

Volume 7 ■ Issue 1 ■ June 2013

# INTERNATIONAL JOURNAL OF SECURITY (IJS)

ISSN : 1985-2320

Publication Frequency: 6 Issues / Year



CSC PUBLISHERS  
<http://www.cscjournals.org>

# **INTERNATIONAL JOURNAL OF SECURITY (IJS)**

**VOLUME 7, ISSUE 1, 2013**

**EDITED BY  
DR. NABEEL TAHIR**

ISSN (Online): 1985-2320

International Journal of Security (IJS) is published both in traditional paper form and in Internet.

This journal is published at the website <http://www.cscjournals.org>, maintained by Computer Science Journals (CSC Journals), Malaysia.

IJS Journal is a part of CSC Publishers

Computer Science Journals

<http://www.cscjournals.org>

## **INTERNATIONAL JOURNAL OF SECURITY (IJS)**

Book: Volume 7, Issue 1, June 2013

Publishing Date: 30-06-2013

ISSN (Online): 1985-2320

This work is subjected to copyright. All rights are reserved whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication of parts thereof is permitted only under the provision of the copyright law 1965, in its current version, and permission of use must always be obtained from CSC Publishers.

IJS Journal is a part of CSC Publishers

<http://www.cscjournals.org>

© IJS Journal

Published in Malaysia

Typesetting: Camera-ready by author, data conversion by CSC Publishing Services – CSC Journals, Malaysia

**CSC Publishers, 2013**

## EDITORIAL PREFACE

This is the *First Issue* of Volume *Seven* of The International Journal of Security (IJS). The Journal is published bi-monthly, with papers being peer reviewed to high international standards. The International Journal of Security is not limited to a specific aspect of Security Science but it is devoted to the publication of high quality papers on all division of computer security in general. IJS intends to disseminate knowledge in the various disciplines of the computer security field from theoretical, practical and analytical research to physical implications and theoretical or quantitative discussion intended for academic and industrial progress. In order to position IJS as one of the good journal on Security Science, a group of highly valuable scholars are serving on the editorial board. The International Editorial Board ensures that significant developments in computer security from around the world are reflected in the Journal. Some important topics covers by journal are Access control and audit, Anonymity and pseudonym, Computer forensics, Denial of service, Network forensics etc.

The initial efforts helped to shape the editorial policy and to sharpen the focus of the journal. Starting with Volume 7, 2013, IJS appears in more focused issues. Besides normal publications, IJS intend to organized special issues on more focused topics. Each special issue will have a designated editor (editors) – either member of the editorial board or another recognized specialist in the respective field.

The coverage of the journal includes all new theoretical and experimental findings in the fields of computer security which enhance the knowledge of scientist, industrials, researchers and all those persons who are coupled with computer security field. IJS objective is to publish articles that are not only technically proficient but also contains information and ideas of fresh interest for International readership. IJS aims to handle submissions courteously and promptly. IJS objectives are to promote and extend the use of all methods in the principal disciplines of computer security.

IJS editors understand that how much it is important for authors and researchers to have their work published with a minimum delay after submission of their papers. They also strongly believe that the direct communication between the editors and authors are important for the welfare, quality and wellbeing of the Journal and its readers. Therefore, all activities from paper submission to paper publication are controlled through electronic systems that include electronic submission, editorial panel and review system that ensures rapid decision with least delays in the publication processes.

To build its international reputation, we are disseminating the publication information through Google Books, Google Scholar, Directory of Open Access Journals (DOAJ), Open J Gate, ScientificCommons, Docstoc and many more. Our International Editors are working on establishing ISI listing and a good impact factor for IJS. We would like to remind you that the success of our journal depends directly on the number of quality articles submitted for review. Accordingly, we would like to request your participation by submitting quality manuscripts for review and encouraging your colleagues to submit quality manuscripts for review. One of the great benefits we can provide to our prospective authors is the mentoring nature of our review process. IJS provides authors with high quality, helpful reviews that are shaped to assist authors in improving their manuscripts.

