# ECTI e-magazine

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# Call for Contribution from members...

We would like to call for contribution from our members, researchers and international students to describe your experiences, research works or research group activities. Please write at a maximum of 1 page including pictures.

Contact: ecti.emagazine@gmail.com



Message from ECTI President

Dear our readers,

What's a great pleasure to have a chance to see you again on our ECTI magazine? This is the vol. 11, No. 1. During the past decade, the magazine has become quite mature. The magazine keeps the track of dynamic change of the technology and the development of Thai Society. We have been trying our best to bring the leading edge topics and some in-depth understanding issues to our reader. Thailand is now entering the aging society. We are challenged by the engineering and technology to facilitate the livelihoods of older adults. On the other hand, the country has to move forward to synchronize with the modern word. Thailand 4.0 is as hot as smart cities. Confronting with several upcoming changes, the information technology is the keyword of technology that the society has to be ready in terms of developer and users. Inevitably, the human resource is the most important component of the success key. In this regard, ECTI, as one of the most relevant academic associations has pushed forward, its roles and actions respond to those national issues. We are conveying several workshops and national/international conferences during this year and next year. We hope our readers and members will obtain benefits from joining those events.

Since its establishment in 2007, the continued success of the magazine of course depends not only on the serious purpose of the editorial team but also good contribution of both authors and readers. I, very much, do appreciate all contribution to the ECTI magazine.



Somsak Choomchuay ECTI President

# Message from Editor

Dear Valued ECTI Members,

Happy New Year 2017, the ECTI E-Magazine readers. We would like to wish you all a productive, healthy and happy time ahead.

As we usher into the new year, amid the potentially volatile political and immigration uncertainty in many parts of the world, to ensure the continual economic prosperity as well as improved livelihood, in many ways, our hope rests on technological innovation and how each society can harness its promise. An impetus to such endeavor inevitably depends our cooperation efforts and mutual understanding across national border.

As an important medium to disseminate new knowledge and innovation, during each quarter, ECTI E-Magazine hopes to offer readers new and interesting articles and news update of each Academic area as well as outreach activities from ECTI Association.

In this issue, we are certainly pleased to publish a review article titled "Wireless Positioning Technologies and Applications: A Review" by Asst. Prof. Dr. Panarat Cherntanomwong (King Mongkut's Institute of Technology Ladkrabang). It reviews existing and recent trends in positioning systems, both indoor and outdoor applications. In addition, the comparisons of all these techniques are presented.



Pornchai Supnithi ECTI E-Magazine Editor



Watid Phakphisut ECTI E-Magazine Assistant Editor

# Congratulations!

### Science and Technology Awards, Thailand Toray Science



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Source: http://www.ttsf.or.th/download/Toray-2016.pdf

# Wireless Positioning Technologies and Applications: A Review

#### Panarat Cherntanomwong

#### ABSTRACT

The wireless positioning has been extensively researched because it can be applied to many applications, e.g. public safety, logistics, navigation, tracking, and guiding. This paper provides an overview of the basic concept of wireless positioning and gives examples of existing and recent-trend positioning systems based on the wireless communication technologies. Since the performance of positioning techniques is based on the applications, wireless systems and networks as well as environments, comparison of used wireless positioning techniques in terms of advantages, disadvantages and applications is presented.

#### **Keywords**

Positioning, RSS, AOA, TOA, TDOA, location fingerprinting

#### I. INTRODUCTION

Wireless positioning is an approach to measure parameters of signals travelling between the mobile station (called the target) and a set of fixed transceivers, or base stations (BSs), or access points (APs), which are subsequently used to determine the target location. The words of positioning, position location, and localization can be used interchangeably. Since most existing position systems uses radio waves, the terms of radiolocation and radio localization are used. Positioning techniques can be classified into 3 main techniques: proximity, triangulation and scene analysis using the measured parameters of signals such as received signal strength (RSS), angle of arrival (AOA), time of arrival (TOA), time difference of arrival (TDOA), and their combinations [1]-[4]. Selection of positioning techniques is based on applications in which the systems and networks and required accuracy are different. Moreover, the good selection of the



positioning techniques also depends on environments.

