LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : PROSIDING

Judul Karya Ilmiah	:	Implementation of Vehicle Traffic Analysis Using Background Subtraction in The Internet of Things (IoT) Architecture		
Jumlah Penulis	:	7 orang **(Aghus Sofwan**, Fuad Ashabus Surur, M. Arfan, Eko Handoyo, Yosua Alvin A.S., Maman Somantri, Enda W.S.)		
Status Pengusul	:	Penulis Ke-1		
Identitas Prosiding	:	a. Judul Prosiding	:	**The 2018 6th International Conference on Information and Communication Technology**
		b. ISBN/ISSN	:	978-1-5386-4572-0, Hal : 24-27
		c. Thn Terbit, Tempat Pelaks.	:	Bandung, 3-5 Mei 2018
		d. Penerbit/Organiser	:	IEEE Xplore (Institute of Electrical and Electronics Engineers)
		e. Alamat Repository/Web	:	https://ieeexplore.ieee.org/document/8528739
		Alamat Artikel	:	https://doc-pak.undip.ac.id/7649/1/ICoICT.2018.8528739.pdf
		f. Terindeks di (jika ada)	:	Scopus

Kategori Publikasi Makalah (beri ✓pada kategori yang tepat) : [√] *Prosiding* Forum Ilmiah Internasional
[ ] *Prosiding* Forum Ilmiah Nasional

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Komponen Yang Dinilai	Nilai Reviewer		Nilai Rata-rata
	Reviewer I	Reviewer II	
a. Kelengkapan unsur isi prosiding (10%)	2,50	2,50	2,50
b. Ruang lingkup dan kedalaman pembahasan (30%)	7,50	7,00	7,25
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	7,00	7,00	7,00
d. Kelengkapan unsur dan kualitas terbitan/prosiding(30%)	7,00	7,00	7,00
Total = (100%)	**24,00**	**23,50**	**23,75**
Nilai Pengusul = (60% x 23,75) = 14,25			

Semarang,

Reviewer 2

Dr. Wahyudi, S.T., M.T.
NIP. 196906121994031001
Unit Kerja : Teknik Elektro FT UNDIP

Reviewer 1

Dr. Eng. Wahyul Amien Syafei, ST, MT
NIP. 197112181995121001
Unit Kerja : Teknik Elektro FT UNDIP

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b. Ruang lingkup dan kedalaman pembahasan (30%)	7,50		7,50
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	7,50		7,00
d. Kelengkapan unsur dan kualitas terbitan/prosiding(30%)	7,50		7,00
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Catatan Penilaian Paper oleh Reviewer :

1. **Kesesuaian dan kelengkapan unsur isi paper:** Makalah telah ditulis sesuai dengan kaidah penulisan proceeding IEEE. Terdapat abstract, introduction, system architecture yang memuat metodologi penelitian yang terstruktur, result and discussion, conclusion, dan references.

2. **Ruang lingkup dan kedalaman pembahasan:** Ruang lingkup makalah cukup fokus dengan pembahasan detil dari teori hingga implementasi sistem anaisis trafik dalam arsitektur IoT.

3. **Kecukupan dan kemutakhiran data/informasi dan metodologi:** Referensi berasal dari paper-paper yang mutahir. Terdapat 10 dari 11 referensi berasal dari 5 tahun terakhir

4. **Kelengkapan unsur dan kualitas terbitan:** Makalah telah terbit di proceeding IEEE dan telah terindeks di database IEEExplore dan Scopus.

Semarang,
Reviewer 1

Dr. Eng. Wahyul Amien Syafei, ST, MT
NIP. 197112181995121001
Unit Kerja : Teknik Elektro FT UNDIP

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		f. Terindeks di (jika ada)	:	Scopus

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[ ] *Prosiding* Forum Ilmiah Nasional

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	Nilai Maksimal Prosiding		Nilai Akhir Yang Diperoleh
	Internasional [25]	Nasional [ ]	
a. Kelengkapan unsur isi prosiding (10%)	2,50		2,50
b. Ruang lingkup dan kedalaman pembahasan (30%)	7,50		7,00
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	7,50		7,00
d. Kelengkapan unsur dan kualitas terbitan/prosiding(30%)	7,50		7,00
Total = (100%)	**25,00**		**23,50**
Nilai Pengusul = (60% x 23,50) = 14,10			