### **Editorial Board Members**

International Journal of Security (IJS)

## EDITORIAL BOARD

### ASSOCIATE EDITORS (AEiCs)

---

**Dr. Elena Irina Neaga**  
Loughborough University  
United Kingdom

### EDITORIAL BOARD MEMBERS (EBMs)

---

**Dr. Jianguo Ding**  
University of Science and Technology  
Norway

**Dr. Lei Chen**  
Sam Houston State University  
United States America

**Professor Hung-Min Sun**  
National Tsing Hua University  
Taiwan

**Dr Yi Yang**  
Catholic University of America  
United States of America

**Dr Wendy Hui Wang**  
Stevens Institute of Technology  
United States of America

**Dr Fengjun Li**  
University of Kansas  
United States of America

## TABLE OF CONTENTS

Volume 7, Issue 1, June 2013

### Pages

- 1 - 7      Malicious Node Detection Mechanism for Wireless Ad Hoc Network  
*Daxing WANG*

# Malicious Node Detection Mechanism for Wireless Ad Hoc Network

**Daxing WANG**

*School of Mathematical Sciences  
Chuzhou University*

*No.1528, Feng-Le Road, Chuzhou, 239000 , Anhui, P.R. China*

*starleewipm@126.com*

---

## Abstract

With the popularity of intelligent electronics which rely on wireless communication in the post-PC era, computing devices have become cheaper, smaller, more mobile and more pervasive in daily lives. Construction of wireless ad hoc network becomes more and more convenient. However, the deployment of sensor nodes in an unattended environment makes the networks vulnerable to a variety of potential attacks. We present a malicious node detection mechanism. In using a monitoring mechanism to detect suspicious behavior, and on the basis of the responses from other monitoring nodes, if the number of suspicious entries concerning a particular node reaches a set threshold, that node is declared malicious. The simulation results show that the time it takes to detect a malicious node is decreased when there are more nodes in the network, and that it provides a fast and efficient way to detect malicious nodes.

**Keywords:** Ad Hoc Network, Malicious Node, Detection, Sybil Attacks, Sinkhole Attacks, Security.

---

## 1. INTRODUCTION

In the past few years, a new wireless architecture has been introduced that does not rely on any fixed infrastructure. In this architecture, all nodes may be mobile and no nodes play any special role. In fact, nodes reach other nodes they need to communicate with using their neighbors. Nodes that are close to each other discover their neighbors. When a node needs to communicate with another node, it sends the traffic to its neighbors and these neighbors pass it along towards their neighbors and so on. This repeats until the destination of the traffic is reached. Such an architecture requires that every node in the network play the role of a router by being able to determine the paths that packets needs to take in order to reach their destinations.

Wireless Ad Hoc networks are also much more dynamic and unpredictable because connectivity depends on the movements of nodes, terrain, changes in the mission (e.g. for a military application or a first responder application), node failures, weather, and other factors. As a result, it is difficult to accurately characterize normal behavior. Hence, it is often difficult to distinguish malicious behavior from normal but unexpected events. For example, a network may be seen connecting and disconnecting from the rest of the network. This may be symptomatic of an attack but can also be due to the fact that a node is moving in and out of range of the network. Existing detection tools (anomaly detection tools in particular) may not be effective in such an environment because they have been developed with a much more static and predictable environment in mind and cannot deal with the dynamism and unpredictability of MANET.

Significant research has been done in detecting intrusion in mobile ad hoc networks [1-8,10]. However, the problem of detecting a malicious node in wireless sensor networks has drawn little attention. Three known efforts towards malicious node detection are Mitigating Routing Misbehavior by Marti et al. [9], Towards Intrusion Detection in WSN by Loanis and Dimitriou [11], and Suspicious Node Detection by Signal Strength by Junior et al. [12].The method presented

here addresses the mobility of sensor nodes in a hierarchical fashion in which nodes form a parent child relationship. The remainder of this paper is organized as follows. We describe proposed malicious node detection mechanism in Section II. Then we presents an evaluation of how well the proposed malicious node detection scheme performs in a multi-hop network in section III. We analyze the security of our scheme in section IV. Finally, the concluding remarks are given in Section V.

