several outstanding experts as keynote speakers to present the state-of-the-art in different research fields. This year we are proud to have three keynote talks: Prof. Dr. Chris Blondia, Professor and head of the research group "Performance Analysis of Telecommunication Systems" (PATs) at the University of Antwerp (UIA) will give a plenary talk "Evaluation of IEEE 802.11 with Interference", Prof. Dr. Jae Hong Lee, Professor with Department of Electrical and Computer Engineering, Seoul National University, will give a plenary talk "Cognitive Radio for Wireless Communications: Concepts and Applications", and Prof. Dr. Dejan Vukobratovic, Associate Professor with the Department of Power, Electronic and Communications Engineering, University of Novi Sad will give a plenary talk "Internet of Things for 5G and Beyond: Should Communications and Data Analysis Remain Separated?".

We are most grateful to them for coming on BIHTEL 2016 symposium. We will do our best to make you feel welcomed and hopefully our Symposium will have a great success.

Emir Turajlić and Branka Zovko-Cihlar

BIHTEL 2016 General Co-Chairs

## Preface

XI International Symposium on Telecommunications – BIHTEL 2016 will be held in Sarajevo, Bosnia and Herzegovina, during October 24-26, 2016.

Being the eleventh in a series of biennial symposiums, BIHTEL 2016 – XI International Symposium on Telecommunications, will bring together researchers from academia and practitioners from industry active in the field of Telecommunications to discuss current development and future perspectives in Telecommunications technologies. The explosive growth in telecom sector, coupled with rapid innovations is throwing up not merely technological but a whole lot of management, regulatory and socio-economic challenges.

BIHTEL 2016 will provide a venue for Telecommunications engineering practitioners, researchers and educators to exchange ideas on recent research work, point out the directions for future research and seek collaboration opportunities on all aspects of Telecommunications technologies.

The XI International Symposium on Telecommunications - BIHTEL 2016 will be organized by the Faculty of Electrical Engineering from the University of Sarajevo. With great effort and experience from IWSSIP 2011, ICAT 2011, AMC 2012, BIHTEL 2012, ICAT 2013, BIHTEL 2014, ICAT 2015 which have all been organized under the technical sponsorship from IEEE region 8, IEEE Bosnia and Herzegovina Section, IEEE Bosnia and Herzegovina Section Communications Society Chapter and IEEE Bosnia and Herzegovina Section Computer and Computational Intelligence Joint Societies Chapter, BIHTEL 2016 will have the same international rating. The main partner - Gold partner, of BIHTEL 2016 is BH Telecom, the Silver partner is Comtrade d.d. Sarajevo, while the Bronze Partner is Rohde & Schwarz. After the first Call for papers, BIHTEL 2016 received 40 papers from 121 authors and 6 countries. The international review process has taken place, resulting in the acceptance of 32 papers for final presentation. These 32 papers have met all the criteria's of IEEE region 8 and the reviewers and will be submitted to the relevant international databases. These databases are very important for the global recognition and validity of the research results in these papers.

Solicited topics include, but are not limited to:

- Communication and Information Theory
- Signal Processing for Communications
- Wireless and Radio Communications and Networking
- Software Defined Networking and Virtualization
- Management in Communication Systems and Networks
- Artificial Intelligence
- Image and Speech Signal Processing
- Natural Language Processing
- Digital Humanities
- Next-Generation Networks

- Communications Software Services and Multimedia
- Applications
- Optical Networks
- Communication and Information System Security
- Education in Communication Engineering
- Modelling and Simulation
- Embedded Systems

## **Conference Information**

## **Conference Committees**

### **Conference Co-Chairs**

Emir Turajlic	University of Sarajevo, Bosnia and Herzegovina
Branka Zovko-Cihlar	University of Zagreb, Croatia

### **Technical Program Co-Chairs**

Mesud Hadzialic	University of Sarajevo, Bosnia and Herzegovina
Dzenana Donko	University of Sarajevo, Bosnia and Herzegovina

### **Conference Treasurer**

Semsudin Masic	University of Sarajevo, Bosnia and Herzegovina
----------------	--

### **Publication Chair**

Sasa Mrdovic	University of Sarajevo, Bosnia and Herzegovina
--------------	--

### **Local Arrangements Chairs**

Tarik Uzunovic	University of Sarajevo, Bosnia and Herzegovina
Nina Slamnik	University of Sarajevo, Bosnia and Herzegovina

### **Technical Program Committee (International Program Committee)**

Huseyin Abut	USA
Melita Ahic-Dokic	Bosnia and Herzegovina
Abdulah Aksamovic	Bosnia and Herzegovina
Himzo Bajric	Bosnia and Herzegovina
Jasmina Barakovic Husic	Bosnia and Herzegovina
Narcis Behlilovic	Bosnia and Herzegovina

Janez Bester	Slovenia
Enisa Brka	Bosnia and Herzegovina
Tarik Carsimamovic	Bosnia and Herzegovina
Aura Conci	Brazil
Branko Dokic	Bosnia and Herzegovina
Irena Galic	Croatia
Mislav Grgic	Croatia
Sonja Grgic	Croatia
Nasuf Hadziahmetovic	Bosnia and Herzegovina
Nijaz Hadzimejlic	Bosnia and Herzegovina
Alan Hanjalic	Netherlands
Zeljko Juric	Bosnia and Herzegovina
Samim Konjicija	Bosnia and Herzegovina
Mladen Kos	Croatia
Ivo Kostic	Montenegro
Fabiana Rodrigues Leta	Brazil
Panos Liatsis	UK
Vladimir Lipovac	Bosnia and Herzegovina
Ignac Lovrek	Croatia
Trueman MacHenry	Canada
Vera Markovic	Serbia
Hermann Maurer	Austria
Steven McLaughlin	USA
Sasa Mrdovic	Bosnia and Herzegovina
Alija Muharemovic	Bosnia and Herzegovina
Milan Martic	Serbia
Fahrudin Orucevic	Bosnia and Herzegovina
Branislava Perunicic	Bosnia and Herzegovina
Pavol Podhradsky	Slovakia
Nedzad Residbegovic	Bosnia and Herzegovina



Selma Rizvic	Bosnia and Herzegovina
Nikola Rozic	Croatia
Gregor Rozinaj	Slovakia
Markus Rupp	Austria
Dusan Starcevic	Serbia
Adnan Salihbegovic	Bosnia and Herzegovina
Angel Sanchez	Spain
Mirko Skrbic	Bosnia and Herzegovina
Asim Smailagic	USA
Emina Soljanin	USA
Zekeriya Uykan	Turkey
Stamatis Voliontis	Greece
Dejan Vukobratovic	Serbia
Branka Zovko-Cihlar	Croatia
Mirsad Zaimovic	Bosnia and Herzegovina

## Reviewers

Adel Handzic	Bosnia and Herzegovina
Adil Kondiloglu	Turkey
Adnan Tahirovic	Bosnia and Herzegovina
Aleksandar Mastilovic	Bosnia and Herzegovina
Alen Begovic	Bosnia and Herzegovina
Almir Mutapcic	Bosnia and Herzegovina
Almir Karabegovic	Bosnia and Herzegovina
Asim Smailagic	USA
Begum Korunur Engiz	Turkey
Behnam Rouzbehani	Portugal
Burak Soner	Turkey
Darko Huljenic	Croatia
Dejan Vukobratovic	Serbia

Dzenana Donko	Bosnia and Herzegovina
Edin Golubovic	Turkey
Emir Sokic	Bosnia and Herzegovina
Emir Turajlic	Bosnia and Herzegovina
Emre Özsoy	Turkey
Enio Kaljic	Bosnia and Herzegovina
Enisa Brka	Bosnia and Herzegovina
Eray A. Baran	Turkey
Gautam Chakrabarti	Germany
Goran Djukanovic	Bosnia and Herzegovina
Haris Supic	Bosnia and Herzegovina
Harun Siljak	Bosnia and Herzegovina
Himzo Bajric	Bosnia and Herzegovina
Iosif Androulidakis	Greece
Irena Galic	Croatia
Ivo Kostic	Montenegro
Jaroslav Koton	Czech Republic
Jasmin Kevric	Bosnia and Herzegovina
Jasmin Azemovic	Bosnia and Herzegovina
Jasmina Barakovic-Husic	Bosnia and Herzegovina
Jelena Bozek	Croatia
Josip Vukovic	Croatia
Mario Mustra	Croatia
Mesud Hadzialic	Bosnia and Herzegovina
Milica Pejanovic-Djurisic	Montenegro
Miroslav Voznak	Czech Republic
Mohammad Tanhaei	Iran
Narcis Behlilovic	Bosnia and Herzegovina
Nedim Srdic	Germany
Niksa Jakovljevic	Serbia

Panos Liatsis

Predrag Valozic

Saida Sultanic

Samir Ribic

Samir Omanovic

Sasa Mrdovic

Sonja Zentner Pilins

Zeljko Juric

Zikrija Avdagic

UK

Croatia

Bosnia and Herzegovina

Bosnia and Herzegovina

Bosnia and Herzegovina

Bosnia and Herzegovina

Croatia

Bosnia and Herzegovina

Bosnia and Herzegovina

# Hosting City

## Sarajevo

Welcome to Bosnia and Herzegovina and Sarajevo that preserve long trails of civilizations throughout millenniums. Great cultures and religions of South and North, Western and Eastern Christianity, Islam and Judaism but also great empires of European history have met and joint here.

Capital of Bosnia and Herzegovina, Sarajevo is the largest city and country's administrative, economic, cultural, university and sport centre. The name Sarajevo is derived from Turkish saray ovası, meaning "the field around saray" (Saray is a Turkish word of Persian origin which means 'palace'). The City of Sarajevo is comprised of four Municipalities: Stari Grad, Centar, Novo Sarajevo and Novi Grad.

Sarajevo is not a huge city - around 400.000 people live in its urban area, but it is very livable, vibrant and busy. The city is historically famous for its traditional religious diversity, with adherents of Islam, Orthodoxy, Catholicism and Judaism coexisting there for centuries.

Sarajevo is one of the most historically interesting and varied cities in Europe. It is a place where the Western & Eastern Roman Empire split; where the people of the Roman Catholic west, Eastern Orthodox east and the Ottoman south, met, lived and warred. It has been both an example of historical turbulence and the clash of civilizations, as well as a beacon of hope for peace and tolerance through multi-cultural integration.

