Performance Analysis of CREIDO Enhanced Chord Overlay Protocol for Wireless Sensor Networks

N. Bhalaji, S. Jothi Prasanna and N. Parthiban

Abstract Wireless sensor networks (WSN) are alluring to the researchers because of its creditable and commendable wide variety of applications in the new era. The main and major impediment for sensor networks is its overall architecture and its coexistence with the other established networks. This paper discusses about the application of chord overlay protocol in mobile wireless sensor networks enhancing the robustness of overlay architecture for the betterment of packet delivery ratio by amending CREIDO packet that changes the traditional operation of stabilize function in the chord protocol. This has been extensively simulated by the help of OMNeT++ simulator and its additional frameworks for mobile wireless sensor networks and overlay networks. The result obtained from the simulation expounds that the enhanced chord accomplishes the traditional chord protocol's packet delivery ratio by 13.7 %.

Keywords Mobility · Overlay · Stabilize · Fingers · Chord

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S.C. Satapathy et al. (eds.), *Proceedings of the International Conference on Data Engineering and Communication Technology*, Advances in Intelligent Systems and Computing 468, DOI 10.1007/978-981-10-1675-2_49

Fig. 1 CREIDO packet specification

VERSION 4 bits	SOURCE ID 6 bits	DEST. ID 6 bits	LAYER 1 bit	RESERVED 2 bits

1 Introduction

Wireless sensor networks (WSN) is gaining new dimensions in the recent time owing to its potential societal application [1]. All the compelling and effective recent solutions are utilized to deploy a complete application over larger scale [2].

Even though it has a wide range of applications and advantages, the WSN falls back in the most important characteristic of integration with other networks. The researchers tend to develop colossal solutions in a vertical manner that may work independently but not with other network architectures [3]. This independent non-acclimatizing architecture of sensor networks impede unswervingly limits the research progress [4]. To surmount the above mentioned problem of integration, many authors propose impending solution as implementation of overlay network protocols in sensor networks (Fig. 1).

Due to the growing nature of consumer-based applications, sensor networks primarily focuses on data collection. They were assumed only to extract data from an isolated network and push data into the main stream network like Internet or LAN. But in the recent applications like body area networks, urban sensing, etc. sensor networks were not deployed in an isolated manner as data collection nodes, also deployed as data generating, people centric node.

In this article, Chord overlay protocol basically designed for P2P networks is implemented over sensor networks. As an amendment to the traditional chord protocol, the CREIDO packet is introduced in order to find the node joins and exits from the topology. The periodical stabilize function and fix_fingers operates only when notified on node joins and exits by the CREIDO packet.

2 Literature Review

Ali et al. primarily establishes the fact that P2P protocols holds a greater potential in sensor networks for making the architecture integral with other networks [4]. Also, they elucidate the advantages of overlapping and propose a DHT-based clustering protocol that places only the more powered master node in the chord ring. Even though this makes the protocol vary from application-specific development, this is not a complete solution satisfying the future focus of sensor networks. There are many pitfalls yet to be rectified as suggested by the authors in the open questions section.

H. Dai et al. focuses on developing an application level overlay networking into the gateway that encapsulates the sensor packets into the IP packets making the sensor network transparent for every device in the network through the database API. This article [5] throws a thought provoking traditional integration method on the readers only in a theoretical perspective. The techniques in [6] are majorly devised to make the autonomous sensor networks cooperate with the de facto TCP/IP standards [6]. They propose spatial IP addressing scheme that provides semi-unique IP addresses to the nodes to overcome the unfeasible dynamic configuration of IP address over a large scale. This article clearly defines the solution for some problems that impedes the overlapping of IP networks and sensor networks. But, there are many other dynamic dimensions like power consumption, etc. yet to be clearly debunked. In [7], authors emphasize that making sensor networks communicable with the internet is inevitable due to its imperative need. They arrive at the requirements needed to develop an optimal solution and finally proposes a system that is more energy efficient for communication with IP networks. But, this system is not for crucial packet delivery scenarios.

3 Chord Protocol

Chord is a resource routing kind of protocol founded on the top of distributed hashing table (DHT) that arranges the nodes contiguously in a one-dimensional ring based on identifiers. Node identifier is obtained by hashing nodes unique address. A node ‘B’ is said to be a successor of another node ‘A’ if its node identifier is the next greatest in the ring and vice versa denotes A is the predecessor of ‘B’ [8].

