

DYNAMIC AND ADAPTIVE REINFORCED MACHINE LEARNING FOR IMPROVED EFFICIENCY AND RELIABLE ROUTING IN SENSOR-CLOUD ENVIRONMENT

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Abstract: Sensor-Cloud and Industrial Internet of Things (IIoT) architectures have brought a phenomenal change in industrial sector particularly in hospital industry both for indoor and outdoor applications. Both are boosting the hospital industry sector by taking into account the concept of smart city, IoT and communication. Many techniques and algorithms are applied to improve network reliability and to reduce latency that eventually help optimized energy consumption and increase in network lifetime. There are problems with network failures that is required to be addressed keeping in mind the dynamics and limiting constraints of the network. Under network breakdown conditions, an alternative route must be selected to have a reliable end-to-end information delivery. This work proposes a reinforced machine learning with dynamic and adaptive approach (DAML), a low-latency reliable routing algorithm for cluster based hospital environment so that a patient's critical parameters are monitored continuously. The DAML method comes with optimized reward, monitor, and risk factor concepts and the patient's critical parameters are interfaced to the sensor-cloud environment. The information is buffered as text files and then transmitted over wireless channels after encoding. The proposed method is evaluated with respect to network throughput, packet delivery ratio (PDR), and end-to-end delay. The proposed method is expected to provide a significant improvement in throughput, PDR and decrease in end-to-end delay as compared to existing approaches.

Index Terms - Cloud Computing, Energy Efficiency, Internet of Things, Medical application, Patient monitoring, Sensor- Cloud, Reinforced Machine Learning, Reliable Routing, Wireless Sensor Networks.

I. INTRODUCTION

Sensor-Cloud infrastructure [1] is boosting the scalability and applicability in real-time application scenario, as they provide powerful computing and high storage facilities. The sensor infrastructure has a limitation towards power and storage, thus cloud infrastructure comes to boost the efficient management of sensed data [2]. Sensor networks are cluster based networks with randomly distributed sensor nodes. A random placement results in higher interference and power dissipation. All nodes in a cluster communicate using a centralized interface node called the head node. Head nodes are selected based on the maximum power and coverage of a node. The selected head node drains rapidly as the head node is continuously engaged in data exchange. Because of high traffic and maximum interference at this node, resulting in faster power dissipation. Rapid power

dissipation results in faster failure of the network. The challenges of cluster head selection with optimized routing is a research concern in WSN that is required to be addressed [3].

Research and suggestions with respect to sensor-cloud architecture, dynamics of network, heterogeneity, design of communication, data management, and security is presented in [4]. A scalable cloud model for IoT based on the concept of modularization and service integration is proposed in [5]. The authors given a hardware and software implementation plan using Service-Oriented Architecture (SOA) and demonstrated its effectiveness by considering a kid safety support system for kindergartens. A detailed survey on energy efficient data transmission in sensor-cloud environment is conducted in [6-9] and presented a comparative result with discussions. The concluding remarks by the authors is that many energy-efficient technique ignores parameters for quality of service, network lifespan and scalability. A systematic review was conducted in [10] with respect to data collection on sensor-cloud architecture using an evidence-based methodology. The authors found that most of the methodologies were giving a stable output but, the authors were given research directions and effective solutions for existing challenges. Taking into consideration the power limiting constraint, the authors in [11&12] carried out category wise survey for energy efficiency and concluded that, many techniques ignore quality of service (QoS) parameters, scalability, and network lifetime and given a multi-parameter optimization technique as a probable solution. The article [13] put forth the routing techniques in the sensor-cloud architecture utilizing deep learning technique. Information is provided to the cloud through WSN and then routing is done using fuzzy convolution. The validation accuracy was shown as 95% with throughput of 93% and marginal reduction in end-to-end delay which was shown as 55%. The first of its kind theoretical modeling of sensor cloud was carried out in [14] and the paper addresses theoretical characterization and analysis, to build models for solving different problems faced in sensor- cloud architecture. The shift in technological paradigm from traditional WSNs to sensor-cloud architecture shows that this method outperforms the traditional WSN. A 3.25% increase in network lifetime and a decrease in energy consumption by 36.68% is observed from the analysis.

