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Wireless Sensor Network Performance and Admission Control Management in Patient Monitoring

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A B S T R A C T

There is an increasing need for collecting patient data for medical sensor diagnosis and continuous health assessment paves the way for biomedical wireless. In spite of collecting patient data, this network should ensure that it satisfies the demanding quality of service requirements while guaranteeing high levels of confidence and reliability. These goals are affected by several factors like network topology, limited throughput, characteristics and dynamics of the surrounding environment which makes it difficult to analyze the network's performance. However the healthcare professional should get a timely indication about the network's performance. In contrast to many other systems, the proposed system does not require assistance from healthcare professional. The central idea of this project is to detect and classify the harmful fluctuations in the quality of service afforded by Biomedical Wireless Sensor Network and to elect a position that offers high quality of service for the incoming new node in the biomedical wireless sensor network without the interference of healthcare professionals. The monitoring module and admission module are analyzed for congested and uncongested network. This QoS based network administrative tool detects the network performance effectively.

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INTRODUCTION

Patients in the critical care unit need to be monitored 24 hours a day. The vital signs of a pregnant woman such as blood pressure and heart rate of both foetus and mother should be monitored continuously and alerted about the abnormality to healthcare professional (Alemdar *et al*., 2012). It is difficult for a healthcare professional to monitor multiple patients at a time. So WSN is used for the same as mentioned in (Megalingam *et al*., 2012).Pervasive healthcare becomes a necessity in this situation. The wireless sensors are placed in patient's body as mentioned in (keerthika *et al*., 2013).BWSN plays a vital role in monitoring patients continuously (Chipara *et al*., 2010).

The Prime task of BWSN is to collect sensor's data from patients and send it to a central database via coordinator node, so that the data can be analyzed later. BWSN has the need to be integrated with the existing network infrastructure at the same time it should guarantee quality of service (Abreu *et al*., 2013).In a dynamic hospital environment, The factors like network congestion and radio interferences will affect quality of service. In such scenario, there may be severe degradation in quality of service, therefore the quality of service has the necessity to be monitored constantly (Balen *et al*., 2011). The quality of service should be maintained even when new nodes are being added to the network. The QoS monitoring and admission control has the potential to achieve high levels of reliability and performance in WSN's as mentioned in (Lindh *et al*., 2009). Few approaches have been proposed for monitoring quality of service and admission control for WSN. In (Abreu *et al*., 2012) framework for

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automatic evaluation of QOS and possible QoS requirements of BWSN are stated. Here the framework proved to be a valuable tool for evaluating test protocols, QoS parameters and metrics. This framework allows straightforward network deployment after simulation so it reduces the debugging time after deployment in real network.

In this paper two modules are mentioned namely monitoring module and admission module. The quality of service based on packet reception ratio (PRR) is monitored by monitoring module and finding position for new nodes based on packet reception rate without health care professional interference is done by admission module. QoS metric value is calculated by time domain analysis. In (Orhan *et al*., 2011) based on real time measurements of packet loss indicated by performance meter running in each sensor node the network performance and admission control is managed. The performance meter runs on each sensor node which leads to more energy depletion in all sensor nodes which is taken as an disadvantage here.

In (Mas *et al*., 2007) mathematical method based on packet loss statistics between sender and receiver is specified to analyze network performance for admission control using an end to end probing technique. The network is analyzed by including admission control to audio-visual real time application, by enabling admission control in transport layer and by deploying admission control at network layer. In (Abreu *et al*., 2014), for the admission of new nodes, the network needs the assistance of healthcare professional. The healthcare professional will select the sensor type, data rate, position of a node and other necessary parameters and sends the information to the sink node. Now the sink node will trigger the node in the appropriate position indicated by him. If the PRR is above the specified range then that position is chosen for new node but if it does not satisfy the condition then the healthcare professional will choose another position which seems to be a time consuming process. So in this paper the sink has the power to automate the admission of new sensor nodes to the network.