All nodes maintain a routing table with m entries called finger table [8]. The information about the other nodes are stored in this system. The kth entry in the finger table of the node K is the smallest node r that is greater than $r + 2(k - 1)$. The existing structure of chord protocol solves the issues like Flexible naming, load balancing, decentralization, availability. and flexibility. A search for the node ‘*f*’ at node ‘*r*’ begins by determining whether ‘*f*’ is the immediate successor of ‘*r*’. If So, The search is terminated. Otherwise, ‘*r*’ forwards the search request to the largest node in the finger table that precedes ‘*f*’.

To improve the lookups, predecessor, and successor pointers of the node should be up-to-date. The following three behaviors will be unveiled if a node join or node exit affects the chord ring before stabilization occurs [8].

1. The nodes in the affected region may have inaccurate successor and predecessor pointers or inaccurate keys impelling to failure of lookups.
2. In other case, successor and predecessor pointers may be correct but the keys may be inaccurate.
3. The final case may be the nodes may have accurate successors, predecessors and keys yielding to a successful lookup.

When a new node joins the finger table, it must initiate its finger table and the other existing nodes must update their finger table to reflect the existence of '*r*' [9].

A new node into the network accomplishes the following three tasks.

1. Instigates its predecessors and fingers.
2. Renovates the fingers of existing nodes to manifest the inclusion of new node in the network.
3. Acquaint higher layer software to renew the values associated with the new node.

4 Operation of CREIDO Packets

In the basic chord overlay protocol, the node entry and exit is exposed with the help of a stabilize function [8]. The archetype discussed in [8] elucidates the following scenario. Node n becomes the member of a chord system with Node ID resting between n_p and n_s. n would procure n_s as its successor. When n notifies n_s, the later takes n as its predecessor. After the run of next stabilize function, n_p queries ns for its successor. n_s expounds its successor as n to n_p. Now, n_p gets hold of n as its successor. Finally n_p will notify n and n acquires n_p as its predecessor. At this juncture, all the successor and predecessor pointers are up-to-date. By this method, chord makes its architecture robust. Even though this makes the chord ring stable, the drawback of this kind is perceiving node enters and departs in the periodical run of stabilize function. The message being sent in between the failure and join of one node and the run of stabilize function will not reach the destination from source in case of inaccurate fingers or keys.

Node entry and exit are notified periodically by the stabilize function in the existing protocol. This is the main detriment. If a node joins or departs from the overlay ring, it is notified to the neighbors only after the next run of stabilize function. Till then the successor, predecessor pointer, and fingers are erroneous priming to lookup insolvency. For example, ruminate a scenario of a node joining or departing the overlay abruptly after the run of stabilize function. Until the next run, the pointers and fingers are inaccurate leading to lookup insolvency. This can be mended with the help of periodic CREIDO packets being passed between the neighbors alluded in this article. Whenever the CREIDO finds a change in the topology, stabilize function is run and the finger table is fixed so as to cope up the dynamic topological changes. The CREIDO packet structure is as given below.

VERSION—Indicates the version of Protocol.
SOURCE ID—Holds the 6 bit Source ID.
DEST. ID—Holds the 6 bit Destination ID.
RESERVED—2 bits are reserved for future use.

5 Simulation Setup

To simulate the proposed scheme of this article, OverSim [10] a framework of OMNeT++ [11], is used for extensive simulation. The most important reason for choosing OMNeT++ is it provides extensible features enabling developers to create custom underlay network for simulating in OverSim framework. In this simulation, a custom underlay network with sensors nodes is configured using the INETMANET modules. Second, in the OverSim framework, chord protocol is appended with the CREIDO packet specification. Finally, with the simulation parameters as specified in Table 1 the custom underlay configured is imported into OverSim for simulation and the results has been obtained.

5.1 Network Model

In this simulation model simulated area is a free space with nodes moving according to the mobility model. In the beginning of simulation, all nodes are placed in a manner that all nodes are connected in the network. Nodes are connected through wireless links and said to be in contact, if they fall within the specified sensing range of each other.

5.2 Performance Metrics

For the comparison and performance analysis of the existing and proposed system, the packet delivery ratio, throughput, and control packet overhead were taken into consideration.