Machine Learning (ML) finds application in different fields and more recently distributed machine learning is playing a pivotal role in cloud infrastructure particularly in resource allocation utilizing reinforced machine learning [15]. Effective routing and power management are the two important considerations that must be adopted in WSN [16] as the power limitation of the remotely deployed device, is a significant problem for effective wireless communication. This has been addressed initially by considering cluster based approaches [17-19], but reliability was again a concern. A heuristic reinforcement learning machine learning approach was presented in [20]. This method proposes Q-learning approach [21] to compute the monitoring factor based on the reward value, which is measured as a function of residual power. The reward monitoring and cluster head selection increased network throughput, node life time, and decreased latency due to dynamic head selection.

II. METHODOLOGY

Cloud computing provides appliances, storage and infrastructure above the internet [9]. Knowing how weak WSNs are with regards to communication ability, how to collect and upload sensory data to the cloud in limited time has become an issue in the sensor- cloud architecture [10]. One of the major concern of the existing techniques is the optimized utilization of available power and to reduce its dissipation such that working networks life time and reliability can be increased. The proposed approach, dynamic and adaptive reinforced machine learning (DAML), a low-latency reliable routing achieves it. An approach to sensor-cloud architecture and cluster optimization is outlined in [1, 3, 15 & 20-22]. In monitoring of data flow through a clustered approach, each head node updates the communication status to a centralized monitoring unit in a periodic manner. The centralized monitoring unit observes the residual energy level of each head node and controls the head selection process based on the residual energy at each node. Q-Learning approach [20 & 21] is an optimal method used in reinforcement learning that determines ideal route under dynamic network conditions. The Q-learning approach compute a reward value (Rv). The reward value for an action ‘a’ (Rv) is defined by

the energy usage for a volume of data exchange (dtt), over all paths in the network at time ‘t’, defined as:

$$Rt = \sum(\min(E(n)+\sum E(n)) - t \quad n \subseteq \text{pth} \quad (1)$$

$$a \quad \sum n(\text{Pth})$$

Where, $E(n)$ is the residual energy at a node after data exchange, which is defined as:

$$E(n) = Et - dtt \times Et \quad (2)$$

$$k \quad k \quad \text{cost}$$

Where, Et is the available energy at time t for kth node, dtt represents the volume of data in the buffer, Et is the energy cost for

$$k \quad k$$

a unit data, and t is the time slot.

$$\text{cost}$$

The path with the highest reward value, defined by the residual energy, is chosen as the optimal path for data exchange [3]. Selection of a cluster head is limited by a threshold value (Thn), which is dynamically computed based on the probability of cluster head selection of a node’ residual energy, and is defined as:

$$Thn$$

$$= \{ \quad \text{Prob}(p)$$

$$1 - \text{Prob} \times (\text{rmod} \times (1))$$

Prob

$$n \in G\} (3)$$

Where, *Prob(p)* is the percentage (probability) of cluster head nodes at *r*th iteration,, *G* is the last 1/*p* round. The node energy increases when the threshold *Th(n)* is increased.

