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A Survey on Efficient Routing Techniques for Maximization of Network Lifetime in WSN

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Abstract: Wireless sensor networks (WSN) are becoming extremely attractive for both telecommunication and network industry. It is the promising technology to solve a number of present problems and creates new understanding to the future applications. In the past the wired sensors were implemented in limited applications in industries. However, wireless implementation makes the wide deployment of sensor nodes more feasible than before. There has been much research regarding the great potential capabilities of wireless sensor networks (WSNs) in applications such as environmental monitoring, habitat study, military surveillance in the battlefield and home automation. Research on several aspects of WSNs like energy efficiency, power management, topology control, data management and security are progressing extensively. In this paper we are going to compare the very famous routing protocols like LEACH, PEGASIS, GSSC and weighted sum method this algorithm has achieved significant increment in network lifetime.

Keywords: WSN; Clustering; LEACH, PEGASIS; GSSC and Weighted Sum Method; Routing Protocols.

I. INTRODUCTION

A wireless Sensor Network (WSN) is a focused wireless network that composes of a number of sensor nodes deployed in a specified areas including structural engineering, agriculture, healthcare, transportation and for monitoring environment conditions such as temperature, air pressure, humidity, light, motion or vibration, manufacturing lines, aviation, building maintenance and so on. Wired sensor networks have long been used to support such environments and, until recently, wireless sensors have been used only when a wired infrastructure is infeasible, such as in remote and hostile locations. But the cost of installing, terminating, testing, maintaining, trouble-shooting, and upgrading a wired network makes wireless systems potentially attractive alternatives for general scenarios. These wireless sensors are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors. These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user[1]. Smart sensor nodes are low power devices equipped with one or more sensors, a processor, memory, a power supply, a radio, and an actuator. A variety of mechanical, thermal, biological, chemical, optical, and magnetic sensors may be attached to the sensor node to measure properties of the environment. Since the sensor nodes have limited memory and are typically deployed in difficult-to-access locations, a radio is implemented for wireless communication to transfer the data to a base station (e.g., a laptop, a personal handheld device, or an access point to a fixed infrastructure). Battery is the main power source in a sensor node. Secondary power supply that harvests power from the environment such as solar panels may be added to the node depending on the appropriateness of the environment where the sensor will be deployed. Depending on the application and the type of sensors used, actuators may be incorporated in the sensors.

A WSN typically has little or no infrastructure. It consists of a number of sensor nodes (few tens to thousands) working together to monitor a region to obtain data about the environment. These sensors have the ability to communicate either among each other or directly to an external base-station (BS)[5]. WSNs have great potential for many applications in scenarios such as military target tracking and surveillance, natural disaster relief, biomedical health monitoring, and hazardous environment exploration and seismic sensing. In military target tracking and surveillance, a WSN can assist in intrusion detection and identification. Specific examples include spatially-correlated and coordinated troop and tank movements. With natural disasters, sensor nodes can sense and detect the environment to forecast disasters before they occur[4]. A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. Figure 1 shows the schematic diagram of sensor node components. Basically, each sensor node comprises sensing, processing, transmission, mobilizer, position finding system, and power units (some of these components are optional like the mobilizer).

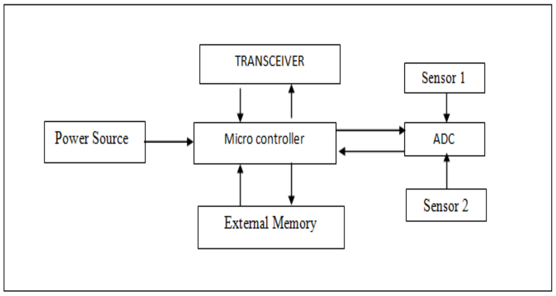

Figure 1: diagram of sensor node components.

Sensor nodes are usually scattered in a sensor field, which is an area where the sensor nodes are deployed. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base station(s)[5]. A base-station may be a fixed node or a mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data.

A. Network model:

In this paper, we consider a sensor network consisting of N sensor nodes uniformly deployed over a vast field to continuously monitor the environment. The BS is located very far away from the sensor field, as shown in Figure 2. During the phrase of cluster initialization, we assume the following properties about the sensor networks.