Table 1 Simulation parameters

Parameter	Value
Examined protocol	Chord and CREIDO chord
Routing type	Recursive routing
Transmission range	150 m
Message packet size	512 bytes
CREIDO periodicity (s)	10, 15, 20
No. of nodes	25 nodes
Area	3000 m * 3000 m
Simulation time	1500 s
Propagation model	Free space
Movement model	Random waypoint model
Pause time	5 s
Maximum speed	10 m/s

5.3 Mobility Model

Mobility plays a vital role in ad hoc networks. It increases the capacity and packet delivery ratio [12]. Mobility model incorporated for this experiment is the random waypoint model.

Random Waypoint Mobility model: This mobility model mimics erratic movement. In this model, a node moves from its extant location to a new location by randomly choosing a direction and speed. Each node moves in the random walk mobility model occurs in either a constant time interval t or a constant distance traveled d.

5.4 Simulation Parameters

This section describes the parameters smeared for the simulation analysis for the purported protocol. The performance analysis is studied by the simulation of the conventional protocol and the titivated protocol by insinuating the parameters in the below table.

6 Performance Analysis and Results

The proposed technique is simulated with a scattered network consisting of 25 mobile sensor nodes parameters. When two nodes encounter each other in their transmission range, communication is ensued. The influence of packet delivery ratio, throughput, and control packet overhead of the protocol put forward in this article is swotted by varying the CREIDO periodicity facilitated by the parameters as given in the Sect. 5.4 and its performance is analyzed with the metrics throughput, packet delivery ratio, and control packet overhead as defined in the Sect. 5.2.

Figure 2 depicts packet delivery ratio while the CREIDO periodicity is set as 10 s. While random waypoint (RWP) mobility model shows an average 12 % of increase in delivery ratio. Packet delivery ratio while the CREIDO periodicity is set as 15 s is illustrated in Fig. 3. RWP mobility model delivers a 19 % increase in delivery ratio. Figure 4. portrays the Packet delivery ratio while the CREIDO periodicity is set as 20 s. RWP mobility model shows an average 17 % of increase in delivery ratio.

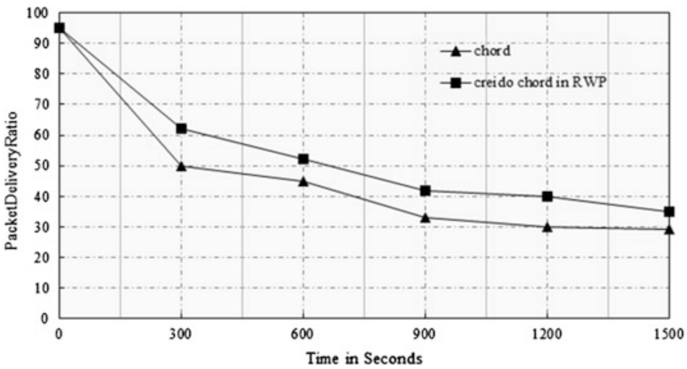

Fig. 2 PDR for 10 s interval

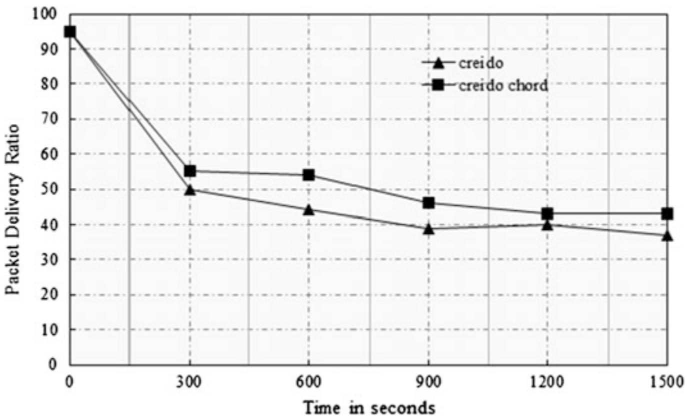

Fig. 3 PDR for 15 s interval

Figure 5 portrays throughput while the CREIDO periodicity is set as 10 s. In RWP model throughput is increased to 10 % in average. Throughput obtained for the CREIDO periodicity set at 15 s is illustrated in Fig. 6. RWP model has 14 % increased average. The throughput decreases slightly when the transitions of CREIDO packet falls off due to comparative increase in CREIDO periodicity. Figure 7 describes throughput while the CREIDO periodicity is set as 20 s. In RWP model throughput is increased to 13 % in average. The throughput slightly decreases as the number of transitions of CREIDO packet is decreased due to comparative increase in CREIDO periodicity.