## 2. PROPOSED MALICIOUS NODE DETECTION MECHANISM

This In the proposed malicious node detection mechanism has been designed for the dynamic and scalable nature of sensor networks where sensor nodes are replaced once they have exhausted their energy. The message sending node observes the packet receiving node hence functioning as a monitor of the receiving node’s behavior. It watches to see whether the receiving node alters the packet contents other than adding its header information. A malicious node is a compromised node where an adversary has somehow managed to break the encryption and has gained access to the secure keys and routing protocols of the Ad Hoc network. The proposed malicious node detection mechanism provides an additional countermeasure against attacks on the sensor network in the unlikely event that the secure triple key scheme is compromised. In Figure 1 a routing path has been formed from cluster leader 4 to 5 to 2 to the base station.

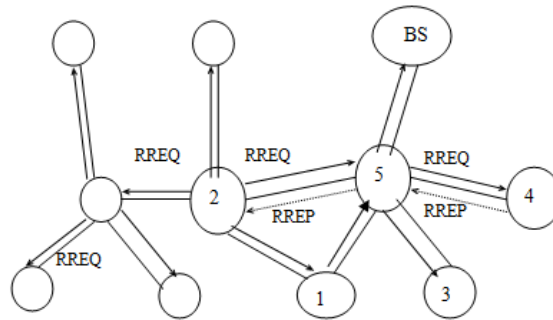


FIGURE 1: Establishment of a Routing Path.

In the proposed technique the monitoring mechanism used works as follows: Immediately after Node A sends a message to Node B, it converts itself to a monitoring node, referred to here as Am, and monitors the behavior of Node B. When Node B transmits the message to the next node, Am listens and compares this message with the one it has sent to Node B, thus establishing an original and an actual message. If the message transmitted by Node B is the same as the original then node Am ignores it and continues with its own tasks; however, if there is a difference between the original and actual messages greater than a certain threshold, the message is considered suspicious and Node B is now considered suspicious thus Node Bs.

Each node builds a Suspicious Node table containing the reputation of nodes in the cluster. Entries in this table contain the node ID, and the number of suspicious and unsuspecting entries. Nodes update this table every time they identify suspicious activity. In Table 1, ID is the unique ID of sensor node; NS denotes a suspicious node and NU is the entry for unsuspecting behavior by a node.

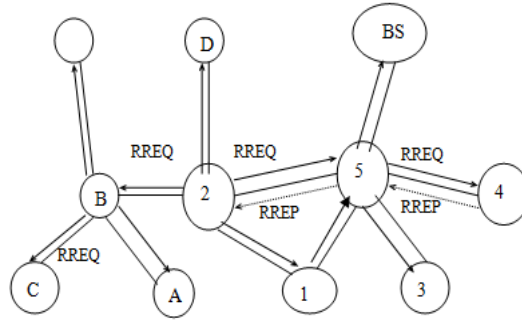
Node ID	Suspicious entries	Unsuspecting entries
ID	NS > 1	NU > 1

TABLE 1: Suspicious Node Table.

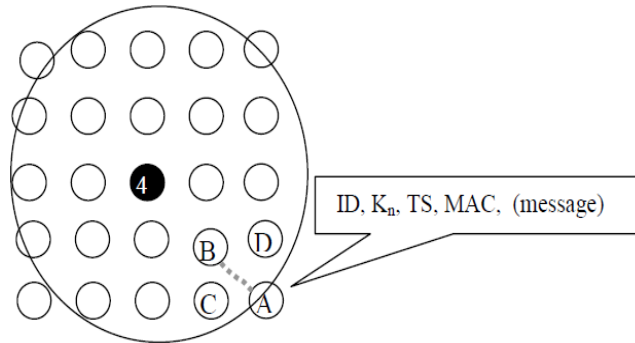
Each node builds its own Suspicious Node table. Every time Am identifies a suspicious entry it adds into its node suspicious table but also disseminates this information among its neighbors. Those nodes listening to the message update their Suspicious Node table. The broadcast