Catatan Penilaian Paper oleh Reviewer :

a) **Kesesuaian dan kelengkapan unsur isi paper:**
Unsur makalah telah lengkap ada pendahuluan, metodologi, pembahasan, kesimpulan, dan daftar pustaka

b) **Ruang lingkup dan kedalaman pembahasan:**
Pembahasan cukup mendalam, fungsi cukup lengkap, namun pembahasan merupakan hal yang sederhana

c) **Kecukupan dan kemutakhiran data/informasi dan metodologi:**
Metodologi yang dipakai sudah biasa dilakukan, dan data referensi sebagian besar baru

d) **Kelengkapan unsur dan kualitas terbitan:**
Unsur makalah telah lengkap dan kualitas terbitan pada seminar internasional terindeks Scopus

Semarang,
Reviewer 2

Dr. Wahyudi, S.T., M.T.
NIP. 196906121994031001
Unit Kerja : Teknik Elektro FT UNDIP

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Certificate of Appreciation

This is to certify that

AGHUS SOFWAN

has participated as a

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"Implementation of Vehicle Traffic Analysis Using Background Subtraction in The Internet of Things (IoT) Architecture"

in the

6th International Conference On Information And Communication Technology (ICoICT 2018)

Theme:

"Connecting Sensors, Machines and Societies"

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8 November 2018, Article number 8528739, Pages 24-27
6th International Conference on Information and Communication Technology, ICoICT 2018;
Bandung; Indonesia; 3 May 2018 through 4 May 2018; Category numberCFP18ICZ-USB;
Code 142364

Implementation of vehicle traffic analysis using background subtraction in the Internet of Things (IoT) architecture (Conference Paper)

Sofwan, A. ✉, Surur, F.A. ✉, Arfan, M. ✉, Handoyo, E. ✉, Yosua Alvin, A.S. ✉, Somantri, M. ✉, Enda, W.S. ✉

Department of Electrical Engineering, Diponegoro University, Indonesia

Abstract

View references (11)

Vehicle traffic analysis is one of the features that are provided in a smart city application. A camera is used to capture vehicles that are moving through on the road. Background subtraction is applied in order to detect the moving object, i.e., Gaussian Mixture Model. The system is developed under the Internet of Things (IoT) architecture, which all devices are associated using Internet connection. The calculated value is transmitted into cloud and received at the virtual server. Data are saved to a database and are able to be accessed through a web interface. We observe the applied system provides a good performance in terms of average accuracy exceeds 95.64%. © 2018 IEEE.

SciVal Topic Prominence

Topic: Sensor networks | Sensor nodes | wireless visual

Prominence percentile: 87.850

Author keywords

Background subtraction | Gaussian Mixture Model | Internet of Things | Smart city | Vehicle traffic

Indexed keywords

Engineering controlled terms: Gaussian distribution | Object detection | Smart city | Vehicles

Engineering uncontrolled terms: Background subtraction | Calculated values | Gaussian Mixture Model | Internet connection | Internet of thing (IOT) | Smart city applications | Vehicle traffic | Virtual servers

Engineering main heading: Internet of things

ISBN: 978-153864571-0
Source Type: Conference Proceeding
DOI: 10.1109/ICoICT.2018.8528739
Document Type: Conference Paper

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0 days 0 hrs 0 min 0 sec

Prof Robin Ram Mohan Doss

Keynote Speaker

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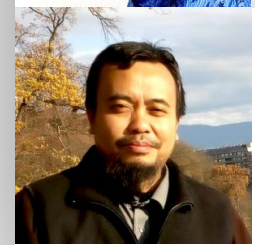

Deputy Head of School, Faculty of Science, Engineering and Built Environment, School of Information Technology
Deakin University, Australia

Professor Robin Doss is the Deputy Head of the School of Information Technology at Deakin University, Australia. Prior to joining Deakin University, Robin was a part of the technical services group at Ericsson Australia and a research engineer at RMIT University. He holds a Bachelor's of Engineering from the University of Madras, India and a Masters and PhD from the Royal Melbourne Institute of Technology (RMIT), Australia.