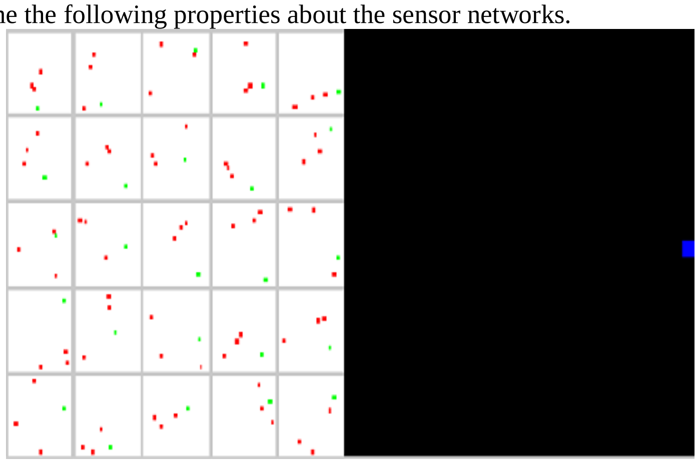

Figure 2: Random 100 nodes topology with base station at (50,200)

1. The location of all the nodes and BS is fixed after the deployment.
2. Data is transmitted at regular intervals from cluster head to the base station
3. All sensor nodes are homogeneous and power limited
4. Each node has its own unique identifier (ID).
5. All nodes be able to access the base station.
6. No mobility of sensor nodes.

B. Routing Protocols in Wireless Sensor Network

Routing protocols in WSNs have a common objective of efficiently utilizing the limited resources of sensor nodes in order to extend the lifetime of the network. Different routing techniques can be adopted for different applications based on their requirements. Applications can be time critical or requiring periodic updates, they may require accurate data or long lasting, less precise network, they may require continuous flow of data or event driven output. Routing methods can even be enhanced and adapted for specific application. Generally, the routing protocols in WSNs can be classified into data-centric, hierarchical, location based routing depending on the network structure as shown in figure 3. In data-centric, all the nodes are functionally equivalent and associate in routing a query received from the base station to the event. In hierarchical approach, however, nodes will play different roles in the network and some nodes have added responsibilities in order to reduce the load on other nodes in the network. In location based, the knowledge of positions of sensor nodes is exploited to route the query from the base station to the event. A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt to the current network conditions and available energy levels. In addition to the above, routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols depending on how the source finds a route to the destination. In proactive protocols, all routes are computed before they are really needed, while in reactive protocols, routes are computed on demand. Hybrid protocols use a combination of these two ideas. When sensor nodes are static, it is preferable to have table driven routing protocols rather than using reactive protocols. A significant amount of energy is used in route discovery and setup of reactive protocols. Another class of routing protocols is called the cooperative routing protocols. In cooperative routing, nodes send data to a central node where data can be aggregated and may be subject to further processing, hence reducing route cost in terms of energy use.

i) Data-Centric Routing Techniques
A large number of sensor nodes are deployed over a region making it incomprehensible to assign a global identifier for each node. This has led to the development of query based routing techniques known as data-centric routing protocols. In query based, the base station sends a query to a certain region in the network whose data it requires. The query is sent to a random sensor node form the base station, and has to be forwarded to the intended region.

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a) SPIN: protocols are a family of negotiation based information dissemination protocols used in WSN. In this protocol, the nodes name their data using high level descriptors called metadata. Metadata is used to negotiate and avoid the transmission of the redundant data. This allows the sensors to use their energy and bandwidth efficiently. The classical Flooding has 3 major obstacles are

1. *Implosion*: A node receives multiple copies of the same data from its different copies of the neighbours, because the sender node has no way of knowing whether the receiving node has already got the information from a different neighbour.
2. *Overlap*: Sensor nodes often cover same geographical area, and nodes gather overlapping pieces of sensed data. Since the nodes send redundant data to the same destination, bandwidth and energy are used inefficiently. Implosion is a function of only the network topology, whereas overlap is a function of both network and sensor attributes, making overlap a much harder problem than the implosion.
3. *Resource blindness*: The nodes are unaware of the status of its resources which makes them die sooner. It can be rectified by using a local resource manager at each node.
   SPIN family of protocols overcome these limitations by negotiation and resource adaption.

b) Direct Diffusion
Direct diffusion is a data centric query based and application-aware protocol where data aggregation is carried out at each node in the network. The nodes will not advertise the sensed data until a request is made by the BS, and all the data generated by sensor node is named by attribute-value pairs. The gradient specifies data rate and the direction in which to send the events. The node which receives the events information from the source attempts to find a matching entry in its interest cache.