In this paper, the basic concepts and fundamentals of wireless positioning are described. In section II, categories of wireless positioning is explained, followed by summary of positioning techniques in section III. Section IV shows examples of wireless positioning for existing and recent wireless systems. Finally, the conclusion is in section V.

#### II. Wireless Positioning Categories

There are 2 main categories for wireless positioning technologies [5]:

1) Mobile-based positioning technology: it is a selfpositioning system where the mobile station (MS) calculates its own position based on signals received from several base station (BSs) in which their positions are known. The obvious example in this category is the global positioning system (GPS). For this category, the MS needs to be modified in that it is able to achieve highly accurate location estimation; leading to increased cost, size and battery (power) consumption. Moreover, network synchronization is required.

2) Network-based positioning technology: it is a form of remote location system. The BSs measure signals from the MS and relay them to a central site for further estimating the MS position. The advantage is that modification of the MS is needed because the MS not involved in the position-estimation process. The network-based positioning needs 2 operations at the BSs: (1) the BSs measure signal parameters (such as RSS, AOA, TOA, TDOA, etc.) from the MS, and (2) the measured signal parameters are combined in a data fusion stage to give the final position estimation. The examples in this category are shown in Fig 1 for an outdoor environment using a cellular system and in Fig 2 for an indoor environment using wireless local area network (WLAN) or wireless personal area network (WPAN).

#### III. Positioning Techniques

Wireless positioning techniques are mainly classified into 3 types as shown in Fig. 3 [4].

1) Proximity

The proximity technique usually provides symbolic relative location information. The location of the target is roughly estimated by referring its location to the nearest reference points (BSs). If only one BS connect with the target, the location of the target refers to 'near' with that BS. Nevertheless, if more than one BSs can connect with the target, the location of the target refers to 'near' the BS received the strongest signal from the target. This technique can be called Cell identification, or cell ID technique. The examples of using proximity technique are radio frequency identification (RFID), infrared radiation (IR), and pressure and touch sensors.

2) Triangulation

Triangulation uses the geometric properties of triangles to estimate the target location. There are 2 subcategories of triangulation: one is lateration, using distance measurement, and another one is angulations, using angle measurement.



Figure 1: Example of network-based positioning technology for outdoor environment using the cellular system



Figure 2: Example of network-based positioning technology for indoor environment using WLAN or WPAN systems

2.1) Lateration: target position is estimated by measuring the distance from multiple reference points (BSs) to its position. Since it uses the distance for estimating the position, this technique is sometimes called the range based technique. The distance can be measured by many parameters such as received signal strength (RSS), time of arrival (TOA), and time difference of arrival (TDOA).



Figure 3: Three types of positioning techniques

#### i) Received Signal Strength (RSS)

The RSS based localization method uses a mathematical model which describes the path loss attenuation with distance. The distance between each BS and the MS calculated from the path loss model refers to as the radius of the circle where the BS is at the center. In this method, at least three BSs have to be installed, and the target position is geometrically determined by the intersection of 3 circles as shown in Fig. 4.

#### ii) Time of Arrival (TOA)

The TOA based positioning method uses the travelling time from the MS to each BS which is further used to calculate the distance between the MS and each BS to estimate the target position. Let  $t_i$  be the TOA of the signal of MS at  $BS_i$ , the distance between the MS and  $BS_i$  can be calculated by

$$R_i = (t_i - t_0)c_{,}$$
(1)

where  $t_0$  is the time instant at which the MS begins transmitting the signal, and c is the signal propagation speed (speed of light:  $c = 3 \times 10^8 \ m/_S$ ). The target position can be estimated in the same manner as the RSS as shown in Fig. 4.

#### iii) Time Difference of Arrival (TDOA)

The TDOA based positioning technique estimates the target position by finding the

intersection of hyperboloids which are the set of range difference measurement between 3 or more BSs as shown in Fig. 5.



Figure 4: the RSS based positioning technique.