Robin leads the Internet of Things (IoT) and Cyber Physical Systems(CPS) security program at the Deakin Centre for Cyber Security Research (CSSR) and is the Co-Director of the IoT research cluster at Deakin University, Australia. He leads a team of researchers and PhD students in the broad areas of communication systems and cyber security with a focus on

Prof. Koo Voon Chet

Keynote Speaker

OTHER SPEAKERS

Faculty of Engineering and Technology, Multimedia University (MMU), Malaysia

Voon-Chet KOO graduated from University of Malaya in 1997, and received his MEngSc and PhD degrees in Microwave Engineering from the Multimedia University (MMU), Malaysia in 1999 and 2005, respectively. He is currently a full Professor of Multimedia University. His research interest includes remote sensing technologies, signal processing, and embedded system design. Prof Koo has been a principal consultant for various government agencies and engineering firms since 2000. He has published more than 100 papers in refereed journals, international conferences, 2 books, and 9 patents. He is also the recipient of the inaugural Young Engineer Award by the Institution of Engineers, Malaysia in 2004.

Prof. Koo has more than 20 years of experience in remote sensing and related technologies, particularly on high-resolution imaging system for environmental monitoring and earth resource management. He is a regular invited speaker in international conferences and has delivered guest lectures and

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Bandung, Indonesia. 3-4 May 2018

0 days 0 hrs 0 min 0 sec

Dr. Eng. Khoirul Anwar

Keynote Speaker

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OTHER SPEAKERS

Center for Advanced Wireless Technologies, School of Electrical Engineering
Telkom University, Indonesia

Dr. Anwar graduated (cum laude) from the department of Electrical Engineering (Telecommunications), Institut Teknologi Bandung (ITB), Bandung, Indonesia in 2000 for his Bachelor degree (S.T.). He received Master and Doctor Degrees from Graduate School of Information Science, Nara Institute of Science and Technology (NAIST), Nara, Japan, in 2005 and 2008, respectively. He received best student paper award from the IEEE Radio and Wireless Symposium 2006 (RWS'06), California, USA, Best Paper Award of Indonesian Student Association (ISA 2007), Kyoto, Japan in 2007, Best Paper Presenter for the Advanced Technology in International conference on Sustainability for Human Security (SUSTAIN), Kyoto, October 2011, Indonesian Diaspora "**Award for Innovation**", Congress of Indonesian Diaspora, Los Angeles, USA, July 2012, Achmad Bakrie Award 2014, Jakarta, December 2014, and Anugerah of

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David Rydeheard, The University of Manchester, United Kingdom (Great Britain)
Norsaremah Salleh, International Islamic University Malaysia, Malaysia

occur once in a 100 years (100 year return period), historical wind data of at least 30 years is needed for extreme value analysis. For longer return period, longer historical wind and wave data are needed. This may lead to a new challenge, big data of of historical climate data (specifically wind and wave). In this talk, we present briefly about modelling process of water wave, numerical implementations, computing process, and extreme value analysis, that are put in a perspective of scientific work as well as real applications in industry.

Saturday, May 5, 09:20 - 09:50

Coffee Break TOP

Saturday, May 5, 09:50 - 10:40

Best Paper Award Announcement TOP

Saturday, May 5, 10:40 - 11:00

Closing Speech by ICoICT 2018 Chairman TOP

Saturday, May 5, 11:00 - 11:45

Lunch TOP

Thursday, May 3, 14:00 - 15:15

Parallel Session Track 1B: Connecting Machines TOP

Toward Full Enterprise Software Support on nDPI
Gregorius Radityatama (Swiss German University, Indonesia); Charles Lim (Swiss German University & Universitas Indonesia, Indonesia); Heru Ipung (Swiss German University, Indonesia)
pp. 1-6

Utilization of Onboard Diagnostic II (OBD-II) on Four Wheel Vehicles for Car Data Recorder Prototype
Satrio Nugroho and Endro Ariyanto (Telkom University, Indonesia); Andrian Rakhmatsyah (School of Computing - Telkom University, Indonesia)
pp. 7-11

Collision-Aware Rate Adaptation Algorithm for High-Throughput IEEE 802.11n WLANs
Fajari Setia, Teuku Yuliar Arif and Rizal Munadi (Syiah Kuala University, Indonesia)
pp. 12-17

An Architecture for M2M Communications over Cellular Networks Using Clustering and Hybrid TDMA-NOMA
Md. Farhad Hossain (Bangladesh University of Engineering and Technology (BUET), Bangladesh); Anthonya Rozario (BRAC University, Bangladesh)
pp. 18-23