Situated in the area called Sarajevo Field, the town is surrounded by Olympic Mountains – Jahorina, Bjelašnica, Igman, Treskavica and Trebević. River Miljacka flows through the city. Sarajevo is national cultural capital with numerous International festivals taking place every year (Sarajevo Film Festival, MESS International Theatre Festival, International "Sarajevo Winter" Festival, Jazz Festival, and Bašćaršija Nights). The city is famous for its traditional religious diversity, with adherents of Islam, Christian Orthodoxy, Catholicism and Judaism coexisting there for centuries. Due to this long and rich history of religious diversity and coexistence Sarajevo has often been called "The Jerusalem of Europe".

The area that Sarajevo occupies has been continuously inhabited since the Prehistoric period. It becomes a city with arrivals of the Ottomans in the 15th century, and a capital of independent B&H in 1992. Sarajevo has always connected East and the West thus creating a unique blend of history, culture and heritage.

The modern city arose as an Ottoman stronghold in the 15th century. Sarajevo has attracted international attention several times throughout its history: In 1914 it was the site of the assassination that sparked World War I, while seventy years later it became the host city of the 1984 Winter Olympics. More recently, Sarajevo underwent the longest siege in modern military history during the Bosnian War.

Today the city is recovering and adjusting to a post-war reality, as a major centre of culture and economic development in Bosnia and Herzegovina. Sarajevo was also the first city in Europe and the second city in the world to have a full-time operational electric tram network running through the city, the first being San Francisco. Lonely Planet has named Sarajevo as the 43rd best city in the world and in December 2009 listed Sarajevo as one of the top ten cities to visit in 2010.

Sarajevo is located near the geometric centre of the triangular-shaped Bosnia and Herzegovina and within the historical region of Bosnia proper. The Sarajevo valley once formed a vast expanse of greenery, but gave way to urban expansion and development in the post-World War II era. The city is surrounded by heavily forested hills and big mountains. The highest of the surrounding peaks is 2,088 meters. On average, Sarajevo is situated 500 meters above sea level. The city itself has its fair share of hilly terrain, as evidenced by the many steeply inclined streets and residences seemingly perched on the hillsides.

The Miljacka river is one of the city's chief geographic features. It flows through the city from the east to the west where eventually meets up with the Bosna river. The source of Miljacka several kilometres to the east of Sarajevo and the Bosna's source, Vrelo Bosne near Ilidža (west Sarajevo), are notable natural landmarks and popular destinations for citizens of Sarajevo and tourists.

## **Time Zone**

CET - Central European Time (Europe), GMT +01:00

## **Climate**

Medium continental climate with average temperatures:

Summer: 19,1 °C

Winter: -1,3 °C

Annual: 9,5 °C

## **Population**

The city of Sarajevo in (the area of) four municipalities (Old City, Centre, New City and New Sarajevo) has 297,416 residents.

Area: 141,5 km<sup>2</sup>

## **Important Phone Numbers**

Police: 122

Fire-fighters: 123

First Aid: 124

Sarajevo Taxi: 1515

Airport: +387 33 289 100

## **Electricity**

The electric supply is 220V with 50Hz frequency.

## **Water Supply**

It is safe to drink tap water in Sarajevo.

## **Currency**

Currency in B&H is Convertible Mark. The international abbreviation for currency is BAM, while KM is used locally (1.95583 KM = 1 Euro). You can exchange your currency in any bank or post office. Banks are generally open from 08:00 to 18:00 on working days, and from 09:00 to 13:00 on Saturdays. Main post office is open from 07:00 to 20:00 from Monday to Saturday.

## **Public Transport**

Sarajevo is well connected with a network of trams, trolley-buses, buses and minibuses. The one-way ticket for an inner-city zone is 1,6 KM if you purchase it in a kiosk and 1,8 KM if you purchase it with a driver. The ticket must be punched as soon as you enter the vehicle. Failure to do so will result in a fine, on the spot. The bus line connecting airport with Baščaršija runs several times per day and it costs 6 km (3 Euros) one way.

## **Taxis**

Sarajevo has one of the cheapest taxi services in Europe. Several private taxi companies operate in the city 24 hours a day. For example, taking a taxi from Sarajevo Airport to the city centre will cost between 17 and 20 KM. All vehicles use the taxi meter. The driver will issue the receipt upon a request.

## **How to get to BIHTEL 2016 Venue**

The taxi from the Sarajevo Airport (SJJ Sarajevo Intl.) should cost approximately 10 EUR.

## **Where to shop**

### **Souvenirs**

To pick up authentic souvenirs, head to Baščaršija, the city's Turkish quarter. For centuries, Baščaršija was the city's centre of trade and craftsman. During its golden period, it boasted 12000 various shops selling products and services of 80 different craftsmen and tradesmen. You can still find Baščaršija's shops filled with souvenirs, traditional household items, silver and gold jewellery. Baščaršija's most popular street is Kazandžiluk (Coppersmith Street), where you can find superbly created engraved copper products: džezve (coffee pots), fildžani (coffee cups), ibrici (copper water dish). The city's jewellery makers were well known throughout Ottoman Empire for their particular designs. Some of the unique jewellery items are beautifully crafted belenzuci (thick wrist bracelets), rings, and necklaces. Jewellery makers (silver and gold smiths) are mostly located on Gazi Husrev-begova Street (Zlatarska or Goldsmiths' Street). While in Baščaršija you can also visit the Gazi Husrev Bey's Bezistan (covered bazaar) which was built between 1537 and 1555.

### **Shopping Centers**

Sarajevo is increasingly becoming an interesting shopping destination. Modern boutiques and fashion shops, as well as those featuring designs of local designers, can be found along Ferhadija and Titova Street. We recommend a visit to BBI Center, located in the city center, where various shops selling apparel, fashion accessories and household items are found. Importanne Center, located near the Wilson's Walkway and Historical Museum of BiH, is perfect for combining shopping with quick bites. There are also Alta and Sarajevo Shopping Center. Sarajevo City Center is comprised of four separate but at the same time complementary parts: a modern five-

star hotel, commercial and office space, shopping center with entertainment complex and an underground parking garage to accommodate for the entire Center.

### **Useful Websites**

**Sarajevo International airport:** <http://www.sarajevo-airport.ba>

**Tourism association of Sarajevo:** <http://www.sarajevo-tourism.com/eng/default.wbsp>

**Official Web of Sarajevo:** <http://www.sarajevo.ba>

**City Tours:** <http://www.sarajevofunkytours.com>



## **Accommodation**

Courtyard by Marriott Sarajevo

Skenderija 1 71000 Sarajevo

Bosnia and Herzegovina

**Phone:** +387-33-954500

**Fax:** +387-33-954501

**Sales:** +387-33-954503

**Sales fax:** +387-33-954501

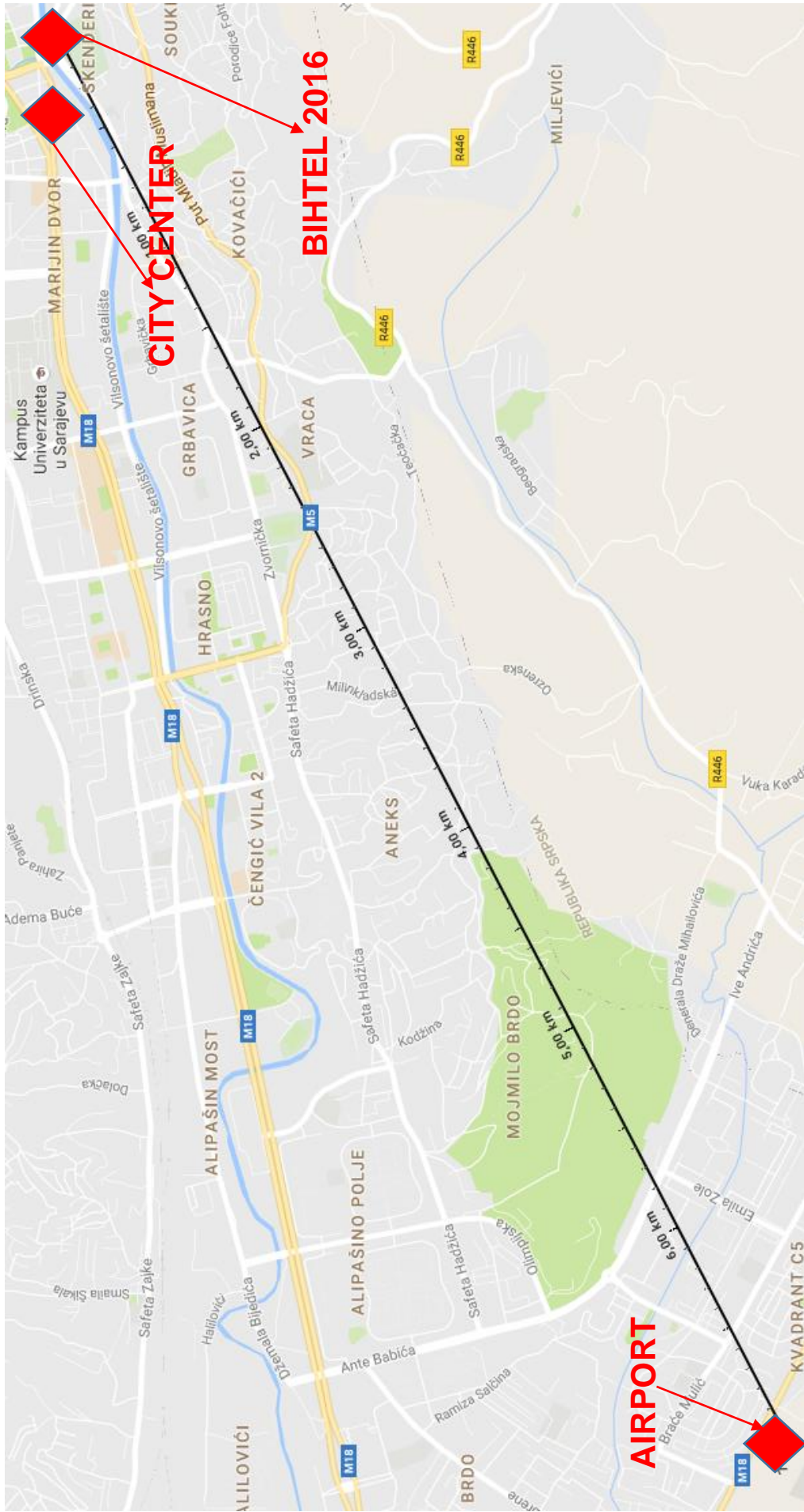
**Toll-Free Reservation Center:** 387-33-954507

**Website:** <http://www.marriott.com/hotels/travel/sjjcy-courtyard-sarajevo/>

# Locations



- 1 – Courtyard by Marriott
- 2 – Faculty of Electrical Engineering, University of Sarajevo
- 3 – National Museum
- 4 – Historical Museum
- 5 – Sarajevo City Center
- 6 – Importanne Center
- 7 – BBI Center
- 8 – Parliament



# Conference Program

## Social Events

### Monday, 24<sup>th</sup> October, 2016

Welcome reception will be held in Courtyard by Marriott (Conference venue) from 09:30 to 11:15.