Figure 5: the TDOA based positioning method



Figure 6: the AOA based positioning method



Figure 7: Location estimation using the location fingerprinting technique.

The range difference between 2 BSs is obtained by measuring the difference of TOA of the signal between them, i.e. the time difference of arrival, or TDOA. Let  $R_{i,j}$  be the range difference between  $BS_i$ and  $BS_i$ , and defined as

$$R_{i,j} = R_i - R_j = ct_{i,j} , \qquad (2)$$

where  $t_{i,j} = t_i - t_j$  is the TDOA between  $BS_i$  and  $BS_j$ , and c is the speed of light.  $R_i$  and  $R_j$  are the distances between the target and  $BS_i$  and  $BS_i$ , respectively.

2.2) Angulation: the target position is estimated by calculating the angle relative to multiple reference points (BSs) such as in angle of arrival (AOA).

The AOA based positioning technique determines the target position by first estimating the angle of the signal received at BSs. The AOAs at 2 BSs are sufficient to estimate the target position as shown in Fig. 6 ( $\theta_1$  and  $\theta_2$  be AOAs of the signal from the MS arriving at BS1 and BS2, respectively).

#### 3) Scene analysis

In general, this technique collects and extracts features from observed scene. The scene could be the radio frequency waves, optical waves, acoustic sounds, visual images or measurable physical phenomena which usually exist near the object. The wireless positioning based scene analysis is also known as location fingerprinting (LF). The observed features (fingerprints) are usually specific and unique. The fingerprints are used to estimate the target position in the scene.

The location fingerprinting has two-phase processes. The first phase is called the off-line or calibration phase in which the received signal parameters (fingerprints) at selected locations are recorded in the database. For the scene of the radio waves, this database is often referred to as the radio map. Then, for the second phase, called the on-line phase, the MS position can be estimated by comparing the signal parameters received by the MS with the fingerprints (previously recorded signal parameters in the database) through pattern matching algorithms. The location in the database providing the best match between the fingerprint and the received signal parameter is represented as the estimated position of the target. Figure 7 shows the overview of the location fingerprinting technique. Each wireless positioning technique has its advantages and disadvantages which are summarized in Table I.

#### Hybrid positioning techniques

The hybrid techniques which are the combination of the above mentioned techniques have been widely proposed to improve the performance of the system, i.e. higher accuracy of the estimated target position.

# IV. Examples for Wireless Positioning Systems and Technologies

This section gives the concise review of the existing wireless positioning systems, technologies, and its accuracy. Here, the positioning systems are classified into wireless systems and networks.

#### Satellite Positioning

Global Positioning System (GPS) [1], [3]

GPS, the worldwide satellites-based radio navigation systems, composes of 24 satellites with 20,200 km above the Earth. The MS equipped with the GPS receiver uses the signals transmitted from the satellites to determine its own position by computing position in 3D-latitude, longitude, and altitude-with an accuracy of 10 m or less. In order to estimate the position correctly, the MS needs a clear view of the sky and the signals from at least 3 or 4 (depending on the type of information needed) satellites. Therefore, it does not work well in indoor environments.

• Assisted-GPS (A-GPS) [3]

As its name, for the A-GPS, the mobile network or a third party service provider can assist the MS to look directly for the specific satellites. A reference GPS receiver that can detect the same satellites as the MS equipped with a GPS receiver help the MS to find weak GPS signals. All measured signal are combined by the location server and further used to estimate the location. Moreover, it can also collect data from the MS for the position calculation in the case that the MS itself may be unable to perform due to limited power. The A-GPS can perform the good accurate position estimation, ranging from 1 - 10 m.

• Indoor GPS [4], [6]

Indoor GPS systems employ the advantages of GPS for developing the indoor positioning system. As previously mentioned, the GPS does not usually work in indoor environments since the signal strength from the GPS is too low to penetrate the building. Nevertheless, indoor GPS solutions can be applicable to wide space areas where less significant barriers exist. One example of positioning technologies introduced for the indoor GPS systems is Snaptrack from Qualcomm Company. It uses the A-GPS positioning for indoor positioning. Another example announced by Atmel and U-blox uses a new GPS software allowing GPS to track weak signal with the sensitivity beyond -158 dBm.

