American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-4, Issue-9, pp-26-30
www.ajer.org
Research Paper Open Access

Estimation Technique of the number of nodes in underwater wireless communication network

Eng. Md. Ismail Haque[1], Eng. Md. Nurul Anwar Tarek[2], Eng. Md. Ar Rafiul Faisal[3]

[1](EEE, International Islamic University Chittagong, Chittagong, Bangladesh)
[2](EEE, International Islamic University Chittagong, Chittagong, Bangladesh)
[3] (Instrument Tx Testing, Energypac Engineering Ltd, Rangpur, Bangladesh)

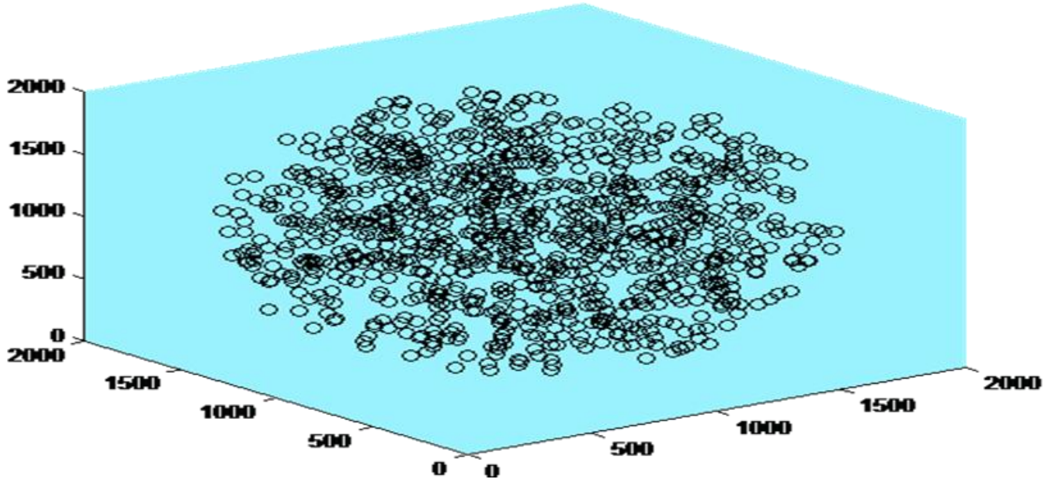
ABSTRACT : *Node estimation is very essential for a network's proper operation. It is so complicated to estimate in underwater soundings using conventional techniques. An alternative method of node estimation based on cross correlation of the signals from the nodes has proposed in this paper. It can be applied to any environment networks, from underwater to space. But in this paper, underwater wireless communication network (UWCN) is most significant network. 3D space has considered in this experimental phenomena. For estimating the number of node, two sensors are used as receiver. In this method, different number of bin has been used for node estimation. A relative parameters have been discussed which leads us to select the suitable estimation of network.*

Keywords - *Bin, Wireless Sensor Network (WSN), Cross-Correlation Function (CCF), Underwater Communication network (UCN), Node- Estimation*