Implementation of Vehicle Traffic Analysis Using Background Subtraction in The Internet of Things (IoT) Architecture
Aghus Sofwan, Fuad Surur, M Arfan, Eko Handoyo, Yosua Alvin A. S., Maman Somantri and Enda Sinuraya (Diponegoro University, Indonesia)
pp. 24-27

Parallel Session Track 1C: Connecting Societies TOP

An Evaluation of E-Readiness Cloud Computing Service Model Adoption On Indonesian Higher Education
Soni Fajar Surya Gumilang and Heru Nugroho (Telkom University, Indonesia)
pp. 28-33

Throughput Maximization Based On User Association In Heterogeneous Networks
Khalid Mohamed and Mohamad Yusoff Alias (Multimedia University, Malaysia); Mardeni Roslee (MMU, Malaysia); Mohammed Jaber Alam (Multimedia University, Malaysia)
pp. 34-37

Rejuvenation Action Model for Application Software
Jamaiah Yahaya (The National University of Malaysia & Faculty of Information Science and Technology, Malaysia); Zaiha Nadiah Zainal Abidin (Faculty of Information Science and Technology, UKM, Malaysia); Zuriani Hayati Abdullah (Universiti Kebangsaan Malaysia, Malaysia); Aziz Deraman (University Malaysia Terengganu, Malaysia)
pp. 38-43

Artificial Neural Network for Predicting Indonesia Stock Exchange Composite Using Macroeconomic Variables
Andry Alamsyah (Telkom University & School of Economics and Business, Indonesia); Asri Nurfathi (Telkom University, Indonesia)
pp. 44-48

Usability Evaluation of Digital Service Company Portal Using Importance Performance Analysis
Yati Rohayati, Sari Wulandari and Kartika Sari (Telkom University, Indonesia)
pp. 49-54

Parallel Session Track 1E: Connecting Data TOP

Analysis of Non Negative Double Singular Value Decomposition Initialization Method on Eigenspace-based Fuzzy C-Means Algorithm For Indonesian Online News Topic Detection
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Implementation of Vehicle Traffic Analysis Using Background Subtraction in The Internet of Things (IoT) Architecture

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***Abstract*—Vehicle traffic analysis is one of the features that are provided in a smart city application. A camera is used to capture vehicles that are moving through on the road. Background subtraction is applied in order to detect the moving object, i.e., Gaussian Mixture Model. The system is developed under the Internet of Things (IoT) architecture, which all devices are associated using Internet connection. The calculated value is transmitted into cloud and received at the virtual server. Data are saved to a database and are able to be accessed through a web interface. We observe the applied system provides a good performance in terms of average accuracy exceeds 95.64%.**

Keywords— Internet of Things; background subtraction; Gaussian Mixture Model; vehicle traffic; smart city.

I. INTRODUCTION

The term Internet of Things (IoT) was first coined by Ashton at the end of the last century [1]. It is a network of Internet-connected objects that gather and exchange data using embedded sensors. Nowadays, after almost two decades, the IoT continuously evolves and penetrates to our live like transport, healthcare[2], education, utilities, disaster [3], etc. It delivers the paradigm of anytime and anywhere connectivity [4]. Many of the devices that surround us now perform machine-to-machine connection using the Internet [5]. They harvest, sense, and share information from the environment without the aid of human intervention [6]. In a smart city, the government serves many features that provide information of city situations, such as a vehicle traffic of a road, through IoT architecture. The remote device as node captures and detects the vehicles that go through a road, and then it autonomously analyzes the traffic. Along with decreasing of the price of sensor devices and processor, and easiness in obtaining the Internet broadband connection, it is more convenience to provide the vehicle traffic system in IoT architecture.