#### Cellular Positioning

The MS positioning in cellular networks has been discussed over the past ten years focusing on GSMbased network. Later on, the positioning methods supported UMTS was specified in the specification (3GPP 2008a) [7]. Cellular positioning uses both mobile-based positioning and network-based positioning. For the former, the MS calculates its own position using the signal received from BSs. For the later, the MS position is calculated on a server in the network. In cellular network, the network-based positioning is more commonly deployed. The cell ID technique is one of the simple techniques based on the cell coverage. The position of the MS connected to the BS, which is identified by its cell ID, is referred to as the position of the BS itself. Other positioning techniques applied to cellular network are time-based positioning techniques, like the TOA and TDOA. Since the location base services (LBS) are increasing in demand, 3GPP has specified the location service features in the GSM and UMTS standards. Although there are many location service features, obvious features supporting subscribers (MSs) are the commercial location services and emergency location services. For the commercial location services, they are typically associated with the value-added services to subscribers, such as "where are" applications providing a directory of restaurants, gas stations, hospitals, etc. in the surroundings of the MS, and together with directions from the current position of the MS to the destination. For the emergency location services, it is the applicability to locate the subscriber who makes the emergency call.

#### WLAN and WPAN positioning

• WLAN (WiFi)

Many positioning researches use the existing WLAN infrastructure. Ref [8] introduced the in-building tracking system based on the IEEE 802.11 WLAN using the RSS-based positioning. The access point measures the RF signal strength and signal-to-noise ratio of signal sent by the MS and then used these measured data to calculate the MS position. Nevertheless, the obstacles in indoor environment reduce the precision of the RSS measurement. Another example of the WLAN-based positioning system is called Loki [9]. This system works similarly to the cell ID technique. Instead of the cell IDs of BSs, the MAC addresses of nearby access points of WLAN are used to estimate the MS position.

• Radio Frequency Identification (RFID)

Many RFID based positioning techniques have been proposed. The RFID based positioning can be categorized into two main types: one is the reader positioning in which the reader will be the target and its position will be estimated and another one is the tag positioning in which the tag will be the target and its position will be determined. The selection of these two types depends on applications and system cost.

The example of the reader positioning proposed by Lee and Lee [10] is the mobile robot positioning. Another example of the reader localization using location fingerprinting was proposed by [11]. Some of passive tags used as references are placed to the ceiling and their IDs detected by the reader are stored in the database and used as fingerprints.

For the example of the tag positioning, Ni and et al. [12] proposed LANDMARC technique which employs reference tags and readers at known locations as landmarks to the system. The active tags are used in this technique because they can provide the signal strength. The position of the target tag is estimated similarly as cell ID where the position of the landmark received the strongest signal strength of the target tag is referred to as the target position. The LANDMARC was introduced for indoor environment. Another example of the tag positioning is the RFID based positioning in the outdoor environment proposed by Chon et al. [13]. For this system, RFID tags are installed on the road. The coordinate of the location where the tag is installed is needed to be written into each tag. The vehicle will be equipped with the RFID reader that can communicate with the tags on the road. While the vehicle is driven, the RFID reader constantly monitors the presence of the tag and retrieves the information from the tag including its coordinate.

#### • Wireless Sensor Networks (WSNs)

WSNs are the networks compose of small, selforganized, low-power nodes including a transceiver unit, sensors and a processing unit. It is initially designed in order to communicate the observations gather locally by sensors to a remote gateway or user via multi-hops communication. Node positioning techniques in WSNs have been proposed by many researchers. Triangulation and fingerprint techniques are popularly deployed in WSN-based positioning [14]-[15]. The ZigBee module as IEEE 802.15.4 standard [16] is widely used for the node positioning, not only physical advantages of cost-effective, lowpower consumption, robustness, and reliability, it also provides the value of receive signal strength indicator (RSSI) which is a useful signal parameter node positioning. The examples using the RSSI for the

lateration-based positioning are in [17] and for the fingerprinting-based positioning are in [18]-[19]. In [20], the RSSI is used for both lateration and fingerprinting-based techniques where the results from both techniques are compared.