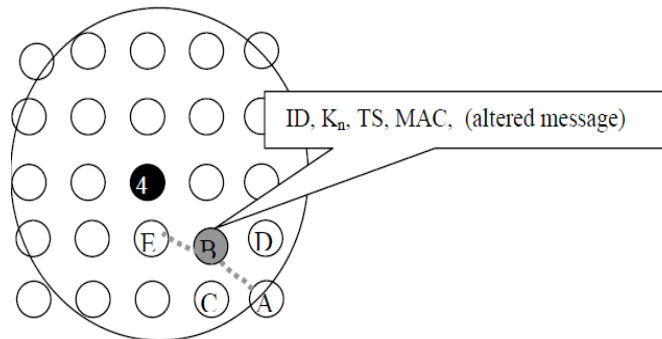
message also acts as an inquiry to which the nodes listening reply with their statistics regarding Bs. In Figure 2 Nodes C and D are neighboring nodes of Am and Bs; they listen to the transmission from Bs and respond with a suspicious entry if the suspicious count for Bs in their Suspicious Node table is greater than its unsuspecting count; otherwise they respond with unsuspecting. Figure 3(a) shows a message sent by Node A, secured with the network key  $K_n$  while in Figure 3(b) shows an altered message from Node B.



**FIGURE 2:** Monitoring Node Am, Suspicious Node Bs and Neighboring Nodes C&D.



**FIGURE 3:** (a) Message Sent by Node A.



**FIGURE 4:** (b) Message Altered by Node B.

In each of the diagrams above, ID is the node's unique identifier,  $K_n$  is the network key, TS is an encrypted time stamp, MAC is the message authentication code generated using  $K_n$  and for message  $m$ .

Node Am collects the replies from its neighbors and updates its Suspicious Node table, it increases its own suspicious entry for Bs by one and the unsuspecting entries accordingly. Once the suspicious entries reach a certain threshold, Node Am broadcasts that Node Bs is a suspicious node and all the neighboring nodes update their Suspicious Node tables to the presence of a malicious node in the cluster. When notification of this reaches a cluster leader, it isolates Bs by erasing Bs ID from its Nodes Table and discarding any messages coming from Bs. The cluster leader also broadcasts a message saying that node Bs has been isolated, so that any message originated from Bs is immediately discarded by its neighboring nodes hence isolating and effectively removing Node Bs from the network.

### **3. EXPERIMENTAL EVALUATION**

This section presents an evaluation of how well the proposed malicious node detection scheme performs in a multi-hop network. J-SIM was used to simulate malicious node detection. Starting with a scenario of 100 nodes randomly deployed over an area of 100×100 meters, a node transmission range of 30m was assumed. One of the nodes was to randomly become malicious. The scheme works as follows:

Neighboring nodes assess a malicious node by monitoring the actual and sent values of data. Whenever any node detects a malicious neighbor, it increases its suspicious node counter by 1 and broadcasts a message to inform other neighboring nodes. Whenever the counter reaches a threshold of 3 for a specific node, its neighbors consider that node malicious.

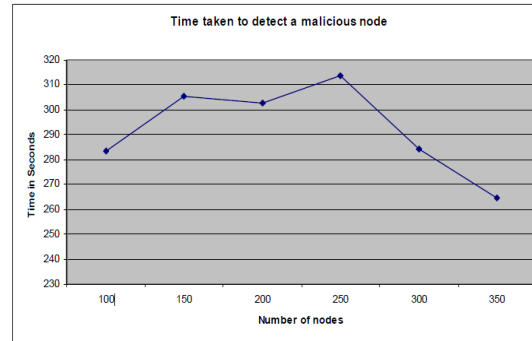
The sending node stays awake until the receiving node has forwarded the packet. Because of interference, this scenario might not work all the time; therefore, nodes receive a trust value from their neighbors, the threshold for which can be increased or decreased depending on the application.