An improved approach to update the existing reward function to improve reliability factor in WSN head selection, routing, and cluster formation, is proposed. The proposed DAML approach defines two parameters of forwarding and blockage of packet as φ and, ρ respectively. During communication, the head node updates these two monitoring factors and shares them with the decision unit to select the optimal path for member nodes. The updating of the two factors is given as:

$$\varphi t = (\varphi + \varphi') + \delta \quad (4)$$

$$\rho t = (\rho + \rho') + (1 - \delta)(5)$$

Where, δ is the updation factor which is given value 1 on forwarding and 0 on blocking. The monitoring factor (*M*) for a path is given as:

$$M = \varphi t$$

$$\rho t$$

$$(6)$$

This monitoring factor (*M*) is applied to the reward function, giving a updated reward value for an action ‘*a*’, and is given as:

$$Rt_update = (\sum(\min(E(n)+\sum E(n)) - t) \times M \quad (7)$$

$$a \quad \sum n(Pth)$$

Substituting *M* define the updated reward value as:

$$Rt_update = (\sum(\min(E(n)+\sum E(n)) - t) \times (\varphi+\varphi')+\delta$$

$$(8)$$

$$a \quad \sum n(Pth)$$

$$(\rho+\rho')+(1-\delta)$$

Change in forwarding condition, updates δ , φ , which effects the reward factor and the path selected for communication. This path is energy efficient and reliable for data exchange. The

reward factor provides a higher path existence probability and a longer life time for the network. Random clustering and node inclusion into cluster results in unbalanced loading in the network and to minimize this, a risk factor is introduced, and is define as:

$$Risk(Nr) = (Prob(\sum E(n) + E(nr)) - (Nc) \times D) \quad (9)$$

Where, $E(n) + E(nr)$ defines the aggregated energy due to a registering node $E(nr)$ and the current energy level $E(n)$ in the network. $(Nc) \times D$ indicates the volume of data increase due to Nr nodes in the network, and the total node (Nc) is defined by:

$$Nc = (N + Nr) \quad (10)$$

For a balanced network, a node with risk value below a limiting value Lc is included in the cluster and is defined as:

Lc

$Prob(p)$

$$1 - Prob \times (rmod \times (\quad))$$

$Prob$

$\times Enr \times Nc$

$Eini \times Nc$

(11)

Where, Enr and $Eini$ are the overall network energy and initial energy respectively. Optimal clustering and reliable head selection offer high performance operation in WSN. The proposed approach interfaces multiple sensors for sensing patient vitals and exchanges the processed data via selected head node. Interfacing of vital parameter is performed using patient records, which are buffered as text file and encoded for transmission over wireless channel. The block schematics of the proposed approach is shown in Figure 1.