#### Ultra-Wide Band (UWB)

UWB is a short-range communication using a large frequency bandwidth (from 3.1 to 10.6 GHz) at low spectral power density. Its main advantage is that it can transmit a signal in the same frequency bands of existing narrowband systems with less interference. In [21]-[22], recent trends and advances in UWB positioning are well reviewed.

#### • Visible Light Communication (VLC)

VLC is a wireless communication technology that uses light wave length between 375 nm - 780 nm which is visible to humans as a carrier [23] and is considered as one of the most promising alternatives radio wave communication to due to the scarcity of radio frequency band. Moreover, the advantages of VLC are license-free, harmful less to security human, high and immunity to electromagnetic interference. Nowadays, low-cost LEDs are going to replace the existing fluorescent and incandescent lights for illumination. Therefore, VLC can reduce the cost to implement the wireless system since the LEDs (act as light sources) becomes very low cost and are already installed for illumination. Positioning based on VLC can be applied to both indoor and outdoor environments where LEDs are already installed. However, researches on outdoor positioning are few because of many difficulties occurring when visible light is used in outdoor environment such as ambient light noise and optical defects in lens, etc. Readers can referred to [24]-[25] for a nice review of indoor positioning based on VLC and referred to [26] for an investigation on potentialities and challenges of outdoor positioning based on VLC. All positioning techniques can be applied for VLC and also the hybrid methods are also proposed, such as in [27], Proximity and fingerprinting are used for indoor positioning.

Table I: Comparison of wireless positioning techniques in terms of advantages, disadvantages and applications

Positioning Tech.	Advantages	Disadvantages
Proximity,	- Simple	- Roughly estimated position of the target (unable to estimate the coordinate of the target position)
Lateration (RSS, TOA)	<ul> <li>Able to estimate the coordinate of the target position</li> </ul>	<ul> <li>Performance is easily degraded in shadowing and multipath environments.</li> <li>At least 3 BSs are required.</li> <li>For TOA, the accurate clock synchronization between the MS and BSs is required.</li> </ul>
Lateration (TDOA)	<ul> <li>Able to estimate the coordinate of the target position</li> <li>The clock synchronization between the MS and BSs is not required because it does not need to know the instant time starting to transmit the source signal as TOA does.</li> </ul>	<ul> <li>Performance is easily degraded in shadowing and multipath environments.</li> <li>At least 3 BSs are required.</li> </ul>
Angulation (AOA)	<ul> <li>Smaller number of BSs is required compared to other triangulation techniques (only 2 BSs is required).</li> <li>Special antenna is required.</li> </ul>	- Performance is easily degraded in shadowing and multipath environments.
FP	<ul> <li>Work well in shadowing and multipath environments.</li> <li>At least 1 BS is needed.</li> </ul>	<ul> <li>Need to have the database of known signal-location information first.</li> <li>More process compared to other positioning techniques.</li> <li>Require the very detailed spatial resolution of the database to achieve the accurate estimation of the target; leading to time consumption and expensive human efforts.</li> <li>The new database has to be constructed if the environments or the equipment are changed.</li> </ul>

#### V. CONCLUSIONS

This paper has provided an overview of wireless positioning techniques. Tradeoffs among them are briefly discussed. The accuracy, complexity, and environments for different applications are the main concern to select the appropriate wireless positioning techniques. The positioning has been involved in any wireless networks and technologies because the location information is needed to have value-added and useful applications. The examples of positioning in existing and recent-trend wireless technologies in a variety scale of wireless networks are shown, including satellite positioning, cellular positioning, and WLAN and WPAN positioning.

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#### BIOGRAPHY



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currently Assistant Professor, Faculty of Engineering, KMITL. Her research interest is wireless communication, especially in location estimation and tracking of mobile and wireless module, improvement of direction finding algorithms, and visible light communication.