Each node transfers one packet every 100 seconds. When a node receives a packet not intended for it, it first checks the destination to see whether it is for one of the neighboring nodes. If not, it discards the packet. The probability that the node stays awake to monitor its neighbors is 50%. If a malicious node is detected, the detecting node broadcasts the ID of the malicious node to its neighbors.

Once the base station has received the alert about a malicious node from at least 3 neighboring nodes, it declares the node malicious and isolates it from the network. The base station waits for the alerts from 3 nodes to ensure that the malicious node itself is not generating an alert about the legitimate nodes.

The level of this scheme's security depends entirely on the application. The percentage of neighbors being awake all the time could be 100 percent thus providing complete security. Instead, in order to be more energy efficient, the topology works by letting each node go to sleep when it is not sending or receiving a packet.

As seen from the experimental results shown in Figure 4 below, the time required to detect a malicious node decreases when the number of nodes in the network is increased. This is because in dense network, the probability of node detection is higher and faster because there are more neighbors monitoring the nodes. The results in Figure 4 are an average of 10 runs.



**FIGURE 5:** Time Taken to Detect a Malicious Node.

## 4. ANALYSIS OF THE PROPOSED SCHEME

The proposed malicious node detection mechanism mitigates the routing attacks discussed as follows.

### 4.1 Detection of Sybil Attacks

In Sybil attacks, the malicious node presents multiple identities by spoofing the identities of neighbor nodes. This attack can easily be prevented through the proposed monitoring mechanism since if Node B received a packet from Node A, Node B cannot forward this packet claiming that it is being forwarded by one of its neighbors, say Node C because the transmission is being monitored by Node A. Thus the monitoring node prevents a forwarding node from spoofing neighbor's identity.

### 4.2 Detection of Sinkholes, Wormholes and Selective Forwarding Attacks

In sinkhole attacks, the malicious node attracts the traffic from many nodes to pass through it by claiming to be a short route to the base station and thus acting as a sinkhole. In this attack, the malicious node is a more powerful node in terms of resources. Sinkhole attacks enable selective forwarding attacks.

### 4.3 Performance Metrics

In our First experiment, we vary the number of misbehaving nodes as 20,40,60,80 and 100. Our scheme achieves more delivery ratio than the [11] and [12] scheme since it has both reliability and security features. At the same time, from the results of average end-to-end delay for the misbehaving nodes 20, 40...100, our scheme has slightly lower delay than the [11] and [12] scheme because of authentication routines.

In our Second experiment, we vary the speed as 20,40,60,80 and 100, with 5 attackers. Our scheme achieves more delivery ratio than the [11] and [12] scheme since it has both reliability and security features. At the same time, from the results of average end-to-end delay for the mobility 10, 20, 30, 40, and 50, we can see our scheme has slightly lower delay than the [11] and [12] scheme because of authentication routines.

The proposed monitoring mechanism detects any attempt to establish a sinkhole or wormhole by preventing the nodes from accepting any traffic from a malicious node. In addition, within the proposed framework a destination node will not accept any traffic from a source node unless it is authenticated.

## 5. CONCLUSION AND FUTURE WORK

The malicious node detection mechanism prevents many routing attacks such as selective forwarding, wormholes, sinkholes and Sybil attacks. In using a monitoring mechanism to detect suspicious behavior, and on the basis of the responses from other monitoring nodes, if the number of suspicious entries concerning a particular node reaches a set threshold, that node is

declared malicious. This message is broadcast, alarming all the neighbors and eventually reaching the base station. The base station then isolates the malicious node and all traffic coming from that node is ignored. The simulation results show that the time it takes to detect a malicious node is decreased when there are more nodes in the network, and that it provides a fast and efficient way to detect malicious nodes.

## 6. ACKNOWLEDGEMENTS

This work is partially supported by the Natural Science Research Project of Education Office of Anhui Province (KJ2013B185), and the Natural Science Research Project of Chuzhou University (2012kj001Z).