Figure 8 describes Control packet overhead when CREIDO packets are transmitted at a period of 10 s. Control overhead rate is averagely increased to 9 % in RWP. Even though increase in Control Packet overhead is havoc, it is tolerable because average Control Packet overhead is only 9 %. Figure 9 illustrates control

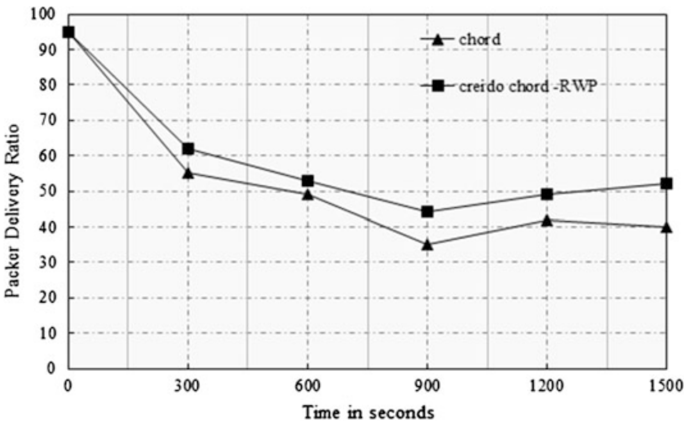

Fig. 4 PDR for 20 s interval

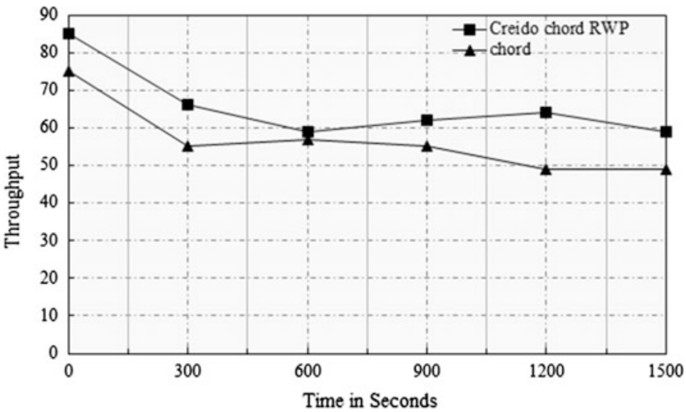

Fig. 5 Throughput for 10 s interval

packet overhead when CREIDO packets are transmitted at a period of 15 s. Control overhead rate is averagely elevated to 12 in RWP model. Control Packet overhead decreases significantly as the CREIDO periodicity increases. Figure 10 gives a picture of control packet overhead when CREIDO packets are transited at a period of 20 s. Control overhead rate is averagely increased to 9 % in RWP. Control packet overhead decreases comparatively because of the increase in CREIDO periodicity.

