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An Investigation and Performance Analysis of Routing with Fork-Join Optimization for IOT enabled Software Defined Networks

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Abstract:

In the era of IoT, the Software-Defined Networks play a vital part. In these networks, many Sensors were placed in hostile areas. Since the capabilities of the sensors has its own limits when it comes to computational and energy efficiency. It is hard to replace them once they run out of battery. So there is an obvious need to develop an energy-efficient and software-defined routing system that enables us to handle wireless sensor networks with ease regardless of their complexity and increasing their lifespan. Even though the existing methods are widely adopted they have their own set of problems that need to be eliminated by implementing a set of techniques that optimizes the flow of data between two nodes which makes the network efficient. This paper recommends integration of FJAPSO along with Aggregation in the existing Software-Defined Networks. The EFJAPSO uses dual optimization techniques towards the optimal number of control nodes while clustering them as well. The data aggregation methods are used to satisfy the defined specifications of software-defined wireless sensor networks such as RSSI, TTL, Bandwidth, Power Consumption (i.e) battery consumption, MRIC, etc. These given factors determine the list of nodes to be placed inside a cluster. So the implementation of these methods will be more efficient in terms of operational and computational efficiency.

***Keywords:** Software Defined Networks, energy-efficiency, EFJAPSO, Data aggregation.*

I. INTRODUCTION

With Blooming technologies that make our lives smart, there is an underlying need to make these technologies more efficient and affordable. These technologies are mainly based on WSN abbreviated as Wireless Sensor Networks. There is an underlying need to reconfigure the sensors automatically based on the operations to be performed. So the deployment of SDWSN (Software Defined Wireless Networks) comes to the act. With the help of SDWSN, The Sensors in the network can be configured dynamically. As tremendous numbers of IoT and other smart technologies are deployed in large geographical areas the complexity of operations like collect, Transmit and Process data from and by the sensors are becoming more complex. Apart from processing the data from sensors, the life span of those sensors is another side of the complexity. To increase the life span of the sensors we need an effective routing mechanism. In this paper, an EFJAPSO algorithm along with Data Aggregation Methods is being implemented to improve the life span and power efficiency of the sensors.

The EFJAPSO (Enhanced Fork and Join Adaptive Particle Swarm Optimization) has two main goals upon its implementation where the first one is about optimal control nodes of the sensors and the other is the clustering of nodes. The clustering of nodes

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carried out based on the results of data collected using data aggregation methods.

II. Related Process Work

Sensor Nodes may experience elevated energy consumption while data/packet processing or transmission. LEACH protocol is widely deployed as well as recognized as one of the predominant clustering and routing algorithm in WSN. The LEACH applies pre-determined probability for a cluster head (CH) selection to avoid frequent depletion in the energy level of CH. This process couldn't meet the requirement when the sink nodes are located far away from the CH. To reduce the depletion of energy, an enhanced algorithm DF-LEACH [5] is implemented. Even after the implementation of DF-LEACH, the energy efficiency of the CH is continuously affected. In-Order to eliminate this certain issue, The HEED algorithm [6] is been introduced. This approach identifies the CH by the amount of available node energy and the experimental outcomes are satisfying. An acquisitive approach of selecting CH is introduced by Hausdorff [7]. In addition to addressing the same issue of power depletion in CH with unequal clustered, Distance-based algorithm which works on the load balancing methods been implemented by Mottalo and Pico [8] and also [9] and [10] who also suggested an algorithm for many-to-many communications which is widely familiar as an "adaptive energy-aware multi sinking algorithm".

An architecture that classifies the data and control plane was introduced later. Open Flow was a definitive communication protocol of SDWSN to improve power-efficiency between these two planes [2]. The major objective of SDSWN is for load balancing and reducing power consumption on several nodes via intelligent switching. The SDSWN interferes in the decision making tasks of the SDN Controller [3].

In the mentioned situation the controller will be positioned to conduct the base station activities where the Open Flow acts as the main communication method between switching element and controller. Even after all these implementations, the architecture can't reduce energy consumption after a certain level.

Huang et al [4] proposed a tiny-os based architecture as consents for various controllers. Even though the proposal was effective, this has to be implemented at the hardware architecture level. This makes the replacements harder when the sensors are placed in alienated areas. So a method of clustering using the PSO Meta heuristic technique was introduced. However, this has its disadvantages like the replacement of control nodes there is a certain need to create a more energy-efficient routing system.

This paper proposes an EFJAPSO Routing Model which uses Data Aggregation for selecting the cluster heads. All regular sensors transmit data packets to the local aggregator which is the cluster head. The cluster sends a concise digest to Sink.

III. Proposed Methodology

The method proposed here is to improve the power efficiency of the WSN. We combine two widely used algorithms FJAPSO and Data Aggregation. FJAPSO is the most efficient algorithm used in the SDWSN while combining the Data Aggregation methods with the FJAPSO will make it more efficient.

The EFJAPSO (An Enhanced Fork-Join Adaptive Particle Swarm Optimization) is implemented with two main objectives which are energy efficiency and routing path-optimization.