We want to thank the members of our research group, who provided a lot of helpful advice for this paper.

## 7. REFERENCES

- [1] Patrick S. Chen, Shing-Han Li and Yung-Kuei Liu, "Scheduling the Access to Multi-Level Secure Databases in a Wireless Network Environment", *International Journal of Innovative Computing, Information and Control (IJICIC)*, vol.6, no. 12, pp.5381-5404, 2011.
- [2] Samuel Madden, Michael J. Franklin, Joseph M. Hellerstein, "An Acquisitional Query Processing System for Sensor Networks". *ACM Trans. Database Syst.*, 30(1):122–173, 2005.
- [3] M. Palomera-Perez, H. Benitez-Perez and J. Ortega-Arjona, "Coordinated Tasks: A Framework for Distributed Tasks in Mobile Area Networks", *ICIC Express Letters*, Volume 5, Issue 8(B), pp.3941-3946, 2011. pp.2817-2824, 2011.
- [4] Xueyan Tang and Jianliang Xu. "Optimizing lifetime for continuous data aggregation with precision guarantees in wireless sensor networks". *IEEE/ACM Trans.* 16(4):904–917, 2008.
- [5] Yingqi Xu, Tao-Yang Fu, Wang-Chien Lee, "Processing k nearest neighbor queries in location-aware sensor networks". *Signal Processing*, 87(12):2861–2881, 2007.
- [6] Jilong XUE, Xiaogang QI, Chenyu WANG. "An Energy-Balance Routing Algorithm Based on Node Classification for Wireless Sensor Networks". *Journal of Computational Information Systems*, Vol. 7 (7): 2277- 2284, 2011.
- [7] Yiliang Han, Xiaolin Gui and Xuguang Wu, "Parallel Multi-Recipient Signcryption for Imbalanced Wireless Networks", *International Journal of Innovative Computing, Information and Control (IJICIC)*, vol.6, no.8, pp.3521-3630, 2010.
- [8] Mustafa Fayomi, "An enhancement of authentication protocol and key agreement (AKA) for 3G mobile networks". *International Journal of Security*, Vol. 5 (1): 35- 61, 2011.
- [9] Marti, S., T. J., Lai, K. and Baker, M. "Mitigating routing misbehavior in mobile ad hoc networks". In *Proceedings of the 6th Annual International Conference on Mobile Computing and Networking (MobiCom 2000)* August 6-11, 2000, Boston, USA. Boston, MA, ACM Press, pp. 255-265.
- [10] Aamir Shahzad, "Cryptography and authentication placement to provide secure channel for SCADA communication", *International Journal of Security*, Vol. 6 (3): 28- 44, 2012.
- [11] Loanis, K. and Dimitrou, T. "Towards intrusion detection in wireless sensor networks". In *Proceedings of the 13th European Wireless Conference*, April 1-4, 2007, Paris, France.

Daxing WANG

- [12] Junior, W., Figueiredo, T. and Wong, H. "Malicious node detection in wireless sensor networks". In Proceedings of the 18th International Parallel and Distributed Processing Symposium (IPDPS'04), April 26-30, 2004, Santa Fe, New Mexico.

## INSTRUCTIONS TO CONTRIBUTORS

Information Security is an important aspect of protecting the information society from a wide variety of threats. The International Journal of Security (IJS) presents publications and research that builds on computer security and cryptography and also reaches out to other branches of the information sciences. Our aim is to provide research and development results of lasting significance in the theory, design, implementation, analysis, and application of secure computer systems.

IJS provides a platform to computer security experts, practitioners, executives, information security managers, academics, security consultants and graduate students to publish original, innovative and time-critical articles and other information describing research and good practices of important technical work in information security, whether theoretical, applicable, or related to implementation. It is also a platform for the sharing of ideas about the meaning and implications of security and privacy, particularly those with important consequences for the technical community. We welcome contributions towards the precise understanding of security policies through modeling, as well as the design and analysis of mechanisms for enforcing them, and the architectural principles of software and hardware system implementing them.