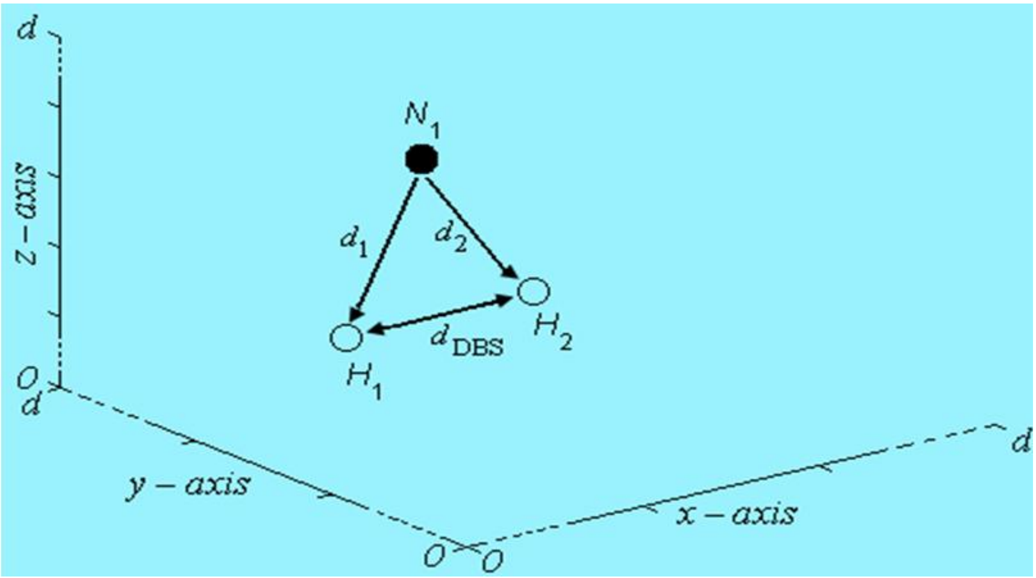
I. INTRODUCTION

The technique of cross-correlation is an essential statistical tool in various fields of interest. It has been used in communication networks to identify and localize nodes, and for angle of arrival (AOA) estimations of signals from the nodes in a WSN. Some researchers have used it for the detection of weak signals in the field of cardiology. In this paper, the use of the cross-correlation function is to estimate the number of signal sources (nodes in WCN). It begins with the formulation of the cross-correlation of random signals, which is the starting material and method for estimating the number of nodes in a network. In ad hoc networks where a node needs to know the number of neighbors, cross-correlation is performed by a computer associated with the node. In other networks, cross-correlation is performed by a remote computer controlled by testing personnel. All the signals transmitted are received by the receiving node and recorded in the associated computer, in which the cross-correlation is performed. Transmission and reception of the signals are performed for a time frame which is called signal length throughout this thesis. The received signals are the delayed copy of the transmitted signals. The proposed method does not require any time synchronization and thus the time stamp is not a performance factor. The communication requirement that need to be satisfied is that the transmitters and the receivers need to be capable of transmitting and receiving signals for the specified recorded time without becoming overheated.

II. FORMULATION OF RANDOM SIGNAL CROSS-CORRELATION



(a)



(b)

Figure 1 Distributions of underwater network nodes in 3D space:

(a) *N* nodes; and (b) only one node

Consider two receiving nodes surrounded by N transmitting nodes in a 3D space, as shown in Figure 1 (a). In this figure red color indicates sensor and others indicate nodes. Assume that the transmitting nodes are the sources of white Gaussian signals and are uniformly distributed over the volume of a large sphere, the Centre of which lies halfway between the receiving nodes, because only a sphere provides equal amounts of signals from every direction. The propagation velocity is assumed to be constant which, in our case, is the sound velocity, S_P, in the medium. To make the distinction between the receiving and transmitting nodes easily understandable, we call them the *sensor/receiver* and *node*, respectively.

To formulate the random signal cross-correlation problem in this analysis, the two sensors, H_1 and H_2, and a node, N_1, are taken at locations (x_1,y_1,z_1), (x_2,y_2,z_2) and (x_3,y_3,z_3), respectively , somewhere inside the sphere, as shown in Figure 1 (b). The distance between the sensors, d_{DBS} is then

$$d_{DBS} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \ .$$

Consider N_1 emits a signal, $S_1(t)$, which is infinitely long. So the signals received by H_1 and H_2 are, respectively:

$$S_{r_{11}}(t) = \alpha_{11} S_1(t - \tau_{11})$$
$$S_{r_{12}}(t) = \alpha_{12} S_1(t - \tau_{12})$$

where, α_{11} and α_{12} are the respective attenuations due to the absorption and dispersion present in the medium, $\tau_{11} = \frac{d_{11}}{S_P}$ and $\tau_{12} = \frac{d_{12}}{S_P}$ the respective time delays for the signal to reach the sensors, and S_P is the speed of wave propagation.

Assuming τ is the time shift in the cross-correlation, and then the CCF is: $C_1(\tau) = \int_{-\infty}^{+\infty} S_{r_{11}}(t) S_{r_{12}}(t - \tau) d\tau$

Which takes the form of a delta function as it is a cross-correlation of two white Gaussian signals where one signal essentially is a delayed copy of the other.

The final CCF between the signals at the sensors is:

$$C(\tau) = \int_{-\infty}^{+\infty} S_{r_{t1}}(t) S_{r_{t2}}(t - \tau) d\tau$$
$$= \int_{-\infty}^{+\infty} \sum_{j=1}^{N} \alpha_{j1} S_j(t - \tau_{j1}) \sum_{j=1}^{N} \alpha_{j2} S_j(t - \tau_{j2} - \tau) d\tau$$

Which takes the form of a series of delta functions as it is a cross-correlation of two signals which are the summations of several white Gaussian signals.