In order to detecting the moving vehicle, there are many literatures exposed algorithms of this need, e.g. in [7-11]. In [7], the authors proposed an algorithm for visual tracking of the human visitor under variable-lighting conditions. The algorithm combines estimation of statistical background images, Bayesian segmentation, and multitarget tracking. The proposed algorithm was compared to three blob algorithms. In [8], the authors proposed an algorithm to classify the object and background regions. The algorithm uses a correlation function to calculate the inter-plane correlation between three consecutive R, G and B planes. Then the correlation matrix results were utilized to develop a segmented image that predicts the object. This process needs a computer with high resources. In [9], the authors described vehicle detection using foreground detection and blob analysis (FDBA). The algorithm subtracts the background from the foreground, and then connects those pixels that are moving and close to each other in the foreground as a blob. The authors applied the algorithm using matlab in built vision object. In [10], the authors evaluated many foreground detection methods in order to distinguish foreground objects either moving or static objects from the background; i.e. Gaussian mixture model (GMM), kernel density estimator (KDE), Code book, Adaptive Gaussian mixture model (AGMM), and Consensus-based method (SACON). Many typical challenges were used to evaluate model methods, such as illumination change, dynamic background, and shadows. Based on the evaluation, the authors stated GMM-based provides promising results. In [11], authors applied universal sample-based background subtraction algorithm called ViBe (Visual Background Extractor) for detecting the human presence. The algorithm is used to trigger the surveillance system. Referring to those literatures and the need of providing a vehicle traffic analysis features in a smart city, we implement a system that using the background subtraction model to calculate a number of vehicles that goes through a road in IoT architecture. The paper has many contributions to the scientific and engineering manner, such as: providing a background subtraction method for moving detection and description of a system in IoT architecture. The contribution of this paper is providing the implementation of the GMM model for vehicle traffic with its performance in an IoT architecture.

The rest of this paper structured as follows. In Section II, the system architecture of the designed system, which considers IoT architecture, is described in detail. The background subtraction method is explained in clearly steps. In Section III, the results from the system and discussions are provided. And in the last section, we provide the conclusions of the paper.

ISBN: 978-1-5386-4571-0 (c) 2018 IEEE

An Architecture for M2M Communications over Cellular Networks Using Clustering and Hybrid TDMA-NOMA

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***Abstract*— Machine-to-Machine (M2M) communications have now become a highly promising affiliate of the future fifth generation (5G) cellular networks. This paper proposes a novel architecture for M2M communications over cellular networks. *k*-mean clustering for machines as well as cluster head (CH) reselection method is applied in order to balance the power consumption within the machines to increase their battery life. For communication between CH and member machines, time division multiple access (TDMA) is proposed. On the other hand, for communication between CH and BS, non-orthogonal multiple access (NOMA) technology is considered. Performance of the proposed architecture is evaluated through extensive MATLAB simulations. Results clearly demonstrates the capability of the proposed architecture in improving the lifetime of machines and reducing communication delays. Comparisons with other counterparts also attests superior energy efficiency and delay performance of the proposed architecture.**

***Keywords*—M2M communications; Clustering; NOMA; 5G Cellular networks; *k*-mean clustering.**

I. INTRODUCTION

Machine-to-Machine (M2M) communications is considered as one of the next generation communication technologies for 5G cellular networks. M2M refers communication among enormous wireless machines without human interaction. The prime objective of M2M communications is to set up extensive connections among all machines distributed over a wide coverage area [1]. M2M is becoming increasingly attractive in cellular networks for offering huge variety of available connectivity solutions due to the enormous economic promise of the Internet of Things (IoT) [2]. However there remains a huge challenge for cellular M2M communication systems in future years as according to Cisco IBSG's prediction, there will be 50 billion machines connected to the Internet by 2020 [3]. As a result, managing this numerous amount of machines simultaneously and to cope up with the access loads, more robust access technology will be required. The next generation cellular network will be dealing with several challenges - energy inefficiency, extensive time delay as well as the resource allocation difficulties.

Non-orthogonal multiple access (NOMA) owns an enormous potential to compete with the next generation challenges than any other multiple access techniques. NOMA is able to serve multiple users simultaneously over same spectrum resources splitting each user in different power domain. It works by superimposing multiple user's message signal into one signal by allotting them into different power domain at the transmitter side. Whereas at the receiver side, the superimposed signal is filtered through a successive interference cancellation (SIC) operation to detect and decode each user's signal. For the 5G wireless networks, NOMA is the fundamental technology that has the ability to meet the heterogeneous demands on maximum reliability, reduced latency, enormous connectivity, enhanced fairness and high throughput [4].

Despite the employment of high potential multiple access technique like NOMA, energy management of billions of machines in the M2M system simultaneously is a massive task. There are chances of collision of data request of the machines as numerous machines try to establish connection with the BS. At the same time, the machines also result in fast energy drains. In such scenarios, clustering is one of the most effective ways to reduce the data congestion and decrease the power consumption of machines. Clustering improves the energy efficiency as well as the lifetime of machines [5]. A clustered network consists of a cluster head (CH) and a number of member machines. In each cluster group, member machines transmit their data to CH and then CH aggregates all the data and delivers to BS.