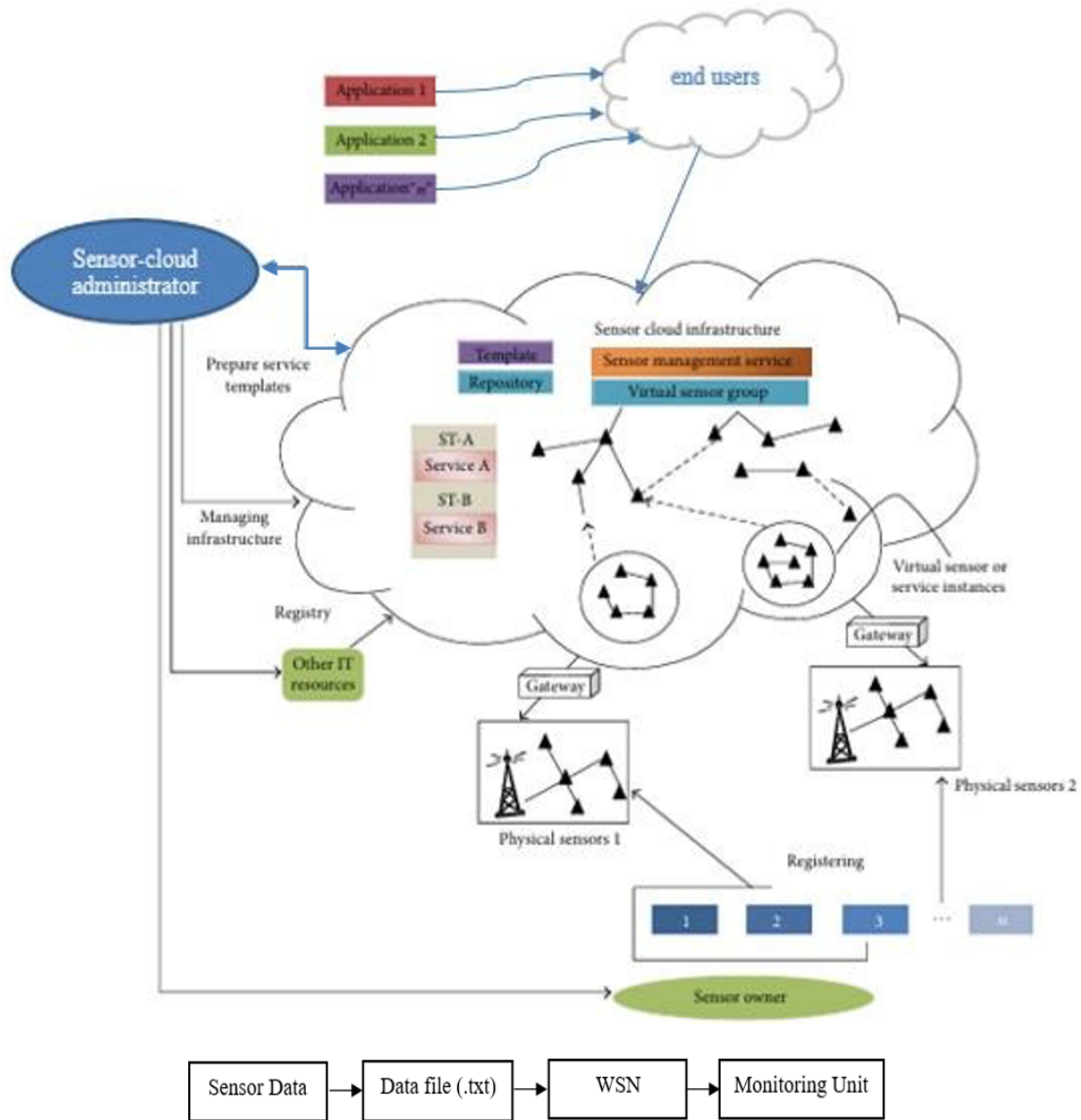


Figure 1. Architectural Overview and Flow diagram of vital monitoring using WSN interface

The proposed work monitors and communicates vital data such as temperature, heart rate and oxygen level through the interfacing sensor nodes. Communication of the patient’s vital parameters via a selected path using an updated reward factor guarantees a reliable path with higher residual energy in data exchange. The dual monitoring factors improve network throughput and minimal loss of information in vital data exchange over WSN. Integration framework performance is measured in terms of performance objectives such as throughput, PDR, End2End delay, and network lifetime metrics. A sensor-cloud communication with WSN patient monitoring is shown in Figure 2.