Conference Banquet will take place at Sarajevo Brewery from 19:30 to 22:00. Additional tickets (Fee: 40 €) for the banquet can be found at the Registration desk during registration.

### Tuesday, 25<sup>th</sup> October, 2016

After the Session 5, second day of the Conference, we will organize Old town tour (Sarajevo - European Jerusalem). The tour lasts about 3 hours. To register for the Tour please go to the Registration Desk.

## Registration

<b>Monday, 24<sup>th</sup> October, 2016</b>	<b>08:30 – 16:45</b>
<b>Tuesday, 25<sup>th</sup> October, 2016</b>	<b>08:45 – 13:00</b>
<b>Wednesday, 26<sup>th</sup> October, 2016</b>	<b>09:45 – 12:00</b>

**Monday - October 24, 2016**  
**Courtyard by Marriott**

<b>TIME</b>	<b>ACTIVITIES</b>	<b>ACTIVITY DETAILS</b>
<b>8:30-09:30</b>	<b>REGISTRATION</b>	
<b>09:30-10:15</b>	<p>Welcome Speech:</p> <p><b>Prof. Dr. Samim Konjicija</b>  Dean, Faculty of Electrical Engineering, University of Sarajevo</p> <p><b>Doc. dr. Emir Turajlić</b>  Conference Co-Chair</p> <p><b>Sponsors</b></p> <p>BH Telecom  Comtrade  Rohde &amp; Schwarz</p>	
<b>10:15-11:15</b>	<b>Welcome Cocktail</b>	
<b>11:15-11:55</b>	Keynote Speech 1	<p><b>Prof. Dr. Chris Blondia</b></p> <p>Evaluation of IEEE 802.11 with Interference</p>
<b>12:00-14:00</b>	<b>Session 1</b>	Artificial Intelligence; Signal Processing 1
<b>14:00-15:00</b>	<b>LUNCH</b>	
<b>15:00-16:40</b>	<b>Session 2</b>	Artificial Intelligence; Signal Processing 2
<b>16:40-17:00</b>	<b>COFFEE BREAK</b>	
<b>17:00-18:40</b>	<b>Session 3</b>	Communication and Information Theory; Communication and Information System Security
<b>19:30-22:00</b>	<b>BANQUET</b>	

**Tuesday - October 25, 2016**  
**Courtyard by Marriott**

<b>TIME</b>	<b>ACTIVITIES</b>	<b>ACTIVITY DETAILS</b>
<b>09:00-09:40</b>	Keynote Speech 2	<b>Prof. Dr. Jae Hong Lee</b>  Cognitive Radio for Wireless Communications: Concepts and Applications
<b>09:40-10:00</b>	<b>COFFEE BREAK</b>	
<b>10:00-12:00</b>	<b>Session 4</b>	Next Generation Networks; Wireless and Radio Communications and Networking
<b>12:00-12:20</b>	<b>COFFEE BREAK</b>	
<b>12:20-14:00</b>	<b>Session 5</b>	Modelling and Simulation; Management in Communication Systems and Networks
<b>14:00-15:00</b>	<b>LUNCH</b>	
<b>16:30</b>	<b>TOURIST TOUR</b>	

**Wednesday- October 26, 2016**  
**Courtyard by Marriott**

<b>TIME</b>	<b>ACTIVITIES</b>	<b>ACTIVITY DETAILS</b>
<b>10:00-10:40</b>	Keynote Speech 3	<b>Prof. Dr. Dejan Vukobratović</b> Internet of Things for 5G and Beyond: Should Communications and Data Analysis Remain Separated?
<b>10:40-12:20</b>	<b>Session 6</b>	Communications Software Services and Multimedia Applications; Embedded Systems
<b>12:20-13:20</b>	<b>LUNCH</b>	

## Sessions

### Sessions on Monday, 24<sup>th</sup> October, 2016

SESSION 1 - Artificial Intelligence; Signal Processing 1		12:00-14:00
<b>Session Chairs:</b> <b>Emir Sokić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Emir Turajlić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina		
12:00-12:20	<b>VoIP Call Quality Assessment based on RPROP Neural Networks</b>	<b>Miroslav Voznak</b> , CESNET z.s.p.o, Prague, Czech Republic <b>Jan Rozhon</b> , CESNET z.s.p.o, Prague, Czech Republic <b>Filip Rezac</b> , CESNET z.s.p.o, Prague, Czech Republic <b>Erik Gresak</b> , CESNET z.s.p.o, Prague, Czech Republic
12:20-12:40	<b>Application of Neural Networks to Denoising of CT Images of Lungs</b>	<b>Emir Turajlić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
12:40-13:00	<b>Application of Big Data and Text Mining Methods and Technologies in Modern Business Analyzing Social Networks Data about Traffic Tracking</b>	<b>Emir Žunić</b> , Info Studio Ltd, Sarajevo, Bosnia and Herzegovina <b>Dženana Đonko</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Almir Djedović</b> , Info Studio LTD, Sarajevo, Bosnia and Herzegovina
13:00-13:20	<b>Forecasting PM10 concentrations using neural networks and system for improving air quality</b>	<b>Maja Muftić Dedović</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Samir Avdaković</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Irfan Turković</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Nedis Dautbašić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Tatjana Konjić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina



13:20-13:40	Optimization of business processes by automatic reallocation of resources using the genetic algorithm	<b>Almir Djedović</b> , Info Studio LTD, Sarajevo, Bosnia and Herzegovina <b>Emir Žunić</b> , Info Studio LTD, Sarajevo, Bosnia and Herzegovina <b>Zikrija Avdagić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Almir Karabegović</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
13:40-14:00	Weighted-function based Algorithm for Retrieving Handwriting Trajectory from Off-line Data	<b>Nermina Ahmić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Emir Sokić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Melita Ahić Đokić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

SESSION 2 - Artificial Intelligence; Signal Processing 2		15:00-16:40
<b>Session Chairs:</b> <b>Zikrija Avdagić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Samir Omanović</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina		
15:00-15:20	A Sequential Approach for Short-Term Water Level Prediction Using Nonlinear Autoregressive Neural Networks	<b>Adis Hamzić</b> , JPEPBiH, Sarajevo, Bosnia and Herzegovina <b>Zikrija Avdagić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Samir Omanović</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
15:20-15:40	Application of Neural Networks to Compression of CT Images	<b>Emir Turajlić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Sarajevo, Bosnia and Herzegovina
15:40-16:00	Decision support system for candidates classification in the employment process based on ANFIS method	<b>Emir Žunić</b> , Info Studio Ltd, Sarajevo, Bosnia and Herzegovina <b>Zikrija Avdagić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Almir Djedović</b> , Info Studio LTD, Sarajevo, Bosnia and Herzegovina
16:00-16:20	The influence of wind speed, humidity, temperature and air pressure on pollutants concentrations of PM10 -	<b>Samir Avdaković</b> , Faculty of Electrical Engineering, University of

	<b>Sarajevo case study using wavelet coherence approach</b>	<p><i>Sarajevo, Sarajevo, Bosnia and Herzegovina</i></p> <p><b>Nedis Dautbašić</b>, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</p> <p><b>Maja Muftić Dedović</b>, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</p> <p><b>Jasenka Dizdarević</b>, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</p>
<b>16:20-16:40</b>	<b>Classification of ON-OFF states of Appliance Consumption Signatures</b>	<p><b>Emir Salihagić</b>, International Burch University, Sarajevo, Bosnia and Herzegovina</p> <p><b>Jasmin Kevrić</b>, International Burch University, Sarajevo, Bosnia and Herzegovina</p> <p><b>Nejdet Dogru</b>, International Burch University, Sarajevo, Bosnia and Herzegovina</p>

<b>SESSION 3 -Communication and Information Theory; Communication and Information System Security</b>		<b>17:00-18:40</b>
<b>Session Chairs:</b> <b>Saša Mrdović</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Alen Begović</b> , BH Telecom JSC, Sarajevo, Bosnia and Herzegovina		
<b>17:00-17:20</b>	<b>A Performance Analysis about Impact of I/Q Imbalance in AF Two-Hop Relay System</b>	<p><b>Tam Nguyen Kieu</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Tan Phuoc Huynh</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Miroslav Voznak</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Thuan Do Dinh</b>, Ho Chi Minh City of Technology and Education, Thu Duc Dist., Ho Chi Minh City, Vietnam</p>

17:20-17:40	An Operation Analysis in DF Full Duplex Relay Network	<p><b>Tam Nguyen Kieu</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Khanh Nhan Nguyen Huu</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Hung Ha Duy</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Long Nguyen Ngoc</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Miroslav Voznak</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p> <p><b>Thuan Do Dinh</b>, Ho Chi Minh City of Technology and Education, Thu Duc Dist., Ho Chi Minh City, Vietnam</p> <p><b>Dominik Uhrin</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p>
17:40-18:00	Security Issues in Wireless Networks: An Overview	<p><b>Sabina Baraković</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Ena Kurtović</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Selmir Ljevaković</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Aleksandar Jokić</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Olja Božanović</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Anes Mirojević</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Mladen Peranović</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Jasmina Baraković Husić</b>, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</p>
18:00-18:20	Short and Sweet: Cloud Computing and Its Security	<p><b>Sabina Baraković</b>, American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina</p> <p><b>Jasmina Baraković Husić</b>, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</p>

<b>18:20-18:40</b>	<b>A simple analysis of copper local loop faults in FTTB environment</b>	<b>Alen Begović</b> , <i>BH Telecom JSC, Sarajevo, Bosnia and Herzegovina</i> <b>Namir Škaljo</b> , <i>BH Telecom JSC, Sarajevo, Bosnia and Herzegovina</i> <b>Narcis Behlilović</b> , <i>Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i>
--------------------	--	---

