Clock Drift Management Using Nature Inspired Algorithms

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ABSTRACT

Time Synchronization is common requirement for most network applications. It is particularly essential in a Wireless Sensor Networks (WSNs) to allow collective signal processing, proper correlation of diverse measurements taken from a set of distributed sensor elements and for an efficient sharing of the communication channel. The Flooding Time Synchronization Protocol (FTSP) was developed explicitly for time synchronization of wireless sensor networks. In this paper, we optimized FTSP for clock drift management using Particle Swarm Optimization (PSO), Variant of PSO and Differential Evolution (DE). The paper estimates the clock offset, clock skew, generates linear line and optimizes the value of average time synchronization error using PSO, Variant of PSO and DE. In this paper we present implementation and experimental results that produces reduced average time synchronization error using PSO, Variant of PSO and DE, compared to that of linear regression used in FTSP.

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Many synchronization algorithms (Stojmenovic, 2005) have been proposed for WSNs (Sohraby, Minoli, & Taieb Znati, 2007). In the Reference-Broadcast Synchronization (RBS) (Elson, Girod, & Estrin, 2002) a reference message is broadcasted. The set of receivers that are within the reference broadcast of a sender synchronize with each other. It is a receiver–receiver synchronization method, eliminates sender side uncertainty. This decreases the synchronization error and improves the efficiency. RBS is applicable to any medium which has broadcast capabilities including wired and wireless networks. In the Timing-sync Protocol for Sensor Networks (TPSN) (Ganeriwal, Kumar, & Srivastava, 2003) hierarchical structure is used to synchronize the whole wireless sensor network to a single time server. TPSN requires the root node to synchronize all or parts of the nodes in the sensor field. It consists of two phases: (1) the level discovery phase, where the hierarchical structure is built in the network starting from the root node; and (2) the synchronization phase, where pair wise synchronization is performed throughout the network.

The Flooding Time Synchronization Protocol (FTSP) (Maroti, Kusy, Simon, & Ledeczi, 2004) achieves a network wide synchronization of the participating nodes. In FTSP, a sender synchronizes one or more receivers with a single radio broadcast, where the broadcast message contains the sender’s time stamp. The FTSP achieves its robustness by utilizing periodic flooding of synchronization messages, and implicit dynamic topology update. The unique high precision performance is reached by utilizing MAC-layer time-stamp and comprehensive error compensation including clock skew estimation. FTSP achieve network wide synchronization among network nodes with error in microsecond range, scalability up to hundreds of nodes, and is robust to changes in network topology. In FTSP root node is selected dynamically, it maintains the global time and all nodes synchronize their clock to root node clock’s global time. FTSP uses single broadcast message to synchronize multiple receivers where broadcast message contains the sender’s timestamp (global time). Upon arrival, a receiver extracts the time stamp from the message and time stamps the arrival using its own local clock (local time). The global–local time pair provides a synchronization point. The difference between global and local time of synchronization point estimates the clock offset of the receiver. The non deterministic error sources such as jitter in interrupt handling are eliminated as the time-stamps are taken deep in radio stack. It reduces all uncertainties in radio message delivery except for highly deterministic delays such as propagation time, transmission/reception time. Drift of the receiver clock with respect to the sender clock is estimated using linear regression (Elson, Girod, & Estrin, 2002; Woodbury, 2002). This enables each node to maintain accurate estimate of root node’s global time.

In this paper we present a detailed analysis of clock offset and clock skew estimation. The proposed algorithms utilize the concepts of Nature Inspired Algorithm. The algorithm used in this paper is PSO, Variant of PSO and DE. They generate linear line and calculate the value of average time synchronization error. The error is optimized for reduction in its value. While the idea of linear regression has been utilized before, the unique combination with Nature Inspired Algorithm yields significant reduction in average time synchronization error.

We start with a brief discussion about nature inspired algorithms covering concepts of particle swarm optimization and differential evolution. Next, methodology for clock drift management using nature inspired algorithms is proposed and discussed. Thirdly, results are discussed for each algorithm. Finally comparative study of results generated using nature inspired algorithms and existing approach is presented followed by the conclusion and future work.

**NATURAL INSPIRED ALGORITHMS**

Nature-Inspired Algorithms (Chiong, 2009) have been gaining much popularity in recent years due to the fact that many real-world optimization problems have become increasingly large, complex and dynamic. The size and
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