The EFJAPSO works based on iterations. EFJAPSO forks out each particle into pre-defined sub-particles then merges together with the widely used solution for forked particles. A Productive process is formulated which considers the distance between sensor nodes and SDNs to reduce the energy spent for transmission by organized size of clusters.

The Parameters like RSSI, TTL. MRIC, Bandwidth, Battery consumption is adapted to verify the energy lies within a cluster. CH is going to be accountable

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for data gathering from different nodes in clusters and collecting the data. The collected data is aggregated and stored in storage space in the DS. Finally the data set is transmitted to sink after aggregating the stored data using data cube approach.

Energy Model Formulation:

$$E_{TX\_SDSN(p,d)} = \begin{cases} p * E\ elec + k * Emp * d\hat{}4 \\ p * E\ elec + k * Efs * d\hat{}2 \end{cases}$$

E TX_CN(p,d) =

$$\begin{cases} p * (E\ elec + EDA) + p * Emp * d\hat{}4) \\ p * (E\ elec\ + E\ DA) + \ p * Efs * d\hat{}2 \end{cases}$$

Velocity Vector Updating rule:

$V_i(p) = w * V_i(p-1) + c_1r_1(Pbesti(k-1) – X_i (k-1)) + c_2r_2(Gbest – X_i(k-1))$

Position vector updating rule:

$X_i(p) = X_i(k-1) + V_i(k)$

ALGORITHM - EFJAPSO

```
P = 0          iteration counter
               Where, 1≤ i ≤ k
for  every i-th particle  do
Randomly initialize the position  x_i^j(p), velocity v_i^j(p)
rVari= Random(mincn ,mincn)
[S_i(p)] = SPV (X_i(p))
[F(S_i(p))] =Fitness(S_i(p), rVar_i)
pbest_i(p) = X_i(p)
end for
G_best = p_best_i(p) for every i-th particle
 F(S_i(p))  >F(S_j(p))
while criteria is not attain do
    P = P+1
Adaptive(w) inertia using  Eq.1
  for every i-th Particle do
    V_i(p) = w × V_i(p−1)+c_1 ×r_1Ã = (p_best_i(p = 1) − X_i(p − 1)) + c_2 ×r_2Ã − (G_best)
      X_i(p) = X_i(p − 1) + V_i(p)
  S_i(P) = SPV(X_i(P))
        for j  from 1 to t do
            [S'_i,j^(p)] = G M O(S_i,j^(p))
                       Where, S'_i,j^(p) is
T(n)=p/1-0[r*mod(1/p)]
[F(S'_i,j^(p))]= Fitness(S'_i,j^(p),rVar_i)
      end for
max_ind = max 1≤ j ≤ k â′! (F(S'_i,j^(P)))
      S_i(p)= S'_i,maxind (p)
  if  F(S_i(P)) ≥ F(S_i(P − 1)) then
          Pbest_i(p) = X_i(k)
     end if
   end for
end for
end while
```