## Sessions on Tuesday, 25<sup>th</sup> October, 2016

<b>SESSION 4 - Next Generation Networks; Wireless and Radio Communications and Networking</b>		<b>10:00-12:00</b>
<b>Session Chairs:</b> <b>Jasmina Baraković Husić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Jasmin Mušović</b> , Communications Regulatory Agency, Sarajevo, Bosnia and Herzegovina		
<b>10:00-10:20</b>	<b>Functional and Service Architecture of Next Generation Network: BH Telecom Case Study</b>	<b>Jasmina Baraković Husić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Tarik Čaršimamović</b> , BH Telecom, Sarajevo, Bosnia and Herzegovina <b>Sabina Baraković</b> , American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina
<b>10:20-10:40</b>	<b>A Straightforward Method to Evaluate the Energy Aware Two-way Relaying Networks Under Effect of Co-channel Interference</b>	<b>Hoang-Sy Nguyen</b> , Technical University of Ostrava, Ostrava, Czech Republic <b>Dinh-Thuan Do</b> , Eastern International University <b>Miroslav Voznak</b> , Technical University of Ostrava, Ostrava, Czech Republic <b>Lukas Sevcik</b> , Technical University of Ostrava, Ostrava, Czech Republic
<b>10:40-11:00</b>	<b>Two-Way Relay Networks with Energy Harvesting and Information Transfer: Throughput Performance with Distance Allocation</b>	<b>Hoang-Sy Nguyen</b> , Technical University of Ostrava, Ostrava, Czech Republic <b>Dinh-Thuan Do</b> , Eastern International University, Thu Duc Dist., Ho Chi Minh City, Vietnam <b>Miroslav Voznak</b> , Technical University of Ostrava, Ostrava, Czech Republic <b>Lukas Sevcik</b> , Technical University of Ostrava, Ostrava, Czech Republic
<b>11:00-11:20</b>	<b>High-Speed Reliable Data Transfer for Distribution Smart Grid Applications</b>	<b>Tarik Hrnjić</b> , International University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Tarik Đonlagić</b> , Siemens, Nürnberg Area, Germany
<b>11:20-11:40</b>	<b>Software Architecture and Communication Protocols for Integration of Renewables in Distribution Smart Grids</b>	<b>Tarik Hrnjić</b> , International University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Indira Huseinagić</b> , International University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Tarik Đonlagić</b> , Siemens, Nürnberg Area, Germany

11:40-12:00	<b>Conceptual Radio Resource Management Approach in LTE Heterogeneous Networks using Small Cells Number Variation</b>	<b>Nina Slamnik</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Armin Okić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Jasmin Mušović</b> , Communications Regulatory Agency, Sarajevo, Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina
-------------	---	--

<b>SESSION 5 - Modelling and Simulation; Management in Communication Systems and Networks</b>		<b>12:20-14:00</b>
<p style="text-align: center;"><b>Session Chairs:</b>  <b>Jasmin Kevrić</b>, International Burch University, Sarajevo, Bosnia and Herzegovina  <b>Miroslav Voznak</b>, VSB Technical University of Ostrava, Ostrava, Czech Republic</p>		
12:20-12:40	<b>The aspects of consistency management of highly-distributed transactional database in a hybrid cloud environment for the energy sector</b>	<b>Jasmina Dizdarević</b> , KJKP Sarajevogas d.o.o, Sarajevo, Bosnia and Herzegovina <b>Zikrija Avdagić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
12:40-13:00	<b>Impact of Packet Size Variation in Overlay Quantum Key Distribution Network</b>	<b>Miralem Mehić</b> , VSB Technical University of Ostrava, Ostrava, Czech Republic <b>Dan Komosny</b> , Brno University of Technology, Brno, Czech Republic <b>Oliver Mauhart</b> , Austrian Institute of Technology GmbH, Seibersdorf, Austria <b>Miroslav Voznak</b> , VSB Technical University of Ostrava, Ostrava, Czech Republic <b>Jan Rozhon</b> , VSB Technical University of Ostrava, Ostrava, Czech Republic
13:00-13:20	<b>Parallelization Challenges of BFS Traversal on Dense Graphs Using CUDA Platform</b>	<b>Huma Milišić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Dina Ahmić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Hamdija Sinanović</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Emina Šarić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Amar Asotić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina <b>Alvin Huseinović</b> , Faculty of Electrical Engineering, University of

		<i>Sarajevo, Sarajevo, Bosnia and Herzegovina</i>
<b>13:20-13:40</b>	<b>Database Design for Multi-Site Smart Grid Management and Operational Activities</b>	<b>Tarik Hrnjić</b> , <i>International University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i> <b>Alen Savatić</b> , <i>International University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i>
<b>13:40-14:00</b>	<b>Object Oriented Graphical User Interface Development Methodologies for Distribution Smart Grid Applications</b>	<b>Tarik Hrnjić</b> , <i>International University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i> <b>Indira Huseinagić</b> , <i>International University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i> <b>Faruk Pašić</b> , <i>Fraunhofer-Einrichtung, Lübeck, Germany</i>

## Sessions on Wednesday, 26<sup>th</sup> October, 2016

<b>SESSION 6 - Communications Software Services and Multimedia Applications; Embedded Systems</b>		<b>10:40-12:20</b>
<b>Session Chairs:</b> <b>Nejdet Dogru</b> , International Burch University, Sarajevo, Bosnia and Herzegovina <b>Mesud Hadžialić</b> , Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina		
<b>10:00-10:20</b>	<b>Implementation of Internet of Things in the Market of Bosnia and Herzegovina</b>	<b>Amra Sofić</b> , <i>BH Telecom, Sarajevo, Bosnia and Herzegovina</i> <b>Jasmina Baraković Husić</b> , <i>Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i>
<b>10:20-10:40</b>	<b>Customization of Software for an Unprepared Environment and Maintaining Software Stability</b>	<b>Samir Omanović</b> , <i>Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i> <b>Emir Buza</b> , <i>Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i>
<b>10:40-11:00</b>	<b>Practical Implementation of Solar Car Optimized Route Estimation</b>	<b>Damir Bilić</b> , <i>International Burch University, Sarajevo, Bosnia and Herzegovina</i> <b>Mehrija Hasičić</b> , <i>International Burch University, Sarajevo, Bosnia and Herzegovina</i> <b>Harun Šiljak</b> , <i>International Burch University, Sarajevo, Bosnia and Herzegovina</i>
<b>11:00-11:20</b>	<b>An example of mapping the degradation of network parameters with video QoE parameters in case of IPTV service</b>	<b>Nermin Goran</b> , <i>BH Telecom, Sarajevo, Bosnia and Herzegovina</i> <b>Berina Bećiragić</b> , <i>BH Telecom, Sarajevo, Bosnia and Herzegovina</i> <b>Mesud Hadžialić</b> , <i>Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i>
<b>11:20-11:40</b>	<b>Embedded Automatic Scheduling System</b>	<b>Damir Bilić</b> , <i>International Burch University, Sarajevo, Bosnia and Herzegovina</i> <b>Tarik Uzunović</b> , <i>Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina</i>



## Keynote Speakers



### **Evaluation of IEEE 802.11 with Interference**

**Prof. Dr. Chris Blondia**

Professor and head of the research group  
“Performance Analysis of Telecommunication  
Systems“(PATS) at the University of Antwerp  
(UIA)

Oostkamp, Belgium



### **Cognitive Radio for Wireless Communications: Concepts and Applications**

**Prof. Dr. Jae Hong Lee**

IEEE Fellow  
Past President, IEEE Vehicular Technology  
Society, 2010-2011  
Professor, Dept. of Electrical and Computer  
Engineering  
Seoul National University

Seoul, Korea



**Internet of Things for 5G and Beyond:  
Should Communications and Data Analysis  
Remain Separated?**

**Prof. Dr. Dejan Vukobratović**

Associate Professor with the Department of  
Power, Electronic and Communications  
Engineering, University of Novi Sad

Novi Sad, Serbia

## **Book of Abstracts**

## Keynotes

### **Evaluation of IEEE 802.11 with Interference**

**Prof. Dr. Chris Blondia**

Professor and head of the research group "Performance Analysis of Telecommunication Systems"(PATS) at the University of Antwerp (UIA)

While home hotspots offer high and consistent performance, at large-scale events such as conferences and festivals, IEEE 802.11 performance is often poor and highly fluctuating. We start from the results of a large-scale measurement study carried out at a music festival with 80,000 visitors over a geographical area of 0.3 square kilometres. The impact of interference factors such as crowds and RF equipment is illustrated. In order to understand the impact of this interference on the throughput and the delay in an IEEE 802.11 network, we present an analytical model of such a network in the presence of an interfering source, both for the saturated and unsaturated case. Using this model, we derive results for the packet delay and for the throughput of an individual station. The impact of the type of interfering source on the packet delay is also investigated. We also derive a simple approximation of the mean packet delay as a function of the mean packet delay in the IEEE 802.11 network without interference and the characteristics of the interfering source.

This work has been done in collaboration with members of the MOSAIC research group, in particular with Patrick Bosch and Steven Latré.

# **Cognitive Radio for Wireless Communications: Concepts and Applications**

**Prof. Dr. Jae Hong Lee**

IEEE Fellow

Past President, IEEE Vehicular Technology Society, 2010-2011

Professor, Dept. of Electrical and Computer Engineering

Seoul National University

To meet rapidly growing traffic demands and accommodate large number of devices, more radio spectrum is needed for future wireless communications. Considering the scarcity of radio spectrum, it is needed to enhance the utilization of radio spectrum licensed exclusively to specific users. In cognitive radio, an unlicensed user, called a secondary user, is permitted to access the spectrum allocated to a licensed user, called a primary user. When the primary and secondary users transmit their signals simultaneously, interference occurs at both users which degrades their performance. Interference at the primary user can be avoided by spectrum sensing technique which prohibits a secondary user from transmitting its signal when it detects a primary user's signal. Also, interference level at the primary user can be limited below a certain threshold by spectrum sharing technique in which the secondary user adjusts its transmit power accordingly. Some recent results on cognitive radio are introduced, and its applications and future research subjects are shown.

# **Internet of Things for 5G and Beyond: Should Communications and Data Analysis Remain Separated?**

**Prof. Dr. Dejan Vukobratovic**

Associate Professor with the Department of Power, Electronic and Communications Engineering,  
University of Novi Sad

In forthcoming years, the Internet of Things (IoT) will connect billions of devices generating and uploading a deluge of data to the cloud. If successfully extracted, the knowledge buried in the data can significantly improve the quality of life and foster economic growth. However, a critical bottleneck for realizing the efficient IoT is the pressure it puts on the existing infrastructures, requiring transfer and storage of enormous data volumes.