1. *Methodology:*

Software Architecture:

The software architecture of BWSN's nodes to build the QoS based network administrative system (Abreu *et al*., 2014) is mentioned in figure 1. Function of QoS Manager is to collect information about network QoS and also to trigger the new node admission procedure (i.e.) when a new node entry is reported the sink node should initiate the virtual node process. The part of QoS Profile is to gather all information about the data flow and network QoS for further analysis of network performance. QoS Daemon takes care of control and signalling communication between nodes in BWSN. QoS probe that runs only in sender nodes, on receiving virtual node request the sender nodes starts to create specific data flow in the network until it gets an stop trigger from the sink node. QoS analyzer and Location adviser runs only in sink node. QoSanalyzer will monitor the network QoS and send alarm in case of critical values. Location adviser provides the best position for incoming nodes based on QoS of several leaf nodes.

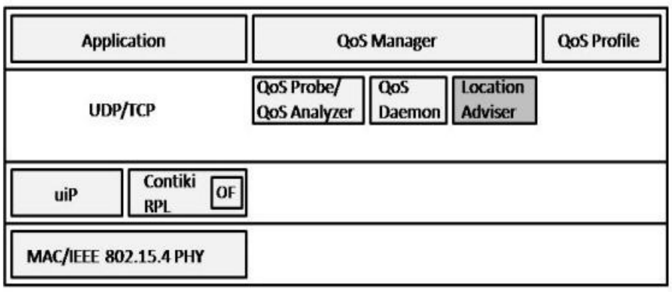

Fig. 1: Software architecture.

Working Principle:

The Monitoring module checks the network continuously for any degradation events occurring in the network. If any degradation is detected in QoS metric it indicates alert signal. The sink node runs a timer in it, Once the timer expires it classifies the network performance and if any critical metric values are found , the monitoring module informs about the critical situation to the health care professional to make relevant actions to increase the network performance.

The QoS metric depends upon packet reception ratio of the BWSN network. The figure of merits used here to find the network performance are namely, metric degradation index, metric tendency, zero crossing rate, single global minimum, and single global maximum. The deviation in these value from the specified ranges of figure of merits indicates the decreased performance of the network. Working of monitoring module is specified in figure 2. The admission module will suggest best position where the QoS metric is higher for the incoming new node. The aim of this admission module is to pre check the

QoS of the network by virtual node method. The network performance is predicted by triggering the virtual node in the places where the sender nodes were already occupied in the network. Working of admission module is as specified in figure 3.

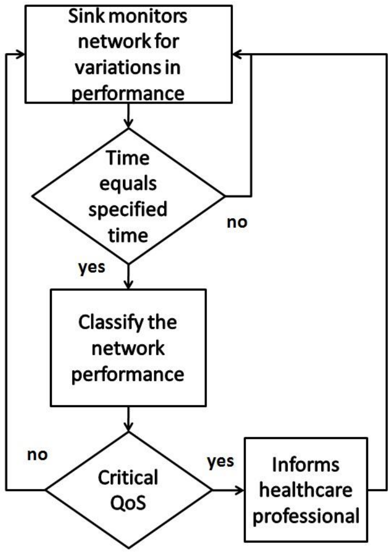

Fig. 2: Monitoring module.

The new incoming node requests the sink node, once the sink node gets the trigger signal it selects the first leaf node and triggers it to act as the new node. After the timer expires the sink node will send stop trigger to the selected node and calculates its PRR value. Now the same procedures is continued until all the leaf nodes are analyzed for its PRR. Then the sink node will select the best PRR from that and places the new node over in that optimal position.

Time Domain Analysis OfQoS Metric:

QoS metric indicates the parameters used for finding the network performance. Packet reception rate is considered as the basic metric value. The derivative of packet reception ratio is also being calculated. Packet reception rate is found by the ratio between the numbers of data packets received by the sink to the number of data packets sent by the sender nodes. With these PRR and PRR derivative metrics other figure of merits are calculated. The PRR of a network is given by the following equation(1).