# My Research and Life Experience

#### Hendi Wicaksono, Indonesia

I started my Doctoral degree at Sirindhorn International Institute of Technology, Thammasat University (SIIT-TU) since January 2016. I was excited when I got an email from my advisor Asst. Prof. Itthisek Nilkhamhang that I could start my study on that January 2016. My adventure began when I was picked up at the airport by my buddy. Later on, I knew that the new international student would be accompanied by the buddy to get an orientation about the facility of a University.

In the first semester, SIIT provides Thai class for all new international students. In Thai class, we learned Thai language and influential cultures. I can speak Thai a little bit when I went to the traditional market and another place in Thailand.

My research is about swarm control strategy investigation, under Electronics and Communication Engineering (EC), School of Information, Computer, and Communication Technology (ICT), SIIT. My research focuses on the design a new framework that makes swarm control or decentralized control strategy to achieve a global performance. We focus on material handling problems. As an introduction, swarm control or decentralized control usually have the local controller. They can achieve the local performance, but a lack of the global performance. The absence of the global performance is one of the disadvantages of decentralized control. The problem makes this hard to convince the industry to implement the decentralized control strategy. They still use the centralized control strategy although the centralized control does not have fault tolerance.

I have a pleasant experience at the end of 2016. Two of my friends and I went to Japan for 12 days of short visitation. Prof. Omae from the Keio University invited us to learn about the self-driving car. Besides working in the laboratory, we also visited famous places on the weekdays. We tried many favorite foods, such as soba, udon, and sushi. Prof. Omae students very much helped us to get what we want to know on this visit.



I am glad to learn and discuss many things related to my study with my advisor. I wish my advisor, and I are still connected to continue the research and strengthen the relationship between two countries in the future.

#### About the Author

Hendi Wicaksono is currently studying in the Doctoral degree program at Sirindhorn International Institute of Technology, Thammasat University, Bangkok, Thailand. He is under the EFS-SIIT scholarship.

# Paper List of ECTI Transaction

ECTI-EEC Transaction: Vol 15, No 1 Website: http://www.ecti-eec.org/index.php/ecti-eec/

Physical insight of Junctionless Transistor with Simulation Study of Strained channel B Vandana, B S Patro, J K Das, S K Mohapatra

Performance Evaluation of Amplify-Quantize and Forward Protocol for Multi-relay Cooperative Networks Nasaruddin Nasaruddin, Yusnidar Yusnidar, Elizar Elizar

Determination of Power System Topological Observability using Improved Hopfield Neural Network *Surender Reddy Salkuti, Jung Chan-Mook* 

Performance Comparison of a Second-order adaptive IIR Notch Filter based on Plain Gradient Algorithm *Wuthiporn Loedwasana* 

Sensor Array Optimization for Complexity Reduction in Electronic Nose System *Md. Mizanur Rahman, Chalie Charoenlarpnopparut, Prapun Suksompong, Pisanu Toochinda* 

ECTI-CIT Transaction: -Website: https://www.tci-thaijo.org/index.php/ecticit

Two issues are available annually. The next issue will be available soon.

# Report from Conferences/Workshops/Seminars/Events

#### ECTI Committee Meeting

#### Date: January 21, 2017 Venue: Swissotel Le Concorde



#### 9<sup>th</sup> International Conference on Knowledge and Smart Technology

Date: February 1-4, 2017

Venue: The Amari Ocean Hotel, Chon Buri, Thailand

Statistics: - 121 papers submitted from 14 countries

- 70 papers accepted (acceptance rate of 57.85%)
- 150 participants from 15 countries attended to the conference
- Keynote: "Explicit and Implicit Aspects of Human Cognition and Behavior"
  - Prof. Dr. Katsumi Watanabe

"Text Mining, Patent Retrieval and its Evaluation: Finding paths in the Labyrinth between Legal and Technical Challenges"

Prof. Dr. Thomas Mandl











### 1<sup>st</sup> Mini Symposium for ISAP 2017

Date: February 3, 2017 Venue: Faculty of Engineering, Chulalongkorn University Gallery: http://iemat.org/Gallery\_1stminisym\_2017.php