In the first part of this talk, we briefly review ongoing efforts in mobile cellular networking community to provide support for IoT in current and upcoming mobile cellular networking standards. We provide state-of-the-art in technologies standardized within 3rd Generation Partnership Project (3GPP) as part of the fourth-generation (4G) mobile cellular system: enhanced Machine Type Communications (eMTC) and NarrowBand IoT (NB-IoT), and discuss evolution of these services into the 3GPP New Radio (NR) standard (5G).

In the second part of the talk, we present a vision of a novel MTC architecture which aims to integrate IoT communication and data analysis services. In the core of this architecture is the generic concept of network function computation: Instead of merely transferring raw data from the IoT devices to the cloud, the proposed architecture offers a flexible and reconfigurable service that delivers function computations over the input data. From both theoretical and implementation side, we describe how such an architecture can be designed and integrated into the 3GPP architecture, as well as the prospects of making it a practically viable technology in a short time frame relying on Network Function Virtualization (NFV) and Software Defined Networking (SDN).

## **SESSION 1**

Artificial Intelligence;  
Signal Processing

1

### **Session Chairs:**

**Emir Sokić**, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo,  
Bosnia and Herzegovina

**Emir Turajlić**, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo,  
Bosnia and Herzegovina

# VoIP Call Quality Assessment based on RPROP Neural Networks

**Jan Rozhon**

*Cesnet, z.s.p.o, Prague, Czech Republic*

*rozhon@cesnet.cz*

**Miroslav Voznak**

*Cesnet, z.s.p.o, Prague, Czech Republic*

*voznak@cesnet.cz*

**Filip Rezac**

*Cesnet, z.s.p.o, Prague, Czech Republic*

*filip@cesnet.cz*

**Erik Gresak**

*Cesnet, z.s.p.o, Prague, Czech Republic*

*gresak@cesnet.cz*

The modelling of the network effects on the quality of speech in the Voice over IP networks is the main focus of this paper. The main purpose of the ideas presented here is to achieve high-precision estimation of the speech quality in the environments where the classical approaches of speech quality determination fail. To achieve this high precision a modular neural network model is used to map the effects of a packet loss on the speech quality based on the PESQ reference. To incorporate the temporal effects E-model is partially utilized as well. This way a universal tool capable of harnessing the information about the speech quality for stress testing and monitoring of the local infrastructure has been developed enabling the telephony infrastructure administrators to evaluate the performance and stability of the systems in their hands. Moreover, a high-performance simulation environment has been developed as well to ensure sufficient amount of measurement data for the statistical analysis.



# Application of Neural Networks to Denoising of CT Images of Lungs

**Emir Turajlić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*emir.turajlic@etf.unsa.ba*

One of the most challenging problems in the field of digital image processing is image denoising. When processing medical images, it is of particular relevance to improve the perceived quality of images, while preserving the diagnostically relevant information. This paper investigates the capacity of a neural network framework for medical image denoising. Specifically, the performance of the proposed image denoising method is evaluated on a database of the computed tomography images of lungs using various image quality metrics, such as peak signal-to-noise ratio and mean squared error. Image denoising relies on block segmentation of noisy and low-pass filtered images to generate the input and the target data for the neural network training. This paper investigates how the choice of block size, network architecture, and the training method affect the denoising performance when image is degraded with additive Gaussian noise. The paper proposes the use of Kohonen's self-organizing maps for segmentation of feature space and the use of multiple, finely tuned multi-layer perceptrons to achieve an improved denoising performance.

# **Application of Big Data and Text Mining Methods and Technologies in Modern Business Analyzing Social Networks Data about Traffic Tracking**

**Emir Žunić**

*Info Studio Ltd Sarajevo, Sarajevo, Bosnia and Herzegovina*

*emir.zunic@infostudio.ba*

**Dženana Đonko**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*ddonko@etf.unsa.ba*

**Almir Djedović**

*Info Studio Ltd Sarajevo, Sarajevo, Bosnia and Herzegovina*

*almir.djedovic@infostudio.ba*

Big Data is becoming one of the most important technology trends with a potential for a dramatic change in which organizations use information in order to improve the customer's experience and transform their own business models. Big Data as a concept is new in the world of technology and therefore requires research in technological or business sense. Management and analysis of large amount of network offer huge benefits and challenges for all organizations. The amount of information floating through social networks increases every day, and represents a rich source of data, if it is properly processed. The aim of this paper is to show on a concrete example the profit of the system implemented over Big Data from social networks using Text Mining methods and technologies, as well as semantic processing and clustering, storing and possibility of later examination and treatment.

# Forecasting PM10 concentrations using neural networks and system for improving air quality

**Maja Muftić Dedović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*mm14843@etf.unsa.ba*

**Samir Avdaković**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*samir.avdakovic@etf.unsa.ba*

**Irfan Turković**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*iturkovic@etf.unsa.ba*

**Nedis Dautbašić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*nd15231@etf.unsa.ba*

**Tatjana Konjić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*tatjana.konjic@etf.unsa.ba*

In this paper using Artificial Neural Network (ANN) are presented forecasting results of PM10 concentrations for the city of Sarajevo. Input data of the proposed model are meteorological variables (wind speed, humidity, temperature and pressure) and pollution variable (PM10 concentration) recorded in the Federal Institute for Hydrometeorology from 2010 to 2013. The proposed model is tested on the several cases and the results are satisfactory. The results of the forecasting show the different effects that certain meteorological parameters have on the temporal prediction of concentrations of PM10. It can also be concluded that ANN approach is very useful in terms of the time series forecast the concentrations of PM10 particles with good forecasting results. Also, it is presented the idea of a unified system for air quality improvement, which involves a variety of systemic measures in the areas affected by an increase of PM10 concentrations.

# **Optimization of business processes by automatic reallocation of resources using the genetic algorithm**

**Almir Djedović**

*Info Studio Ltd Sarajevo, Sarajevo, Bosnia and Herzegovina*

*almir.djedovic@infostudio.ba*

**Emir Žunić**

*Info Studio Ltd Sarajevo, Sarajevo, Bosnia and Herzegovina*

*emir.zunic@infostudio.ba*

**Zikrija Avdagić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*zavdagic@etf.unsa.ba*

**Almir Karabegović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*akarabegovic@etf.unsa.ba*

Business process management is the process of modifying or adjusting an organization's business process in order to achieve higher productivity or lower costs. Each company or organization has a value creating process that usually involves people, machines and information. One of the main problems with such processes is that it is very difficult to predict how much of each resource is actually needed. In light of the above, the objective of this paper is to implement a methodology that is capable of optimizing the allocation of resources to tasks in a given business process. In this paper, the genetic algorithm was used for optimization. The idea is that once the units are properly presented, the optimal schedule of users should be determined using the genetic algorithm. The fitness function includes Key Performance Indicators of process: waiting time and cost of the resource. Since all the users are not qualified in performing all the tasks in the process, the algorithm has to consider minimal and the maximal available number of users for each activity. The usability of this approach is tested in the process of credit requirement. Finally, the results are compared to the current work process.

# **Weighted-function based Algorithm for Retrieving Handwriting Trajectory from Off-line Data**

**Nermina Ahmić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*nahmic1@etf.unsa.ba*

**Emir Sokić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*esokic@etf.unsa.ba*

**Melita Ahić-Đokić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*amelita@etf.unsa.ba*

Individuality of handwriting is the reason why it is used as a common base element for detecting character traits of the writer. It is believed that dynamic information improve the accuracy of the analysis, but they are not contained in an offline handwritten text. In order to recover dynamic information, a novel approach for handwriting trajectory recovery is proposed in this paper. The procedure is based on computing the objective function, which depends on parameters such as the angle of movement, path length, air pen tip movements, etc. The analysis is performed in MATLAB program package, using the text samples from IAM-OnDB database. The experimental results indicate that the average effectiveness of the proposed algorithm is above 75%.



## **SESSION 2**

Artificial Intelligence;

Signal Processing

2

### **Session Chairs:**

**Zikrija Avdagić**, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo,  
Bosnia and Herzegovina

**Samir Omanović**, Faculty of Electrical Engineering, University of Sarajevo,  
Sarajevo, Bosnia and Herzegovina

# **A Sequential Approach for Short-term Water Level Prediction Using Nonlinear Autoregressive Neural Networks**

**Adis Hamzić**

*JPEPBiH, Sarajevo, Bosnia and Herzegovina*

*hamzicadis87@gmail.com*

**Zikrija Avdagić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*zavdagic@etf.unsa.ba*

**Samir Omanović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*samir.omanovic@etf.unsa.ba*

The water level in an artificial lake is important not only for the production of electric energy but also for other activities such as tourism, irrigation and drought control. The water level in the lake is influenced by various factors, among which the most important include: the water inflow, discharge of water and water seepage. In this research, artificial neural networks (ANN) are selected for the water level prediction because of their well-known abilities for learning from examples. A total of 29 years of water level measurement data was used for ANN training and validation. This paper represents a sequential approach for the short-term water level prediction in Jablanicko lake by using only water level data. With regard to sequential approach for every step of the prediction, the most recent data were used for ANN training. Two types of ANNs were used in this study: Nonlinear Autoregressive (NAR) neural networks and Feed Forward Back Propagation (FFBP) neural networks. The main focus of this study was on NAR networks prediction of water level, while FFBP networks were used for comparison purposes. The results showed that neural networks can provide quality water level prediction even if only water level data is used.

## **Application of Neural Networks to Compression of CT Images**

**Emir Turajlić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*emir.turajlic@etf.unsa.ba*

Efficient compression of medical images is needed to decrease the storage space and enable efficient image transfer over network for access of electronic patient records. Since the medical images contain diagnostically relevant information, it is necessary



for the process of image compression to preserve high levels of image fidelity, especially when the images are compressed at low bit rates. This paper investigates the capacity of an artificial neural network framework for medical image compression. Specifically, the performance of the proposed image compression method is evaluated on a database of computed tomography images of lungs, where PSNR and MSE are used as the principal image quality metrics. The compressed image data is derived from the hidden layer outputs, where the artificial neural networks are trained to reconstruct the network input features. The results of image block segmentation are used as the network training features. The paper proposes the use of Kohonen's self-organizing maps for segmentation of feature space and the use of multiple finely tuned multi-layer perceptrons to achieve an improved compression performance. This paper presents a study on how the choice of block size, network architecture, and training method affect the compression performance. An attempt is made to optimize the artificial neural network framework for the compression of computed tomography lung images.