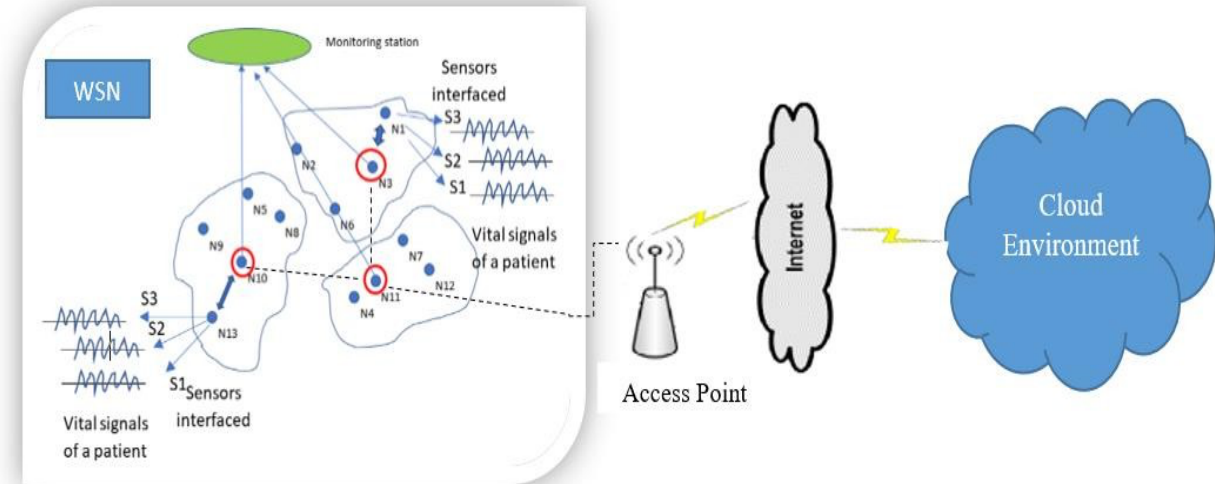


Figure 2: Sensor Cloud patient monitoring Scenario

III. RESULTS AND OBSERVATIONS

The cloud provides access to a variety of services, applications, information, and infrastructure through pools of computing power, network, information, and storage resources [12]. Sensed data is exchanged over the network using an interfacing head and gateway node to the destination. Monitoring of risk and reliability factors in cluster formation and head selection provides a less blockage path. Reliable head node offers a high probability of data exchange with minimal data blockage. Less blockage result in power saving, which improves the overall performance of the network. The optimized network now offers less E2E delay. Figure 3 shows the optimized path of communication and the performance of the proposed DAML approach with respect to Sensor-Cloud technique and clustering techniques are compared and placed in Table 1 and II along with plot in Figure 4 and 5.

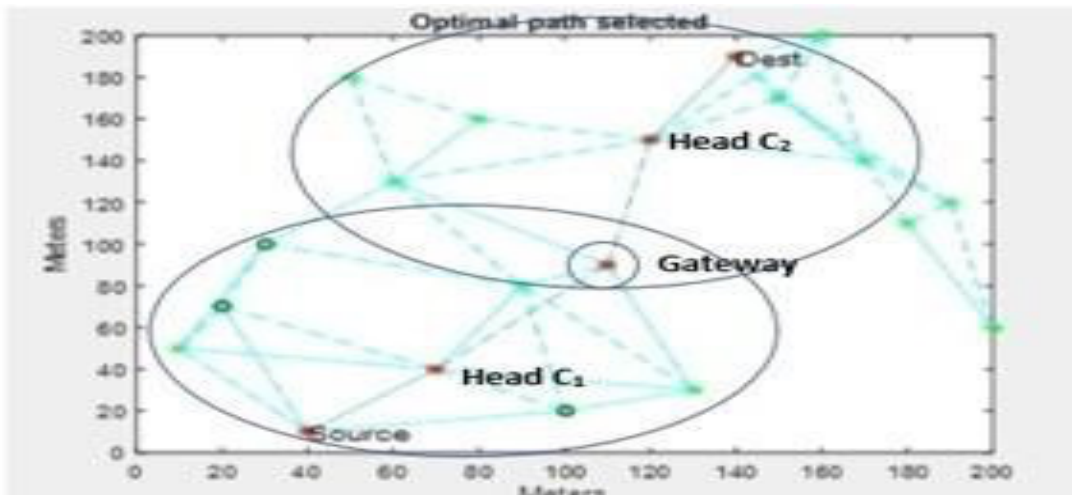


Figure 3. Path selected for commutation Observation Table I: Clustering Techniques

Parameters	Clustering		
	LEACH	LEACH-EFT	Proposed (DAML)
Throughput	52	70	92.5
PDR	87	90.5	93.5
End-to-End Delay	19.8 sec	7.2 sec	2.2 sec