$$P(n) = \frac{1}{M}\sum_{a=1}^{M}\frac{R_a}{S_a} \quad (1)$$

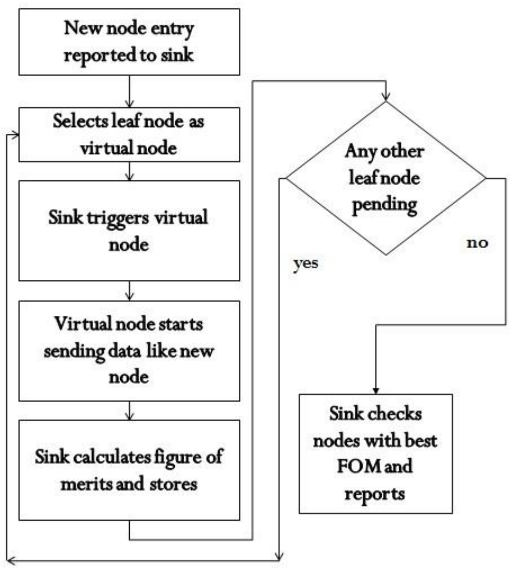

Fig. 3: Admission module.

Where M is the number of sensor nodes innetwork, Ra is the number of data packets received by sink from the node 'a', Sa is the number of data packets sent by node 'a' and n is the index of current observation(Abreu *et al*., 2014). The derivative of Packet reception ratio is indicated by P_{deri}.

After the setup time the network remains stable for some time and also its QoS metric but small fluctuations may be experienced in the network. So to figure out the QoS provided by the network moving average filter is used. The moving average filter considers the PRR value for N observations and takes an average value of it. By using the moving average filter the network performance is analyzed. The following moving average filter (2) is considered:

$$MAF = f(P,N,n) = \frac{1}{k}\sum_{i=0}^{k-1} P(n-i) \quad (2)$$

Where N is the number of observations, P(n-i) is the packet reception rate at n-iobservation, k =n if n<N or k=N in other cases (Abreu *et al*., 2014). The number of observation value depends upon the network deployment environment. Since the network deployment area in this project is an hostile one, N value is considered to be 3. If the network is hostile the N value becomes small and vice versa.

Detecting Large Variations in Network:

Radio interferences or node energy depletion creates big impact on the network and leads to sudden degradation in the QoS metric. These events may cause the network to experience rapidly decrease in its performance. For detecting such events energy of metric differentiation (3) is considered.

$$E(n) = \sum_{i=0}^{k-1} | P_{deri}(n-i) |^2 \quad (3)$$

and an energy threshold (4) is considered as follows:

$$E_t(n) = f(E,N,n) \quad (4)$$

The harmful perturbations in network is found in the network when E(n) > E_t(n) (Abreu *et al*., 2014). In order to find this degradation event metric degradation index is defined as mentioned in (5):

$$MDI = \left\lfloor \frac{E}{E_t} \right\rfloor \quad (5)$$

The potential degradation is higher as the MDI increases. MDI value (Abreu *et al*., 2014) is computed by running the network without any congestion. MDI mean value can also be computed for calibrating it.

Detecting Small Variations in Network:

The previous analysis will be insensitive to the network that has $E \leq E_t$. In order to detect these small variations in network three figure of merits are stated namely, Metric Tendency, Zero Crossing Rate, single global minimum and single global maximum. MT (6) is calculated by slope of linear regression curve obtained with the help of least squares, as:

$$MT = \frac{f(id.P,N,n) - (f(id,N,n) * f(P,N,n))}{f(id^2,N,n) - f^2(id,N,n)} \quad (6)$$

Where id represents identity function (Abreu *et al*., 2014). When MT < 0 metric tends to decrease, when MT > 0 metric tends to increase and when MT = 0 the metric remains constant. ZCR is determined as follows (7):

$$ZCR(n) = \frac{1}{2k}\sum_{i=0}^{k-1} | \mathrm{sgn}(P_{deri}(n-i)) - \mathrm{sgn}(P_{deri}(n-1-i)) | \quad (7)$$

wheresgn is the sign function (Abreu *et al*., 2014). Now, to decide if MAF comes under single global minimum (8) or single global maximum (9) the following equations are considered:

$$MIN(n) = \{^{1, MAF(n) < MAF(i), \forall i \in \{n-k+1, n-1\}}_{0, in-other-cases} \quad (8)$$

$$MAX(n) = \{^{1, MAF(n) > MAF(i), \forall i \in \{n-k+1, n-1\}}_{0, in-other-cases} \quad (9)$$