## **Decision support system for candidates classification in the employment process based on ANFIS method**

**Emir Žunić**

*Info Studio Ltd Sarajevo, Sarajevo, Bosnia and Herzegovina*

*emir.zunic@infostudio.ba*

**Zikrija Avdagić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*zavdagic@etf.unsa.ba*

**Almir Djedović**

*Info Studio Ltd Sarajevo, Sarajevo, Bosnia and Herzegovina*

*almir.djedovic@infostudio.ba*

The aim of this work is to create a decision support system based on Adaptive Neuro-Fuzzy Inference System (ANFIS), which will be used for objective classification of employees in the employment process by analyzing available information about the candidates. Information about the candidates is extracted from the relevant documents on one company during the advertising for job in Information Technology (IT) sector. Filtration and normalization of the data were performed after they had been acquired, the decision support system being realized was implemented in the form of hybrid model, made of fuzzy logic synthesis and neural network, as well as presented by acronym ANFIS. The initial ANFIS system is divided into two subsystems as the result of complexity of the very problem, as well as of more attributes. By training and testing

(checking) the obtained Fuzzy Inference System (FIS) structures, the one with the lowest error is chosen. The operation of the network has been demonstrated by the valuable simulation model. The successful validation of the resulting system has been made by validation data.

## **The influence of wind speed, humidity, temperature and air pressure on pollutants concentrations of PM10 – Sarajevo case study using wavelet coherence approach**

**Maja Muftić Dedović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*mm14843@etf.unsa.ba*

**Samir Avdaković**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*samir.avdakovic@etf.unsa.ba*

**Nedis Dautbašić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*nd15231@etf.unsa.ba*

**Jasenka Dizdarević**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*jd14976@etf.unsa.ba*

The city of Sarajevo as the capital and the largest administrative and economic center in Bosnia and Herzegovina represents one of the most polluted cities in Europe in terms of the concentration of PM10 (particulate matter 10). Scientific and professional communities have particularly been focused on identifying the causes of this situation, and on the introduction of the system of measures to reduce PM10 values to below the limit values. This paper analyzes the impact of meteorological variables (wind speed, humidity, temperature and pressure) to the concentration of PM10 in the city of Sarajevo by using the Wavelet Coherence approach (WTC). Available data indicate actual values recorded in the Federal Institute for Hydrometeorology in 2012. The results of the analysis show the different effects that certain meteorological parameters have on the concentrations of PM10 particles in a time period of one year. It can also be concluded that this approach is very useful in terms of the practical interpretation of available data and it offers a clearer picture of the impact of meteorological conditions on the concentrations of PM10 particles.

# **Classification of ON-OFF states of Appliance Consumption Signatures**

**Emir Salihagić**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*emir.salihagic@stu.ibu.edu.ba*

**Jasmin Kevrić**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*jasmin.kevric@ibu.edu.ba*

**Nejdet Dogru**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*nejdet.dogru@ibu.edu.ba*

Nonintrusive load monitoring (NILM) is a procedure for the analysis of the changes in the power (current and voltage) that goes into households and classifying the appliances used in the house according to their individual energy consumption. Utility companies use smart electric meters accompanied with NILM to examine the particular uses of electric power in households. Focus of this paper is on the analysis of the „ACS-F2 Database of Appliance Consumption Signatures“. The challenge lies in predicting the states of the electrical devices based on the measuring data which had been previously stored. Machine learning techniques have demonstrated to be effective in classification and pattern recognition tasks. In this paper, different algorithms implemented in the WEKA software are going to be used for the classification.



## **SESSION 3**

Communication and Information Theory;  
Communication and Information System Security

### **Session Chairs:**

**Saša Mrdović**, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo,  
Bosnia and Herzegovina

**Alen Begović**, BH Telecom JSC, Sarajevo, Bosnia and Herzegovina

# **A Performance Analysis about Impact of I/Q Imbalance in AF Two-Hop Relay System**

**Tam Nguyen Kieu**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*nguyenkieutam@tdt.edu.vn*

**Tan Phuoc Huynh**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*htphuocsuna@gmail.com*

**Miroslav Voznak**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*miroslav.voznak@vsb.cz*

**Thuan Do Dinh**

*Ho Chi Minh City of Technology and Education, Thu Duc Dist., Ho Chi Minh City, Vietnam*

*dodinhthuan@gmail.com*

**Dominik Uhrin**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*dominik.uhrin@vsb.cz*

In this paper, we investigate the operation of amplify-and forward (AF) two-hop relay networks in the available of in-phase and quadrature-phase imbalance (IQI) at the relay. A close-form analysis is set up in the high signal-to-interference-plus-noise ratio (SINR) mode, where IQI effects in a top result on the SINR. From there, we can see that the time division factor, the energy conversion coefficient, the position of the relay as well as SINR impacting on performance of the IQI system. Depending on practical situation, we can decide to use which model conformably.

# **An Operation Analysis in DF Full Duplex Relay Network**

**Tam Nguyen Kieu**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*nguyenkieutam@tdt.edu.vn*

**Khanh Nhan Nguyen Huu**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*nguyenhuukhanhnhan@tdt.edu.vn*

**Hung Ha Duy**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*haduyhung@tdt.edu.vn*

**Long Nguyen Ngoc**

*Ho Chi Minh City of Technology and Education, Thu Duc Dist., Ho Chi Minh City, Vietnam*

*nguyenngoclong@tdt.edu.vn*

**Miroslav Voznak**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*miroslav.voznak@vsb.cz*

**Thuan Do Dinh**

*Ho Chi Minh City of Technology and Education, Thu Duc Dist., Ho Chi Minh City, Vietnam*

*dodinhthuan@gmail.com*

**Dominik Uhrin**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*dominik.uhrin@vsb.cz*

In recent years, the using of energy having in the natural environment has drawn attention of many researchers in the world. And the energy harvesting (EH) protocol is a ideal point focusing the study of many scientists especially in wireless communication systems. This paper deals with the EH architecture of the full duplex relay networks. Through utilizing the time switching based relaying (TSR) protocol and Decode-and-Forward (DF) model, we extract the approximate clause of throughput and after that work out the maximal throughput of delay-limited (DL) and delay tolerant (DT) models. A worth outcome can be taken evidently that the noise factor, the time fraction, the target ratio as well as the position of relay in TSR effected the maximal throughput. Finally, the numerical results give out a efficient relay strategy of the DT to be better than that of the DL in full duplex cooperative networks.

# Security Issues in Wireless Networks: An Overview

**Sabina Baraković**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*sbarakovic@aubih.edu*

**Ena Kurtović**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*eakc1800@aubih.edu*

**Selmir Ljevaković**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*srlc1730@aubih.edu*

**Aleksandar Jokić**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*arjc1234@aubih.edu*

**Olja Božanović**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*oabc1234@aubih.edu*

**Anes Mirojević**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*asmc1398@aubih.edu*

**Mladen Peranović**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*mnpc1613@aubih.edu*

**Jasmina Baraković Husić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*jasmina.barakovic@etf.unsa.ba*

Wireless mobile communication have grown dramatically in last decades. Due to increased usage of wireless mobile networks and communications in our everyday life, the society has become extremely exposed to cyber security attacks and threats in this environment. In order to provide a basis for further in detail discussion on attacks and security mechanisms in this challenging environment, this paper provides a brief overview of security issues, i.e., attacks, vulnerabilities, and threats in wireless



networks. Based on the review, it may be concluded that future steps in this domain should include in detail investigation of security issues in all addressed networks and their categorization in a unified manner, either by the place they occur, network level, type of damage they cause, security breach level, etc., accompanied by the description of proposed classes.

## **Short and Sweet: Cloud Computing and Its Security**

**Sabina Baraković**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*sbarakovic@aubih.edu*

**Jasmina Baraković Husić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*jasmina.barakovic@etf.unsa.ba*

The emerging and developing technology of cloud computing may be defined as an availability of scalable and easily accessible virtualised resources allowing the various paradigms. Cloud computing thus helps to reduce cost of ownership and management of virtualized resources, lowering the market entry threshold to new players and enabling provisioning of new services. Nevertheless, it is not massively adopted mainly due to tremendous security challenges. Therefore, this paper aims to provide a short overview of cloud computing and its security. The intention is to provide an insight into the basics of the field from the beginner's point of view, including cloud computing security challenges and benefits, as well as current security situation in major cloud players. With this in focus, this paper presents the starting point for our future work, which will follow the world's trends in this field in order to increase the utilization and adaptation of this promising technology.

# **A simple analysis of copper local loop faults in FTTB environment**

**Alen Begović**

*BH Telecom JSC, Sarajevo, Bosnia and Herzegovina*

*alen.begovic@bhtelecom.ba*

**Namir Škaljo**

*BH Telecom JSC, Sarajevo, Bosnia and Herzegovina*

*namir.skaljo@bhtelecom.ba*

**Narcis Behlilović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*narcis.behlilovic@etf.unsa.ba*

This paper introduces a very simple testing scenario for detecting of faults in copper local loop that remains in access network after replacing copper wires from CO (Central Office) to DP (Distribution Point) with optical fibres, i.e. after implementation of FTTB (Fibre to the Building/Basement) solution. The scenario can be useful at first for quick and quite reliable loop troubleshooting, and in particular cases for loop qualification. The first part of the paper gives a short overview of copper loop model in DSL (Digital Subscriber Line) environment, its lead testing scenarios and FTTB solution. A main steps in fault analysis and testing scenario description follow. Below that, a discussion proposed scenario usability and reliability is provided. At the end an experimental verification of the scenario, which is based on data collecting on physical system in commercial exploitation is done.