Recently, various advanced research works have been conducted on M2M communication in cellular networks. For instance, M2M communications is now being considered in software-defined cellular networks with wireless network function virtualization techniques to develop and improve system performance by managing network resources and spectrum efficiency [6]. The energy-efficient clustering issue in M2M systems is investigated in [7] by jointly considering cluster formation, transmission scheduling and power control. This paper considered an optimization problem for minimizing the power consumption in a two-tier M2M network under correlated data gathering. On the other hand, authors in [8] investigated an energy-efficient clustering and medium access control (MAC) for cellular-based M2M networks. Theoretical analyses are provided in this paper on the impact of clustering,

ISBN: 978-1-5386-4571-0 (c) 2018 IEEE

Throughput Maximization Based On User Association In Heterogeneous Networks

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***Abstract*—Cellular networks' endurance limitations are in constant abatement as extra numbers of cellular phone users are persistently occupying the resources of the network. Consequently, network resources, signal quality, Quality of Service (QoS) requirements etc. undergo hazardous conditions. Moreover, edge users are also endangered as they experience poor signal quality due to large separation distance and obstacles. However, smaller cells were introduced to alleviate the burdens from networks and explicitly comfort users. This paper, studies the Femto-cells performance over cellular networks and further proposes a user association scheme to off-load users to the Femto-cells. The simulation results reflect the outstanding performance of Femto-cells capabilities and how deploying 5 Femto-cells can relatively add-up 3Mbps to each user's throughput and approximately 10Mbps in a single iteration.**

***Keywords*—throughput; femto-cell; interference**

I. Introduction

Wireless communication services are progressively being utilized recently, and even demanded on to accommodate the users' appeals of higher speed and quality of transmission. On top of the complications of handling such demands, the environment escalates these adversities specifically indoor habitats such as offices and residential compounds [1]. Furthermore, Macro-cell usually maintain lesser quality in these environments due to the signal losses that appear as a result of high penetration losses and interference that may usually occur from the exposure to a nearby entity [2] which can be a User Equipment (UE) or another Base Station (BS). The resultant signal irregularities are famously termed as interference; which is a comparable non-desired signal. Consequently, users' signals experience a harsh corollaries such as throughput impairments, quality deterioration and even complete signal outage [3] [4].

Generally, the terminology of throughput in wireless communication which signifies the rate of successful message delivery through communication channels in bits per second is used to evaluate the performance of an entity or the network in general.

In this context, Femto-cells as an affiliate of the family of Heterogeneous Networks (HetNets) [5], were introduced to be the guardian to accommodate signals destructions. Femto-cells quickly loomed for their phenomenal power saving for both UEs and service providers and enhanced signal traits considering the relatively small separation between UEs and the Femto Base Station (FBS)s [6] [7]. Moreover, HetNets entities in general contribute to the overall system performance by extending the system accommodation probabilities *capacity* via enlarging the service area and detaching some users from the Macro Base Station (MBS) to relief and reduce the load and consequently extend the resource utilization ability.

TABLE I: Heterogeneous Networks Highlights

Cell Type	Size	Tx Power	Backhaul	Access
Macro	≤ 35km	≤ 46dBm	Optical fiber	Open
Micro	≤ 2km	≤ 33dBm	Optical fiber	Open
Pico	≤ 200m	≤ 30dBm	Optical fiber	Open
Femto	≤ 10m	~ 20dBm	Optical fiber/DSL	Open/Closed
Relay	≤ 200m	≤ 30dBm	Wifi	Open

Precisely, the term HetNets defines the networks that are diverse either in the coverage of the service area and/or the network access as shown in Table I. On the other hand, the Femto-cell is the only HetNets entity that is completely deployed by the user him/herself and not the service provider which additionally reduces the installation costs. However, this may pose certain limitation on-top of the previously quoted performance such as increased number of hand-offs [9].

In that context, the authors of [8] presented a discussion on preserving unequal portions of spectrum to certain cells to provide granted access to resources. User Equipments within these cells enjoy an improved signal quality due to the reduced interference which results a better Signal to Signal to Interference plus Noise Ratio (SINR) and throughput respectively. However, the authors' did not consider neither the cell edge users signal outage that may result from obstacles or terrain losses nor the unbalanced spectrum division.