Based on the classification stated in (Truong *et al*., 2006) the QoS metric can be sorted into PD_{min} (10) and PD_{max} (11)with the following expression:

$$PD_{\min} = (P_{deri} > 0 \wedge E > E_t) \vee \{(P_{deri} > 0 \wedge MT > 0) \wedge (ZCR = 0 \vee MAX = 1)\} \quad (10)$$

$$PD_{\max} = (P_{deri} < 0 \wedge E > E_t) \vee \{(P_{deri} < 0 \wedge MT < 0) \wedge (ZCR = 0 \vee MIN = 1)\} \quad (11)$$

2. *Results:*

The proposed BWSN is developed using Contiki OS (Dunkels *et al*., 2004) and simulated using COOJA which is an hybrid approach consisting of cross level emulation and simulation as mentioned in (Osterlind *et al*., 2004). The BWSN consists of 25 sender nodes (Patients) and 1 sink node which has a radio range of 30 meters. The sender nodes are interfaced with sensors like pulse sensor and temperature sensor. Sender nodes starts sending data packets as the network setup time (65 seconds) expires. The BWSN network performance is analyzed for both congested and uncongested network. Uncongested network is formed by adding radio interferences to it. In cooja the radio interferences are added by changing the transmission and reception ratio of UDGM-DL model in network window of cooja emulator. This evaluation is done both to monitoring and admission modules.

Evaluation of QoS Monitoring Module:

There may be small and large variations in QoS metric, if no action was taken regarding small variations in QoS metric it may lead to large variations in the network which in result will affect the network performance. The QoS monitoring modules takes care of this scenario and it successfully predicts the harmful perturbations in the network and informs them to the healthcare professional. During normal operation PRR and its derivative are studied. PRR tends to have slight variations but it did not fall into the critical region. In figure 4 the PRR and its derivative during normal operation is shown, where these parameters tends to be in normal values.The networks energy, energy threshold is also measured during the normal operation. All the values are found to be in the normal range. The MDI in normal operation is found to be 3. Figure 5 shows the metric values such as energy, energy threshold and MDI. Whenever the energy falls below energy threshold or builds above the threshold, based on the corresponding normal value of the figure of merit alert is generated.

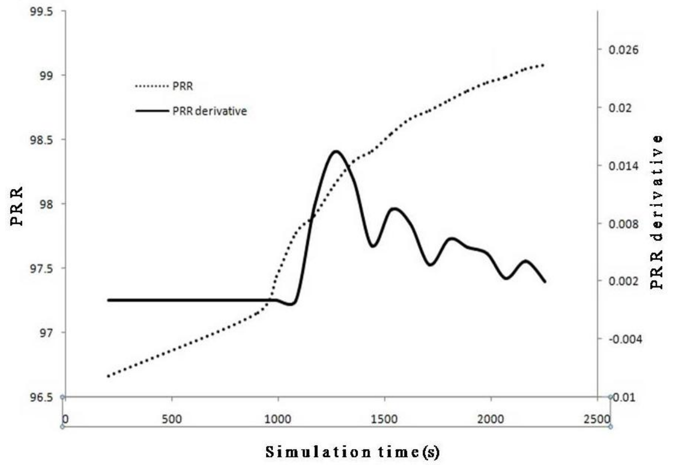

Fig. 4: PRR and its derivative in normal environment.

The QoS monitoring module assures to detect all suspicious events regarding to the QoS degradation. To analyze how the QoS monitoring module reacts to the external interferences the transmission reception ranges are changed.

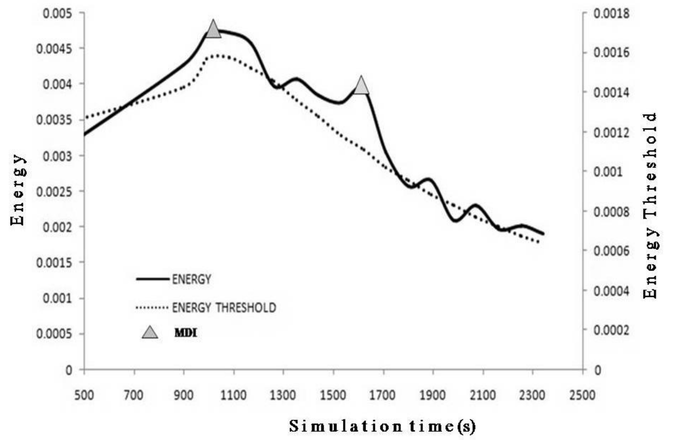

Fig. 5: Energy, its threshold and MDI in normal environment.