## **SESSION 4**

Next Generation Networks;  
Wireless and Radio Communications and Networking

### **Session Chairs:**

**Jasmina Baraković Husić**, Faculty of Electrical Engineering, University of Sarajevo,  
Sarajevo, Bosnia and Herzegovina

**Jasmin Mušović**, Communications Regulatory Agency, Sarajevo, Bosnia and  
Herzegovina

# **Functional and Service Architecture of Next Generation Network: BH Telecom Case Study**

**Jasmina Baraković Husić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*jasmina.barakovic@etf.unsa.ba*

**Tarik Čaršimamović**

*BH Telecom, Sarajevo, Bosnia and Herzegovina*

*tarik.carsimamovic@bhtelecom.ba*

**Sabina Baraković**

*American University in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

*barakovic.sabina@gmail.com*

Nowadays, the competitive market in telecommunications field which is characterized by the alterations in technology, as well as business, together with convergence and regulatory pressures is challenging for telecom operators. In order to achieve, maintain, and improve their market position, telecom operators need to redefine their business and capabilities beyond traditional services, and to address associated issues with the purpose of achieving new revenues and differentiation as well. As a starting point, they need to rationalize the use of entities present in its telecommunication system. Therefore, this survey paper provides an overview of these entities according to the functional requirements and architecture of the next generation networks, as well as service offer classification based on relevant international standards on the example of BH Telecom, Joint Stock Company, Sarajevo.

# A Straightforward Method to Evaluate the Energy Aware Two-way Relaying Networks Under Effect of Co-channel Interference

**Hoang-Sy Nguyen**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*sy.nguyen.hoang.st@vsb.cz*

**Dinh-Thuan Do**

*Eastern International University, Binh Duong, Vietnam*

*thuan.do@eiu.edu.vn*

**Miroslav Voznak**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*miroslav.voznak@vsb.cz*

**Lukas Sevcik**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*lukas.sevcik@vsb.cz*

In the energy harvesting scheme, energy from the received information signal and co-channel interference (CCI) signals is scavenged by the self-power relay before it is used to amplify the received signal and finally transmit to the destination. Particularly, the closed-form outage probability expressions are evaluated for tractable performance analysis. In this paper, we also introduce the results of Monte Carlo simulation to prove the tightness of the proposed approximations outage performance. Additionally, it is assumed that the benefits of CCI signals can extend the lifespan of relaying systems and enhance energy efficiency at the self-power relay.

# Two-Way Relay Networks with Energy Harvesting and Information Transfer: Throughput Performance with Distance Allocation

**Hoang-Sy Nguyen**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*sy.nguyen.hoang.st@vsb.cz*

**Dinh-Thuan Do**

*Eastern International University, Binh Duong, Vietnam*

*thuan.do@eiu.edu.vn*

**Miroslav Voznak**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*miroslav.voznak@vsb.cz*

**Lukas Sevcik**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*lukas.sevcik@vsb.cz*

In this paper, we analyse the performance analysis for two and three time slot transmission schemes (2TS and 3TS) for two-way Amplify-and-Forward (AF) relaying networks which are developed by wireless power and data transfer, where the energy harvesting (EH) relay node helps interchange information between two nodes. We derive the throughput and the approximate expressions of outage probability of the 2TS, 3TS transmission schemes and compare these results with the distance allocation between source node to relay and relay to destination node, and the large scale path loss in order to observe throughput performance. It is noted that these transmission schemes can significantly enhance the system performance.

# High-Speed Reliable Data Transfer for Distribution Smart Grid Applications

**Tarik Hrnjić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*thrnjic00@gmail.com*

**Tarik Đonlagić**

*Siemens PTI, Nürnberg Area, Germany*

*tarik.donlagic@siemens.com*

Smart grid can be viewed as a modern electric power grid infrastructure with enhanced reliability, flexibility and efficiency that is achieved through automated control of production and distribution of electric power, modern communications infrastructure, smart monitoring devices, and renewable energy resources. New features introduced by smart grid means that substation communication is more complex than that of traditional power grid. Due to the data requirements of the smart grid, new challenges have arisen at the network layer of OSI model with respect to the reliable and efficient exchange of data between smart grid substations. This paper aims to analyze applicability of different protocols in distributed smart grid environment. Pragmatic General Multicast (PGM) protocol was tested to identify how it responds to high network traffic conditions, varying message sizes and number of receivers. Obtained transfer rates by PGM was also compared with transfer rates of conventional TCP/IP protocol when applied in multi-site smart grid environment.



# Software Architecture and Communication Protocols for Integration of Renewables in Distribution Smart Grids

**Tarik Hrnjić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*thrnjic00@gmail.com*

**Indira Huseinagić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*ihuseinagic@ius.edu.ba*

**Tarik Đonlagić**

*Siemens PTI, Nürnberg Area, Germany*

*tarik.donlagic@siemens.com*

Electricity market designs are continuously undergoing change in an effort to improve and respond to technology, economic and policy changes. Increasing amounts of variable renewables are a catalyst for additional market evolution. Markets work best when there is transparency between market player. The creation of smarter distribution grid started by developing an advanced metering infrastructure (AMI) and the corresponding communication infrastructure that can take satisfy the communication demands of AMI, as AMI is made up of smart meters which enable almost real-time bidirectional communication. This enables the companies to monitor consumers' energy usage in hourly intervals, as to provide better service. Before the invention of smart meters, power consumption readings were not taking the time of energy consumption into consideration, only the total amount of energy consumed. Smart meters enable the users to optimize their energy consumption to reduce costs. This paper proposes software architecture, communication protocol selection, and provides solution of AMI integration in distribution smart grid applications.

# **Conceptual Radio Resource Management Approach in LTE Heterogeneous Networks using Small Cells Number Variation**

**Nina Slamnik**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*nslamnik1@etf.unsa.ba*

**Armin Okić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*aokic1@etf.unsa.ba*

**Jasmin Mušović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*jmusovic@rak.ba*

As a profound and evident future trend in the field of mobile communication technologies development, heterogeneous networks became one of the crucial points of interests in wireless networks industry and academic research societies. Considering heterogeneous networks as an inseparable concept from LTE networks nowadays, which remain at position of advanced cellular system, the researchers aim to observe and solve the possible problems of inter-cell interference from the aspect of radio resource management. Hence, the lattermost trends consider heterogeneous networks through the process of connecting energy-efficient small cells to macrocells, due to undeniable importance of energy-efficient solution deployment, which was briefly presented in this paper. Also, the combination of radio resource management and heterogeneous networks turned out to be a practical compound of modern telecommunication techniques and technologies which provides a huge spectrum of possibilities for improving telecommunication services with minimized costs and increased efficiency of the whole system. The concept of radio resource management used in this paper was practically tested by small cells number variation within LTE HetNet set up in NS3 simulation environment.



## **SESSION 5**

Modelling and Simulation;  
Management in Communication Systems and Networks

### **Session Chairs:**

**Jasmin Kevrić**, International Burch University, Sarajevo, Bosnia and Herzegovina

**Miroslav Voznak**, VSB Technical University of Ostrava, Ostrava, Czech Republic

# **The aspects of consistency management of highly-distributed transactional database in a hybrid cloud environment for the energy sector**

**Jasmina Dizdarević**

*KJKP Sarajevogas d.o.o., Sarajevo, Bosnia and Herzegovina*

*jasminad@sarajevogas.ba*

**Zikrija Avdagić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*zikrija.avdagic@etf.unsa.ba*

For many years, there are tendencies to support collaborative work of companies of the energy sector, but only the arrival of cloud computing open the door for the implementation of these ideas and aspirations. This actually means a transition to advanced business model and platform with possibilities for launching energy efficient convergent services. From currently available cloud deployment models, as adequate for the energy sector will be considered a hybrid model, as a very efficient, flexible and comprehensive solution. Immediately after the establishment of a common cloud environment the focus of research redirects to the crucial problem of the organization and management of this complex, highly-distributed environment? Especially regarding transactional cloud database and maintaining its consistency. So far, there have been applied conventional methods for preserving consistency and the other ACID rules in highly-distributed transactional environments. However, the actual goal is to make a step forward and to find the optimal solution for preserving the consistency of the entire cloud DBMS. Therefore, this paper discusses adaptable and dynamic approach to preserving consistency of transactional cloud database called TBC (Tree-Based Consistency) approach. It will be shown that this approach provides optimal results and the expected performance of the entire cloud environment.

# Impact of Packet Size Variation in Overlay Quantum Key Distribution Network

**Miralem Mehić**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*miralem.mehic.st@vsb.cz*

**Dan Komosny**

*Brno University of Technology, Brno, Czech Republic*

*komosny@feec.vutbr.cz*

**Oliver Mauhart**

*Austrian Institute of Technology GmbH, Seibersdorf, Austria*

*oliver.maurhart@ait.ac.at*

**Miroslav Voznak**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*miroslav.voznak@vsb.cz*

**Jan Rozhon**

*VSB Technical University of Ostrava, Ostrava, Czech Republic*

*jan.rozhon@vsb.cz*

Quantum Key Distribution (QKD), based on the laws of physics rather than the computational complexity of mathematical problems, provides an information-theoretically secure way of establishing symmetrical binary keys between two geographically distant users. This paper is oriented to the practical realization of QKD public channels which are usually implemented as overlay point-to-point connections. We address the problem of minimizing the key material consumption by changing packet overhead. Our results show that the efficiency of communication in overlay QKD networks may increase when packets of larger sizes are used. However, this tuning directly affects the performance of overall communication. We evaluated this approach using an overlay network module which was implemented in the NS-3 simulator. The obtained results can be used for other overlay networks as well.

# Parallelization Challenges of BFS Traversal on Dense Graphs Using the CUDA Platform

**Huma Milišić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*hmilic1@etf.unsa.ba*

**Dina Ahmić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*dahmic1@etf.unsa.ba*

**Hamdija Sinanović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*hsinanovic1@etf.unsa.ba*

**Emina Šarić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*esaric1@etf.unsa.ba*

**Amar Asotić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*aasotic1@etf.unsa.ba*

**Alvin Huseinović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*ahuseinovic@etf.unsa.ba*

This paper presents challenges encountered while parallelizing an existing sequential algorithm. A breadth-first search implementation in CUDA C++ of quadratic time complexity is used. Even though BFS might seem like an easily parallelizable problem due to many independent iterations over graph vertices, there are other important aspects which need to be considered. Properties like granulation, communication and load balancing are thoroughly examined to find their exact impact in BFS. The implementation is profiled to find bottlenecks and problems which prevent its further optimization.

# Database Design for Multi-Site Smart Grid Asset Management and Operational Activities

**Tarik Hrnjić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*thrnjic00@gmail.com*

**Alen Savatić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*alen@savatic.net*

Smart grid introduces new communication demands, as well as multitude of new hardware, software and other asset types that increase the demand for reliable and secure asset management software. This paper explores the database design and implementation of a smart grid asset management application. While relational databases provide excellent platform upon which to build software, the focus of this paper is on object oriented database management system (OODBMS), which provides excellent model of real-life challenges in asset management. Furthermore, object oriented database can readily be converted into software where each class models one database table. This makes it easier to develop software on target database design.