#### Workshop on Solar Panel Installation & Maintenance

Date: February 17, 2017

Venue: Department of Electrical Engineering, Rajamangala University of Technology Lanna



#### 5<sup>th</sup> ECTI Workshop on Research Paper Writing

Date: March 6, 2017 Venue: Faculty of Engineering, Burapha University



# Announcements/Upcoming events/Call-for-Papers



More information is available at <u>http://www.ecti-con.org/con-2017/</u> https://www.facebook.com/ECTICON2017/



ICROS, Korea

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#### การประชุมวิชาการ งานวิจัย และพัฒนาเชิงประยุกด์ ครั้งที่ 9

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#### **Call for Papers**

งานประชุมวิชาการ ECTI-CARD 2017 ครั้งที่ 9 "การประชุกศ์ใช้เทคโนโลย็สไอตอบสนองท้องอันและภาคอุตอาหกรรม" จัดโดย คณะเทคโนโลยี มหาวิทยาลัยราชภัฏฐตรธานี มหาวิทยาลัยราชภัฏอกสนคร มหาวิทยาลัยราชภัฏและ สถาบันมาตรวิทยา แห่งชาติ และสมาคมวิชาการไท้ท้า ยีเล็กทรอนิกส์ โทรคมมาคมและสารสนเทคประเทคไทย จัดขึ้นระหว่างวันที่ 25-28 การญาคม พ.ศ.2560 ณ เชื่องคาน จ.ลอย มีจุดมุ่งหมายหลักของการจัดงามเพื่อราบรวมแลงาาบวิจัยและหลัดมาเสียประยุกด์ งาน นวัดกรรม และสิงประชุญรามใสเปิดโอกางไห้นักวิจัย ผู้พัฒนาและผู้ให้งานหรือหม่องานต่าง ได้ได้อากสนกเปลี่ยนใจบุรีกด์ วิชาการว่ามกันและสามารณ์จานที่สี่ต้องที่ไปหัฒนาต่อยอดในระดักที่องในและสากเหรือหลิณาสูงสิตภัณฑ์เจ้าหนึ่งข้างการ วิชาการว่ามกันและสามารณ์จากเหรือหมือหวัดจานที่ได้มีมากรองการกร้องสิตภาษฐติดกินตร์เร็จการติดเสียงกัด จำน นทดรามที่ต่อมานักจะได้รับการพิจารแก้ไดยดู้ทรงคุณรูสีจากคุณภาพและครามสนอบูณีของกาน บทความที่ได้รับการติดเลือกและ ได้ถูกนำแนนอในที่ประชุม ECTI-CARD 2017 จะถูกที่ดิมที่นี้ ECTI-CARD Proceedings ซึ่งสามารถสืบดันได้มีเกิรที่เร็จกันเรียงการการเลือนที่มาจนได้ที่การติดมีอากเมตรง

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#### การสงบทความแปงเป็น 2 รูปแบบ ดังปี้

 รูปแบบบทศรามวิจัย เป็นบทศรามดีมรูปแบบภาษาไทยศรีอ ภาษาอังกฤษในปิณ 2-4 หน้ากระดาษ A4 ในรูปแบบ มาตรฐาน 2 คอถัมบัชอง IEEE โดยต้องกล่าวให้ห้มาและมงที่ ได้รับ รายกะะเสียดและ/หรือการนำไปใช้งาน ซึ่งป้องข้องกับ หัวข้อโดหัวข้อหนึ่งหรือมากกร่างรากกลุ่มดางๆ ที่ได้กำหนดไว้

 รูปแบบส์สประติษฐ์และบริศกรรมเป็นบทครามเสียรูปแบบ กำษาไทยหรือภาษาอิงกฤษไม่เกิน 2 หน้ากระดาษ A4 ใน รูปแบบณาตรฐาน 2 คลกัมบัชอง EEE โดยผู้เชื่อบบทคราม อาจบำละงานหรือสิ่งประติษฐ์การกฎโจ้ผแต่คงในงานประชุมได้

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