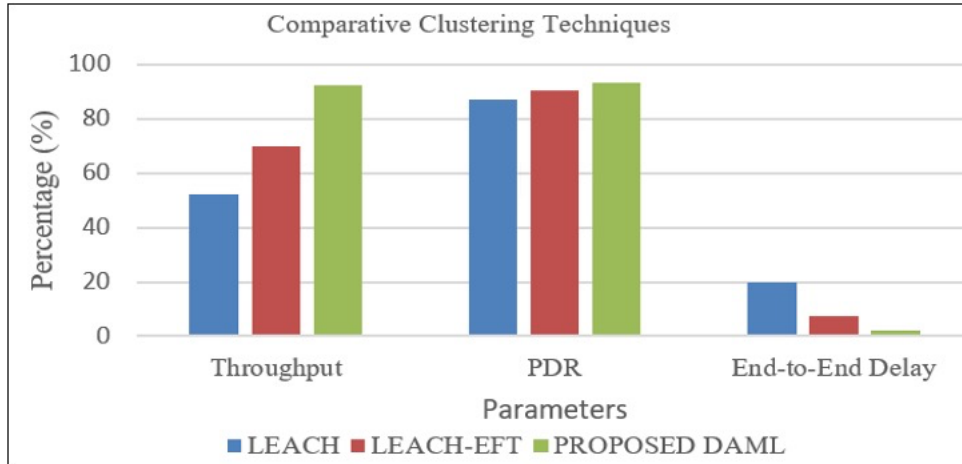


Figure 4: Comparative plot for Clustering Techniques

Observation Table II: Cloud Techniques

Parameters	Cloud Techniques		
	POAS	CC_WSN_DT_RA	Proposed (DAML)
Throughput	88	93	94.5
PDR	63	72	82.4
End-to-End Delay	72	55	22

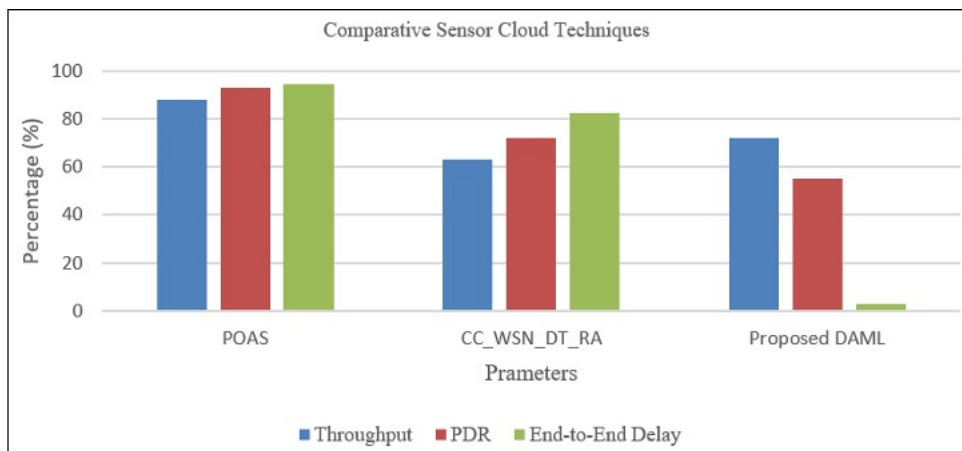


Figure 5: Comparative plot for Sensor-Cloud Techniques

IV. CONCLUSION

The proposed work brings about the sensor-cloud architecture application in real time use using a reinforced machine learning in health care industry. The proposed robust reinforced machine

learning approach helps to build an optimized cluster for communication thereby improves network performance. The randomly deployed sensor network along with probabilistic likelihood model, the reliability factor, and the data forwarding characteristic improves the overall data communication rate, which are the key parameters of critical monitoring of a patient. The health care sector always demands a higher rate of information exchange with highest reliability, and the proposed method satisfies the requirement. The observations put forth proves the robustness of the proposed approach. The information from the local cloud can be forwarded to global cloud, that may be futuristic aspect. The other futuristic aspects may include the extension of the method using different interfaces under varying channel conditions.

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