To build its International reputation, we are disseminating the publication information through Google Books, Google Scholar, Directory of Open Access Journals (DOAJ), Open J Gate, ScientificCommons, Docstoc and many more. Our International Editors are working on establishing ISI listing and a good impact factor for IJS.

The initial efforts helped to shape the editorial policy and to sharpen the focus of the journal. Starting with Volume 7, 2013, IJS will appear with more focused issues. Besides normal publications, IJS intend to organized special issues on more focused topics. Each special issue will have a designated editor (editors) – either member of the editorial board or another recognized specialist in the respective field.

We are open to contributions, proposals for any topic as well as for editors and reviewers. We understand that it is through the effort of volunteers that CSC Journals continues to grow and flourish.

### IJS LIST OF TOPICS

The realm of International Journal of Security (IJS) extends, but not limited, to the following:

- Anonymity
- Attacks, security mechanisms, and security service
- Authorisation
- Cellular/wireless/mobile/satellite networks security
- Public key cryptography and key management
- Cryptography and cryptanalysis
- Data integrity issues
- Database security
- Denial of service attacks and countermeasures
- Design or analysis of security protocols
- Distributed and parallel systems security
- Anonymity and pseudonymity
- Code security, including mobile code security
- Biometrics
- Authentication
- Confidentiality, privacy, integrity, authentication
- Data confidentiality issues
- Data recovery
- Denial of service
- Dependability and reliability
- Distributed access control
- Electronic commerce

- Formal security analyses
- Information flow
- Intellectual property protection
- Key management
- Network and Internet security
- Network security performance evaluation
- Peer-to-peer security
- Privacy protection
- Revocation of malicious parties
- Secure location determination
- Secure routing protocols
- Security in ad hoc networks
- Security in communications
- Security in distributed systems
- Security in e-mail
- Security in integrated networks
- Security in internet and WWW
- Security in mobile IP
- Security in peer-to-peer networks
- Security in sensor networks
- Security in wired and wireless integrated networks
- Security in wireless communications
- Security in wireless LANs (IEEE 802.11 WLAN, WiFi,
- Security in wireless PANs (Bluetooth and IEEE 802.
- Security specification techniques
- Tradeoff analysis between performance and security
- Viruses worms and other malicious code
- Fraudulent usage
- Information hiding and watermarking
- Intrusion detection
- Multicast security
- Network forensics
- Non-repudiation
- Prevention of traffic analysis
- Computer forensics
- Risk assessment and management
- Secure PHY/MAC/routing protocols
- Security group communications
- Security in cellular networks (2G, 2.5G, 3G, B3G,
- Security in content-delivery networks
- Security in domain name service
- Security in high-speed networks
- Security in integrated wireless networks
- Security in IP networks
- Security in optical systems and networks
- Security in satellite networks
- Security in VoIP
- Security in Wired Networks
- Security in wireless internet
- Security in wireless MANs (IEEE 802.16 and WiMAX)
- Security policies
- Security standards
- Trust establishment
- WLAN and Bluetooth security

## **CALL FOR PAPERS**

---

**Volume: 7 - Issue: 2**

**i. Submission Deadline :** August 31, 2013

**ii. Author Notification:** September 30, 2013

**iii. Issue Publication:** October 2013

## **CONTACT INFORMATION**

### **Computer Science Journals Sdn Bhd**

B-5-8 Plaza Mont Kiara, Mont Kiara  
50480, Kuala Lumpur, MALAYSIA

Phone: 006 03 6204 5627

Fax: 006 03 6204 5628

Email: [cscpress@cscjournals.org](mailto:cscpress@cscjournals.org)



CSC PUBLISHERS © 2013  
COMPUTER SCIENCE JOURNALS SDN BHD  
B-5-8 PLAZA MONT KIARA  
MONT KIARA  
50480, KUALA LUMPUR  
MALAYSIA

PHONE: 006 03 6204 5627

FAX: 006 03 6204 5628

EMAIL: [cscpress@cscjournals.org](mailto:cscpress@cscjournals.org)