Figure 6 shows the PRR and its derivative of a congested network. It shows that the introduced radio interferences creates a strong perturbation in the network which affects the network performance in a great way. This degradation event can be detected initially and can alarm the professional. The radio interferences are made as specified in table 1.

PRR tends to fluctuate when transmission reception ratios are changed and it experiences a sudden drop when the TX and RX ratio is set to 50 percentage. Figure 7 supports the fact of detection of the harmful event. Here the MDI value is found to lie between 5 and 9. By this value the network is found to have large variations in network and it is being captured by QoS monitoring module.

Evaluation of QoS Admission Module:

During new node entry, QoS admission module enables virtual node in all leaf nodes one by one and collects the network PRR. This procedure is analyzed for both congested and uncongested network. The new node is placed in the radio range where the node containing highest PRR.

Table 1: Changing Transmission Reception Ranges Wtih Respect to S imulation Time (s).

Simulation Time in Seconds	200	400	500	700	800	900	950
Tx and Rx Success Ratio	100	75	95	50	80	90	100

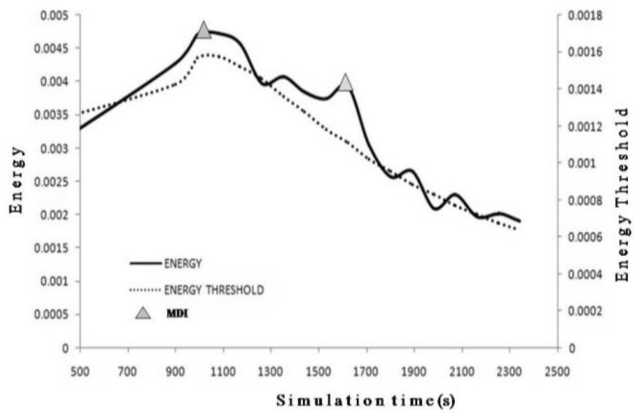

Fig. 6: PRR and its derivative in hostile environment.

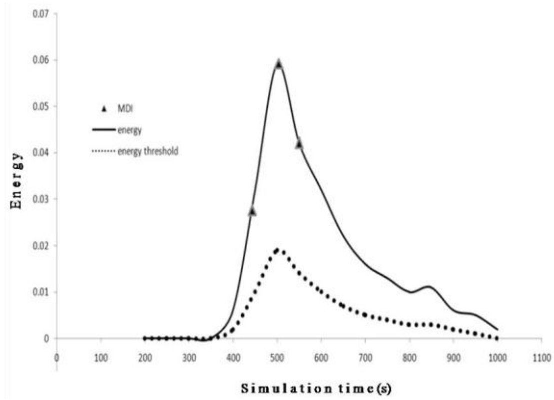

Fig. 7: Energy, its threshold and MDI in normal environment.

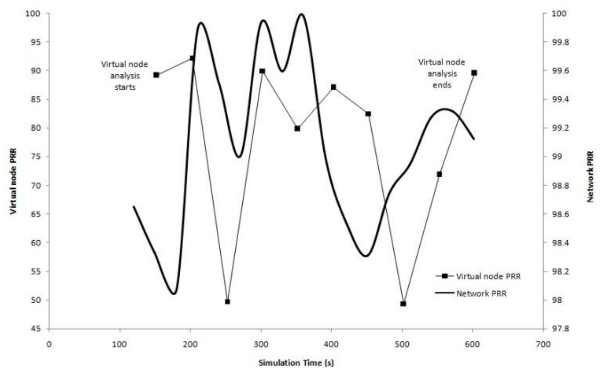

Fig. 8: Network PRR and Virtual node PRR in uncongested network.