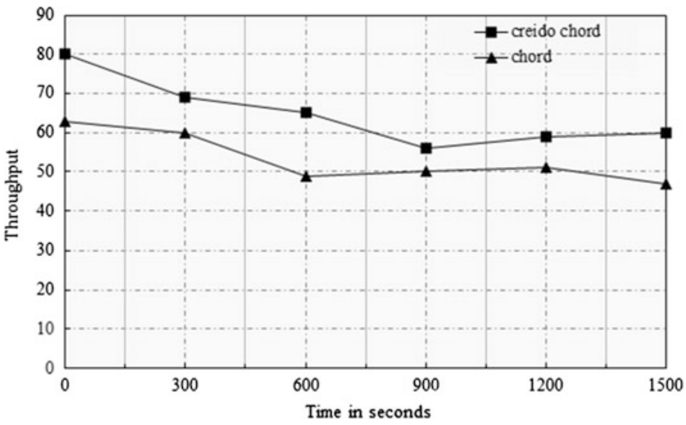

Fig. 6 Throughput for 15 s interval

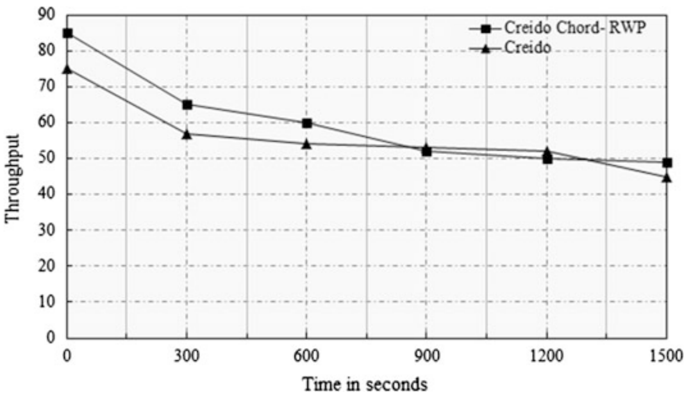

Fig. 7 Throughput for 20 s interval

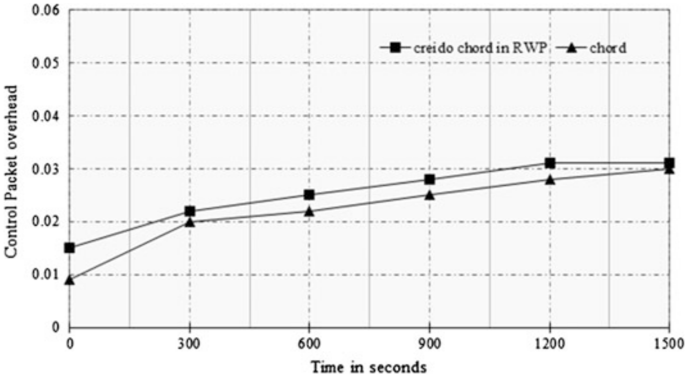

Fig. 8 Control packet overhead for 10 s interval

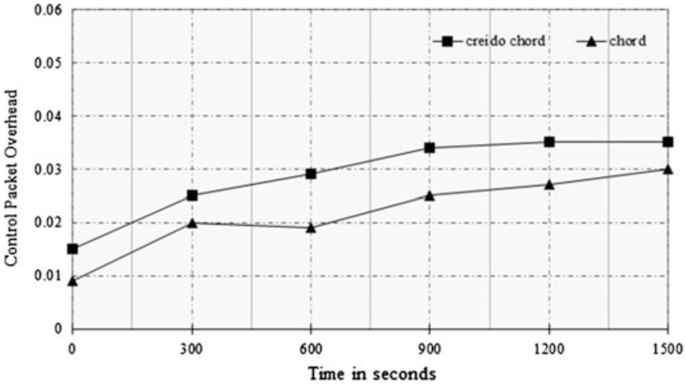

Fig. 9 Control packet overhead for 15 s interval

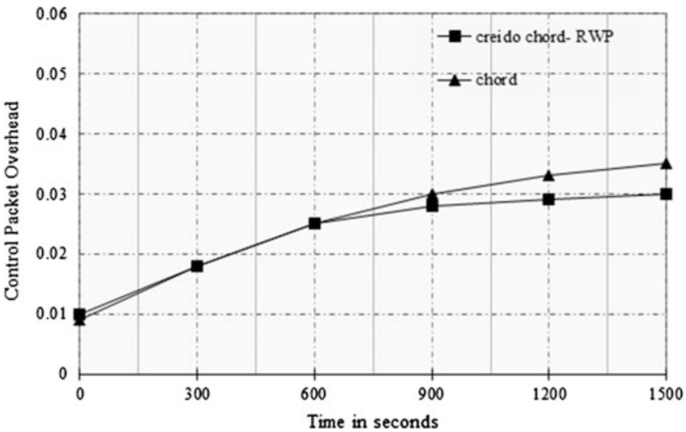

Fig. 10 Control packet overhead for 20 s interval

7 Conclusion

This article fabricates periodic CREIDO packet over chord protocol for Mobile sensor networks. Extensive simulations were carried out with the frameworks of OMNeT++. This improvised the aforementioned performance metrics and noteworthy recuperated results were obtained. An average of 13.7 % step-up in packet delivery ratio, 14.6 % proliferation in throughput and 14 % escalation in control packet overhead is realized. The imminent prospect will be extensively studied for performance of the devised protocol for various movement models and mitigating the security issues that may occur due to the amendment made by the CREIDO packet.

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