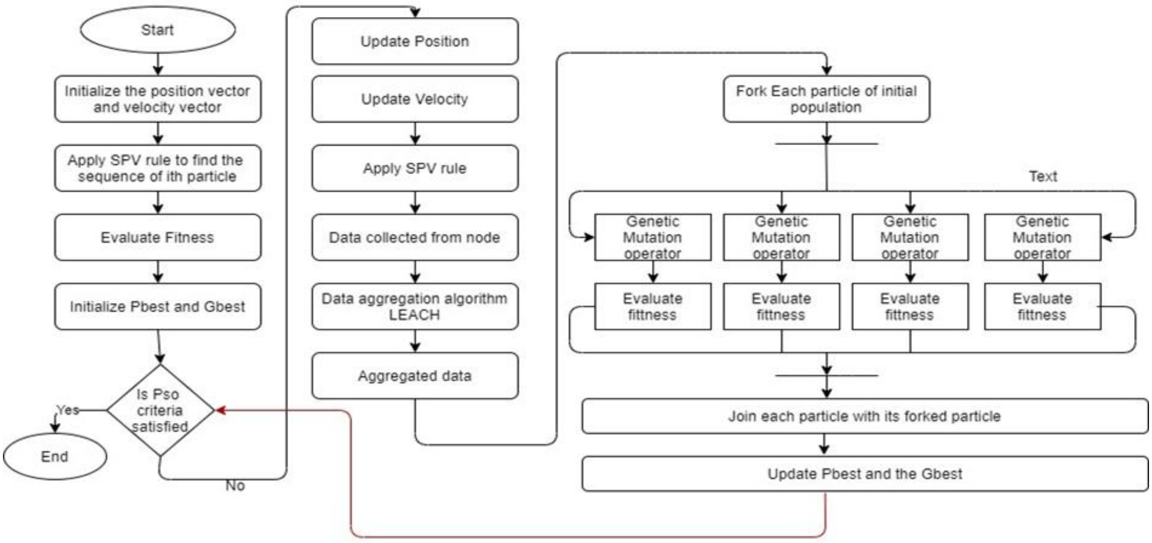

Fig.1 The Proposed EFJAPSO flow Graph

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Here we explain the proposed methodology EFJAPSO. The EFJAPSO meta-heuristic start with a prebuilt P number of arbitrarily provoked particles; V_i^J(p) and X_i^j(p), ($1\leq i \leq K$) are velocity and position vectors of i^{th} particle at p^{th} iteration at j^{th} dimension. Every i^{th} particle is followed with a arbitrary number ($rVar_i$) between a pre specified boundary at minimum (min_{CN}) particles discretely. At last fork-join optimization model, on basis of optimal fitness value, both parent and forked data to be combined as a particle. The aim is to build more sequence of CNs utilizing GMO irrespective of identical position, velocity and number of control node. The Last $Pbest_{i\,(p-1)}$ and current fitness values, $Pbest_i$ (p) and *Gbest* were updated. This process will be repeated till termination norms are obtained.

a. *Fitness Function*

We propose a more efficient fitness function to improve the lifetime of SDN. Before sending the Data to CS the CNs combine data from all common intra cluster nodes and CNs do allocate the work to the intra-cluster common nodes as well. The energy consumption of CH is normally high than the other nodes in a cluster. In the Given Function the CS will select the CN based on its transmission distance and residual energy, which means the CS will obviously select the CN which is at the minimum distance from it, has more residual energy. The Clusters are formed with uniform distribution of SDSNs based on the distance and vestigial energy. The Practical difficulties in selecting the above mentioned specifications are considered as NP-Hard Problem. The mentioned function has to optimize at two stages which leads to unpredicted problems. Hence, to identify the control nodes and to increase the number of CHs (if required) EFAPSO is devised. The residual energy of SDNs on average can be determined by applying the following equation:

$$E_{avgrsdl} = \frac{\sum_{i=1}^{m} Ersdli}{nSDSN}$$

EFJAPSO is implemented to improve fitness, lifespan and energy efficiency of the SDSNs. In order to find the more suitable Control node to be higher residual energy and lesser distance from the midpoint of a cluster. Hence the strategy to find the trade-off is built with α and β values. In EFJAPSO, the location of all sensing nodes are updated and to be found by localization services with the following measures:

$$d_{SDCN\ to\ CN} = \frac{\sum_{j=1}^{nCN}\sum_{i=1}^{nSDSNj}\sqrt{(x_{CNj}-x_{SDSNi})^2+(y_{CNj}-y_{SDSNi})^2}}{nSDSN}$$

$$d_{CN\ to\ CS} = \frac{\sum_{i=1}^{nCN}\sqrt{(x_{CNi}-x_{CS})^2+(y_{CNi}-y_{cs})^2}}{nCN}$$

$$E_{SDCNtoCN} = \frac{\sum_{j=1}^{nCN}\sum_{i=1}^{nSDSNj} E_{TX\_SDSN}}{nSDSN}(k,d_{i,j})$$

$$E_{CNtoCS} = \frac{\sum_{i=1}^{nCN} E_{TX_{CN}}}{nCN}\left(k, d_{i,CS}\right)$$

IV. Performance Study

To analyse our proposed EFJAPSO a SDWSN is simulated as explained in [1]. The results were compared with respect to diverse parameters with constant change in the numbers of nodes in the SDWSN. The comparison of EFJAPSO is analysed on delay on network and jitter.

A. *Delay*

The delay were experienced by packet from cloud server to Software defined Sensor Network *p* during communication is,

$$Del_s = \sum_{i=1}^{p_{path}} Del(v_i, v_{i+1})$$

Where p_{path} denotes the path and e2e delay is calculated as

Del = max_Dels

Where 1<=p<=nSDN

Life span is the most important metric that has to be taken into consideration in this paper. The list of parameters to be tested is given in the table 1.

Type	Parameters	Value
Network area	location(m^2)	100x100
	Initial Energy	2 Joules
	No. of sensing nodes	100
Packet size	Packet size(bit)	100
	No. of Broadcast packet	25
EFJAPSO	IP	45 particles
	Number of Iterations	25
	C1	2
	C2	2
	γ	0.6
	δ	0.4
	maximum value of ω	0.92

TABLE 1
TESTING PARAMETERS

These analysis is proposed to be conducted on 7th Generation processor with 8GB RAM in Mat lab (V2016A)To analyse the proposed EFJAPSO and it is to be tested by changing various parameters of SDWSN and PSO. To simulate various performance of the sensor nodes in a real time deployed region, a topology of 100 SDN nodes are deployed with various parameters given in Table 1.

V. Conclusions

In the era of IoT, the sensor network faces the challenge of minimizing the energy consumption thereby enhance the lifetime of SDN. In this, the routing is taken care by the Enhanced Fork-Join Adaptive Particle Swarm Optimization (EFJAPSO) in SDN. EFJAPSO is the embedded version of FJAPSO and data aggregation function. The Strengthening is done by adding an extra operators and modifying the existing ones adaptively to make it the best-fittest in the requirements. The performance study indicates that EFJAPSO enhances the SDN lifetime. EFJAPSO meets the future needs of automatic reconfigurable networks (SDWSN).

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