Similarly, Bouras et al. in [10] presented a Fractional Frequency Reuse (FFR) scheme that divides the cell area into inner and outer regions and similarly the spectrum. The frequency assignment process is conducted through evaluating the location of the users or cells to the MBS. The scheme successfully reduces the co-channel interference which in return improves the users' throughput as compared to the previous scheme. However, the scheme did not appraise the users' signal levels at different locations.

Furthermore, the work in [11] proposes a hybrid scheme

ISBN: 978-1-5386-4571-0 (c) 2018 IEEE

Connectivity Control Algorithm for Autonomous Wireless Agents

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***Abstract*—In the power-limited sensor network, it is important to optimize the power allocation while maintaining connectivity for each sensor node to guarantee reliable localization. In order to prolong lifetime of sensors, optimizing the power is very crucial while maintaining a proper number of connectivity to ensure a good localizability. In this paper, we propose a connectivity control algorithm, which consider the number of connectivity while optimizing power of sensors. We investigate the information of distribution node statistically, and formulate the relaxation method of utility function in order to get quasi-concave property. Numerically, we show our proposed algorithm gives better performance compared to the recent algorithms with target connectivity $k = 7$, while the other algorithm achieves zero connection with the same trade-off parameter.**

***Index Terms*—WSN localization, connectivity control, quasi-concave function**

I. Introduction

WIRELESS Sensor Networks (WSNs) has become a promising technology that is applicable in many fields due to its low cost and small size. Many researchers are currently investigating the more challenging type of WSNs, one of them is underwater sensor networks (UWSNs) for exploration of inaccessible environments [1]. Many technologies for UWSNs have actually been proposed, such as medium access control and secure routing protocols, localization technique and time synchronization scheme [2].

Localization is the process determining or estimating the location of every sensor. Both in WSNs and UWSNs, localization plays a critical role, especially if the sensors are mobile. Although the sensors are moving, the position of the sensors can be estimated over the period of time, statistically. For this time dependent application, it needs a technique to save the sensors power for efficiency-energy, while ranging the pairwise distance between sensors.

Connectivity is necessary for ensuring the localization. Connectivity can be obtained by measuring time of flight (ToF) between two sensors, which is when one of the sensors transmits the signal and a feedback signal is received by the other, thus obtaining the distance between them. Due to the sensors' power limitation, using full-power in order to get the high connectivities is inefficient.

This work has been conducted during a research stay at RWTH Aachen University where the author was responsible for the implementation of the presented work.

With the considerations stated above, it is important to optimize the transmit power to get a target connectivity number, in order to save the energy to prolong the lifetime of sensors. Therefore, a power optimization algorithm which considers connectivity control is needed in WSNs localization.

A. Related Works

Recently, there are few works that study about power optimization algorithm based on connectivity term for ensuring localization. The popular research among those works is by using power control games with game theoretical approach which has been studied in [3]–[5].

In [3], the authors assume the distance between two sensors in two dimensional area based on time of arrival (TOA) measurements of an incoming signal. They propose supermodular-game for power allocations with positioning constraint, by using Geometric Dilution of Precision (GDOP) with linear pricing, as their approach. In [4], the same authors consider the receive signal strength (RSS) measurement that needed for localization. They minimize the transmit power of anchor nodes as well as perform the selection of a set of anchor nodes for positioning of the target node, while using a positioning error metric based on the GDOP as QoS to maintain an adjustable level of accuracy. However, in these methods the connectivity are not considered.

The authors of [5] propose connectivity reconstruction (CRG) game as a solution for power optimization in localization. The authors obtain a cost function with a localization reliability based on the distributed weighted multidimensional scaling (dw-MDS) algorithm, and the power as the energy trade-off. However, they do not consider the number of connectivity that after the powers reach the equilibrium.

B. Our Contribution

In this paper, we formulate the connectivity control algorithm (CCA) to optimize the transmit power of WSNs while considering energy-efficiency via a trade-off between connectivity and power. In particular, sensors are modeled as the agents that want to achieve a target connectivity while using the minimum possible power. Then, we assume the statistical knowledge to model our system and to exploit the information. To solve the optimization power, we determine the best power response of each agent. Our evaluations shows that CCA can obtain such a target connectivity than CRG [5]

ISBN: 978-1-5386-4571-0 (c) 2018 IEEE