III. CCF FOR INFINITELY LONG SIGNAL

If a source emits an infinitely long unity strength Gaussian signal, which is recorded at two sensors with the corresponding time delays and attenuations, the cross-correlation function of these two signals can be expressed by a delta function, whose amplitude depends on the attenuations and position will be the delay difference of the signals from the Centre of the CCF.

Thus, the CCF for such a source is

$$C_1(\tau) = \alpha_{11} \alpha_{12} \delta\left(\tau - \left[\frac{d_{11} - d_{12}}{s_P}\right]\right)$$

The CCF for N source is summation of N numbers of deltas with their corresponding positions which are determined by the delay differences of the signals in the sensors.

$$C(\tau) = \sum_{j=1}^{N} \delta\left(\tau - \left[\frac{d_{j1} - d_{j2}}{s_P}\right]\right)$$

It is intuitive that if N is larger than the number of bins, b, which is usually the case, the bins are occupied by more than one delta due to the same delay differences. This increases the amplitude of the deltas in the bins, and thus the CCF is expressed in terms of bins as

$$C(\tau) = \sum_{i=1}^{b} P_i \delta_i$$

Where P_i is the amplitude or peak of the Dirac delta δ_i in the i^{th} bin.

The above analytical expression is verified by simulation in the following Figure 2. Here we have used 50 nodes and 29 bins. The nodes are the sources of equal unity power signal. It is shown that some bins are occupied by only one, some of them by more than one, and rest of them is empty due to the delay differences in the cross-correlation process. The results follow the expression where the P_i values are as follows.

$P_1 = P_{21} = P_{24} = 3$, $P_2 = P_5 = P_9 = P_{19} = 1$, … and so on.

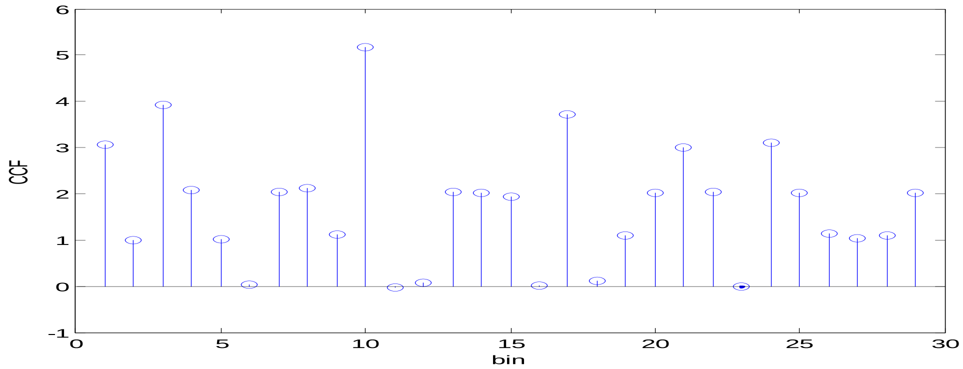


Figure 2 CCF in case: *N*=50, and *b*=29

IV. THEORETICAL ESTIMATION

The cross-correlation problem has been reframed into a probability problem where it is shown that it follows the binomial probability distribution in which the parameters are the number of nodes, *N*, and the inverse of the number of bins, *b*.

The expected value of the first moment (the mean) of the CCF is:

$$E(X) = \text{mean}, \mu = \langle C(\tau) \rangle = np \qquad (1)$$
$$= N \div b$$

Where *b* is twice the number of samples between the sensors (NSBS), *m* minus one, as we cross-correlate two vectors of length $m \times 1$; and the second moment is:

$$E(X^2) = \text{second moment} = \langle C^2(\tau) \rangle \qquad (2)$$
$$= (np)^2 + npq$$

From (1) and (2), we can obtain the variance:

$$\sigma^2 = E(X^2) - E(X)^2 = npq$$
$$= N \times (1/b) \times (1 - 1/b)$$

Then, the standard deviation is:

$$\sigma = \sqrt{E(X^2) - E(X)^2}$$
$$= \sqrt{N \times (1/b) \times (1 - 1/b)}$$

Thus, the ratio of the standard deviation to the mean, *R*, is:

$$R = \sigma \div \mu = \sqrt{\frac{q}{np}} = \sqrt{\frac{(1-1/b)}{N \times (1/b)}} = \sqrt{\frac{(b-1)}{N}} \qquad (3)$$

This is the relationship between the number of nodes, *N*, and the ratio of the standard deviation to the mean, *R*, of the CCF. Since we know *b* and can measure σ and μ (and, therefore, determine *R*) from the CCF, we can readily determine the number of nodes, *N*. Figure 3 shows the theoretical result derived from (3) for *b* (Figure 3 for 29 bins).