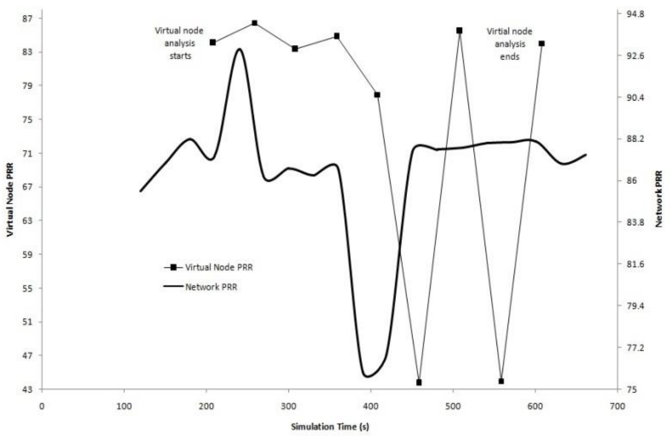

Fig. 9: Network PRR and Virtual node PRR in congested network.

Figure 8 shows the network PRR and Virtual node PRR in the uncongested network. The PRR value is observed to lie in the range of 98 to 99.8 in case of uncongested network. Figure 9 shows the network PRR and virtual node PRR in congested network. The PRR value is observed to lie in the range of 98 to 99.8 in case of uncongested network.

3. *Conclusion:*

The main purpose of this project is to analyze and find the network performance for its critical behaviour and report it as soon as it is been captured. QoS based network administrative system proves to be a valuable tool to monitor and classify the networks performance. The monitoring module and admission module helps to analyze the networks figure of merit and maintain the same. The future work of this project concentrates on finding the best position based on the RSSI value of the best four nodes having high figure of merits.

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REFERENCES

Abreu, C. and P. Mendes, 2013. "Wireless sensor networks for biomedical applications." Bioengineering (ENBENG), 2013 IEEE 3rd Portuguese Meeting in. IEEE.

Abreu, Carlos, *et al*., 2014. "QoS-based management of biomedical wireless sensor networks for patient monitoring." Springer Plus, 3.1: 239.

Abreu, Carlos, Manuel Ricardo and Paulo Mendes, 2012. "Framework for QoS Performance Assessment on Biomedical Wireless Sensor Networks."BIODEVICES.

Alemdar, Hande and Cem Ersoy, 2010. "Wireless sensor networks for healthcare: A survey." Computer Networks, 54(15): 2688-2710.

Balen, Josip, Drago Zagar and Goran Martinovic, 2011. "Quality of service in wireless sensor networks: a survey and related patents." Recent Patents on Computer Science, 4(3): 188-202.

Chipara, Octav, *et al*., 2010. "Reliable clinical monitoring using wireless sensor networks: experiences in a step-down hospital unit." Proceedings of the 8th ACM Conference on Embedded Networked Sensor Systems. ACM.

Dunkels, Adam, Bjorn Gronvall and Thiemo Voigt, 2004. "Contiki-a lightweight and flexible operating system for tiny networked sensors." Local Computer Networks, 2004. 29th Annual IEEE International Conference on. IEEE.

Keerthika, A. and R. Ganesan, 2013. "Pervasive health care system for monitoring oxygen saturation using pulse oximeter sensor." Information & Communication Technologies (ICT), 2013 IEEE Conference on. IEEE.

Lindh, Thomas and Ibrahim Orhan, 2009. "Performance monitoring and control in contention-based wireless sensor networks." International Symposium on Wireless Communication Systems.

Más, Ignacio and Gunnar Karlsson, 2007. "Probe-based admission control for a differentiated-services internet." Computer networks, 51(13): 3902-3918.

Megalingam, Rajesh Kannan, Divya M. Kaimal and Maneesha V. Ramesh, 2012. "Efficient patient monitoring for multiple patients using WSN." Advances in Mobile Network, Communication and its Applications (MNCAPPS), 2012 International Conference on. IEEE.

Orhan, Ibrahim and Thomas Lindh, 2011. "Measurement-based performance and admission control in wireless sensor networks." International Journal On Advances in Systems and Measurements, 4(1,2): 32-45.

Osterlind, Fredrik, *et al*., 2006. "Cross-level sensor network simulation with cooja."Local Computer Networks, Proceedings 2006 31st IEEE Conference on. IEEE.

Truong, Hong-Linh, Robert Samborski and Thomas Fahringer, 2006. "Towards a framework for monitoring and analyzing qos metrics of grid services." e-Science and Grid Computing, 2006. e-Science'06. Second IEEE International Conference on. IEEE.