# **Object Oriented Graphical User Interface Development Methodologies for Distribution Smart Grid Applications**

**Tarik Hrnjić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*thrnjic00@gmail.com*

**Indira Huseinagić**

*International University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*ihuseinagic@ius.edu.ba*

**Faruk Pašić**

*Fraunhofer-Einrichtung, Lübeck, Germany*

*faruk.pasic@iem.fraunhofer.de*

Smart grid introduces numerous tools and services that did not exist in traditional distribution grids. Software for these new services will have to be developed. This paper shows how it is possible to introduce certain software development methodologies in smart grid application development, especially for the development of user friendly interface. Such development methodologies offer increasing benefits at all stages of software development life cycle (SDLC), especially at implementation and maintenance phases. Paper demonstrates how methodologies like model driven software development (MDSD) help developers to deliver reliable software quickly, while making sure future maintenance can be done in a cost efficient way.



## **SESSION 6**

Communications Software Services and Multimedia Applications;  
Embedded Systems

### **Session Chairs:**

**Nejdet Dogru**, International Burch University, Sarajevo, Bosnia and Herzegovina

**Mesud Hadžialić**, Faculty of Electrical Engineering, University of Sarajevo, Sarajevo,  
Bosnia and Herzegovina

# **Implementation of Internet of Things in the Market of Bosnia and Herzegovina**

**Amra Sofić**

*BH Telecom, Sarajevo, Bosnia and Herzegovina*

*amra.sofic@bhtelecom.ba*

**Jasmina Baraković Husić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*jasmina.barakovic@etf.unsa.ba*

The potential benefits of Internet of Things (IoT) are numerous and diverse spreading through all areas of everyday life of individuals, enterprises and society as a whole. Telecommunications sector enjoys a central role in the world of IoT because of owning communication infrastructure and already built relationship of trust with a variety of users including control of large amounts of data about them and their online activities. The growth of IoT requires the change of current communication infrastructure including wireless and wired networks being used in order to fulfil the market needs. In order to provide scalability and flexibility which are required by the market to maximize the potential of IoT, the standardization is needed. Therefore, this paper is intended to the telecommunication sector of Bosnia and Herzegovina with the aim to highlight the importance of necessity of coordinated development of business models and communication infrastructure according to the relevant standards and market needs.

## **Customization of Software for an Unprepared Environment and Maintaining Software Stability**

**Samir Omanović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*somanovic@etf.unsa.ba*

**Emir Buza**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*ebuza@etf.unsa.ba*

Customization of the existing software for a new customer can become problematic if negative factors are not controlled and prevented. This paper discusses customization of software product line (SPL) for an unprepared environment and emphasis

importance of identifying this risk factor. The SPL can be viewed as a set of applications for similar environments that share many common elements (processes, interfaces, data models, etc.), but it is important that each instance in the SPL application family is also viewed as a consistent and stable system that has some specific properties, comparing to others. SPL customization – implementing those specific properties should not endanger stability of the common elements and the system as a whole. Very often preparation for the SPL customization is not as serious as for developing a new software product. That can cause SPL customization for a pretty unknown environment which can be unprepared for accepting such software. Environment that is not willing or not capable to accept (or understand) software in its full potential is named unprepared environment, in this paper. Problems that can arise in an unprepared environment can cause that implemented system is unstable or improperly used, which is described through the case study.

## **Practical Implementation of Solar Car Optimized Route Estimation**

**Damir Bilić**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*damir.bilic@ibu.edu.ba*

**Mehrija Hasičić**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*mehrija.hasicic@ibu.edu.ba*

**Harun Šiljak**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*hsiljak@ibu.edu.ba*

Solar Car Optimized Route Estimation (SCORE) has been proposed in an earlier publication as an alternative navigation principle for solar cars, conducting route optimization based on both distance and solar irradiance data. This paper gives details about the implementation and discusses results of SCORE's use, suggesting possible limitations and future research directions. The results show limited applicability of solar irradiance data for route optimization, but suggesting that parking place selection is an important aspect that needs to be taken care of. The implementation uses both a MATLAB testbed application and C/C++ code for TI's ARM Cortex-M4F based TM4C123G LaunchPad, and the final version of the SCORE client is placed in a custom built solar vehicle. Combined with the previously developed server for sensor data collection and data processing and sensor transmitter infrastructure for solar irradiation, the route optimization system is fully operational.

# **An example of mapping the degradation of network parameters with video QoE parameters in case of IPTV service**

**Nermin Goran**

*BH Telecom, Sarajevo, Bosnia and Herzegovina*

*nermin.goran@bhtelecom.ba*

**Berina Bećiragić**

*BH Telecom, Sarajevo, Bosnia and Herzegovina*

*berina.beciragic@bhtelecom.ba*

**Mesud Hadžialić**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*mesud.hadzialic@etf.unsa.ba*

This paper aims to consider how changes in QoS (Quality of Service) indicators affect the quality of IPTV (Internet Protocol TeleVision) video. Degradation of QoS indicators can occur at any point in time, when the value of transfer channel function changes or if there is an appearance of additional noise. Therefore, for this purpose it is necessary to conduct a temporal analysis of the impact of the QoS indicator degradation on the delivery of MM (Multimedia) service in real time. Also, the phenomenon of degradation of QoS can be associated with queues, flow control or with analog-to-digital conversions that occur on the network elements. The combination of all these phenomena in the higher layers of the OSI (Open System Interconnection) reference model can be identified as packet loss, delay or jitter, and this paper examines their impact on the level of video perception by the end consumer. That perception can be identified as QoE (Quality of Experience).

# **Embedded Automatic Scheduling System**

**Damir Bilić**

*International Burch University, Sarajevo, Bosnia and Herzegovina*

*damir.bilic@ibu.edu.ba*

**Tarik Uzunović**

*Faculty of Electrical Engineering, University of Sarajevo, Sarajevo, Bosnia and Herzegovina*

*tuzunovic@etf.unsa.ba*

This paper describes an embedded system for the automation of scheduling systems such as school bells, factory shift changes, military drills etc. The system consists of two parts: a remote node used for remote control and setup of the system and the real time actuator node which controls a physical object, for example, a bell system. The hardware and software structure are illustrated in detail for both parts of the system through the implementation as an automatic school bell system.





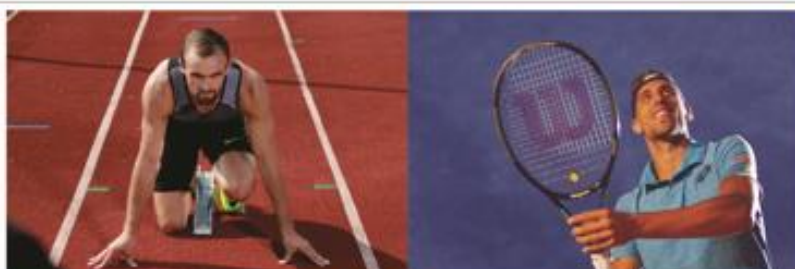
## Author Index

- Adis Hamzić 26  
Aleksandar Jokić 6  
Alen Begović 57  
Alen Savatić 30  
Almir Djedović 36, 37, 44  
Almir Karabegović 44  
Alvin Huseinović 24  
Amar Asotić 24  
Amra Sofić 11  
Anes Mirojević 6  
Armin Okić 62  
Berina Bećiragić 34  
Damir Bilić 21, 42  
Dan Komosny 23  
Dina Ahmić 24  
Dinh-Thuan Do 8, 51  
Dominik Uhrin 5  
Dženana Đonko 36  
Emina Šarić 24  
Emir Buza 20  
Emir Salihagić 41  
Emir Sokić 27  
Emir Turajlić 60, 61  
Emir Žunić 36, 37, 44  
Erik Gresak 9  
Faruk Pašić 52  
Filip Rezac 9  
Ha Duy 5  
Hamdija Sinanović 24  
Harun Šiljak 21  
Hoang-Sy Nguyen 8, 51  
Huma Milišić 24  
Indira Huseinagić 52, 54  
Irfan Turković 40  
Jan Rozhon 9, 23  
Jasenka Dizdarević 39  
Jasmin Kevrić 41  
Jasmin Mušović 62  
Jasmina Baraković Husić 6, 7, 11, 45  
Jasmina Dizdarević 10  
Khanh Nhan Nguyen Huu 5  
Long Nguyen Ngoc 5  
Lukas Sevcik 8, 51  
Maja Muftić Dedović 39, 40  
Mehrija Hasičić 21  
Melita Ahić Đokić 27  
Mesud Hadžialić 34  
Miralem Mehić 23  
Miroslav Voznak 4, 5, 8, 9, 23, 51  
Mladen Peranović 6  
Namir Škaljo 57  
Narcis Behlilović 57  
Nedis Dautbašić 40, 39  
Nejdet Dogru 41  
Nermin Goran 34  
Nermina Ahmić 27  
Nina Slamnik 62  
Oliver Mauhart 23  
Olja Božanović 6  
Sabina Baraković 6, 7, 45  
Samir Avdaković 39, 40  
Samir Omanović 20, 26  
Selmir Ljevaković 6  
Tam Nguyen Kieu 4, 5  
Tan Phuoc Huynh 4  
Tarik Čaršimamović 7  
Tarik Đonlagić 53, 54  
Tarik Hrnjić 30, 52, 53, 54  
Tarik Uzunović 42  
Tatjana Konjić 40  
Thuan Do Dinh 4, 5  
Zikrija Avdagić 10, 26, 37, 44



# Dobre priče nastavljamo...

u sportu



kulturi i  
umjetnosti

humanitarnom  
radu



... nauči i obrazovanju, zaštiti životne sredine i mnogim drugim oblastima,  
jer je život bh. građana i naša društvena odgovornost.

## BH Telecom



[www.bhtelecom.ba](http://www.bhtelecom.ba)







Comtrade Digital Services is a provider of strategic software engineering services and solutions. We enable companies across different industries to innovate faster and reinvent their business models digitally by using agile development methodologies, innovative technology and business acumen.

We focus on global delivery and implementation in digital banking, mobility & travel, healthcare, logistics, public sector and telco. With over 25 years of hands-on experience Comtrade Digital Services has built a proven track records of successful projects with Ryanair, HMM, Vodafone, Skrill (PaySafe), BT, HP, Vanderlande, Addiko Bank, VitaSystems, Roche. Company has over 1500 employees and is headquartered Dublin, Ireland.

**BIHTEL 2016 Notes**