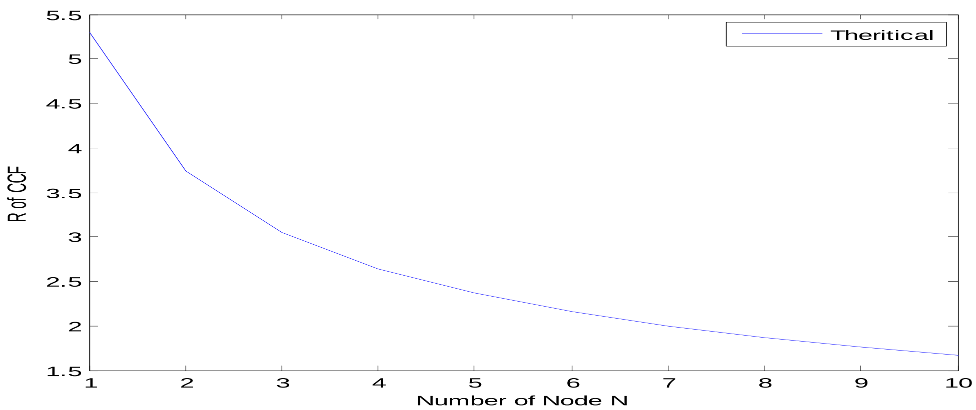


Figure 3 Theoretical *R* versus *N*: for *b* = 29

It is clear from (3) that the ratio, *R*, is also dependent on *b*. Recalling (3), $R = \sqrt{\frac{b-1}{N}}$ and, assuming $b >> 1$, i.e., $b - 1 \approx b$:

$$R = \sqrt{\frac{b}{N}}$$

V. ESTIMATION FROM SIMULATION

After cross-correlating signals received at two sensors from a number of random Gaussian signal sources, the CCF, which is a rectangular pulse over the space between the sensors, can be obtained. Then, it is easy to estimate the mean and standard deviation of this CCF and, therefore, the ratio, *R*, as the sampling rate and d_{DBS} are known. In the particular case in which the sampling rate, speed of propagation and d_{DBS} are fixed, (3) tells us that the ratio, *R*, is inversely proportional to the square root of the number of nodes, *N*. Thus, (3) becomes:

$$R \infty \frac{1}{\sqrt{N}} \quad \text{or} \quad R = \frac{c}{\sqrt{N}}$$

Where $c(= \sqrt{b-1})$ is a known constant. Thus, from the simulation, we can readily estimate the number of nodes by knowing only the ratio of the standard deviation to the mean of the CCF.

VI. CONCLUSION

Estimation of the number of nodes is investigated here with theory (obtained from statistical property of CCF) and simulation. So, R of CCF is the suitable estimation parameter for fast and efficient size estimation of underwater network using cross-correlation based technique. It can be seen from the results that the proposed technique is good enough for estimation. This simple and novel technique might be an effective alternate of the protocol techniques.

REFERENCES

[1] M. S. Anower, S. A. H. Chowdhury,J. E. Giti, A. S. M. Sayem, M. I. Haque, "Underwater network size estimation using crosscorrelation:selection of estimation parameter",The 9th International Forum on Strategic Technology (IFOST), October 21 - 23, 2014, Cox's Bazar, Bangladesh.

[2] C. B. Li, H. Li, and P. W. Wang, "Forward predicting and backward verifying tags number estimation in RFID system," *Applied Mechanics and Materials*, vol. 321–324, pp. 2902−2905, 2013

[3] C. Yihong, F. Quanyuan, Z. Ma, and T. Liu, "Multiple-bits-slot reservation aloha protocol for tag identification," *IEEE Transactions on Consumer Electronics*, vol. 59, no. 1, pp. 93−100, February 2013

[4] J M. H. Nazir, S. Mehmood, N. Sheriff, and A. Adeel, "Improved efficient RFID tag estimation scheme," *International Journal of Computer Applications*, vol. 47, no. 17 pp. 16−19, 2012.

[5] M. S. A. Howlader, M. R. Frater, M. J. Ryan, "Estimating the Number and Distribution of the Neighbors in an Underwater Communication Network", Proceedings of *Second International Conference on Sensor Technologies and Applications (SENSORCOMM'08), 25-31 Aug, 2008, France*