All sensor nodes in a directed-diffusion-based network are application-aware, which enables diffusion to achieve energy savings by selecting empirically good paths, and by caching and processing data in the network. Caching can increase the efficiency, robustness, and scalability of coordination between sensor nodes, which is the essence of the data diffusion paradigm.

c) Rumour Routing
Rumor routing routes the queries to the events in the network and it offers tradeoff between setup overhead and delivery reliability. An event is an abstraction obtained from a set of sensor readings that is assumed to be a localized phenomenon occurring in a fixed region in the network. A query is a request for information, sent by the base station to collect data, and once the query arrives at its destination the data can begin to flow back to the queries originator.

The Rumor Routing algorithm is intended to fill the region between query flooding and event flooding. It is only useful if the number of queries compared to number of events is between the two intersection points. In rumor routing, each node maintains a list of its neighbors, as well as an event table. The event table has paths/ next hop to all the events that the node knows.

d) An Energy Efficient ANT Based Routing algorithm (EEABR)
This routing protocol is based on ANT colony based routing algorithm for MANETs. By introducing energy efficiency parameter to this algorithm, it can be adopted in WSN. It is used for multi-hop ad-hoc networks and is based on swarm intelligence and on the ANT colony based meta-heuristic. These approaches try to map the solution capability of swarms to mathematical and engineering problems. This routing protocol is highly adaptive, efficient and scalable. This feature makes it adaptive to energy constraint WSN.

EEABR can be easily implemented in clustering protocols where there is only one destination node. But if there are multiple destination nodes, the routing table of every node must contain the identification of all nodes. For large network, this can be a problem because of memory and computation constraints of sensor nodes. Enhancements of EEABR considerably reduce the size of routing tables and in consequence, the memory needed by the nodes.

ii) Hierarchical Routing Techniques

Hierarchical routing is the procedure of arranging routers in a hierarchical manner. A hierarchical protocol allows an administrator to make best use of his fast powerful routers as backbone routers, and the slower, lower powered routers may be used for access purposes. In this way, the access routers form the first tier of the hierarchy, and the backbone routers form the second tier. Hierarchical protocols make an effort to keep local traffic local, that is, they will not forward traffic to the backbone if it is not necessary to reach a destination.

a) Low Energy Adaptive Clustering Hierarchy (LEACH)

Low Energy adaptive clustering hierarchy (LEACH) is a popular energy efficient adaptive clustering algorithm that forms node clusters based on the received signal strength. All nodes are capable of communicating with the BS directly. At any point of time, all the nodes have data to send and nodes located close to each other have co-related data. In LEACH the nodes form local clusters with one of the nodes acting as a local sink or cluster head. If the same node would remain as the cluster head throughout the working of the network, it would die quickly because of the extensive load from the participating sensors in the cluster.

LEACH enhances the network lifetime by utilizing the resources efficiently, distributing the load uniformly, aggregating data at the CH to contain only the meaningful information, rotating the CH randomly to achieve balanced energy consumption. Also, the sensors do not need to know the location or distance information. Depending on the applications, the different variations of LEACH such as LEACH-C (centralized), E-LEACH (enhanced) and MLEACH(multi-hop) can be used.

b) Power Efficient Gathering in Sensor Information System (PEGASIS)

PEGASIS is a near optimal chain based protocol. The basic idea is for the nodes to communicate their sensed data to their neighbors and the randomly chosen nodes will take turns in communicating to the BS. It assumes that the BS is fixed at a far distance from the sensor nodes. The sensor nodes are homogeneous and energy constraint with uniform energy. The energy cost for transmitting a packet depends on the distance of transmission. All the nodes maintain a complete database about the location of all other nodes. We begin the chain construction with the node farthest from the BS. Using the greedy approach, each node connects to its closest neighbor and the nodes already on the chain cannot be revisited. During every round, each node receives data from its neighbor, fuses it with its own data and transmits to the other neighbor on the chain. (The nodes take turns transmitting the BS).

Energy balancing PEGASIS is the energy efficient chaining algorithm in which a node will consider average distance of formed chain. PEDAP, Power Efficient Data Aggregating Protocol uses spanning tree approach instead of Greedy approach to form the chain resulting in considerable savings energy.

c) Threshold sensitive energy efficient protocols

Threshold sensitive energy efficient protocol (TEEN) and Adaptive threshold sensitive energy efficient protocol (APTEEN) are the two threshold sensitive hierarchical routing protocols based on the clustering approach used in LEACH. LEACH is targeted at pro active network applications where as TEEN and APTEEN are targeted at the reactive network applications. In pro active network, the sensed data is sent periodically to the sink which provides the snap shot of relevant parameters at regular intervals. In reactive networks the nodes react immediately to the sudden change in the sensed data and transmit it to the sink. Since they remain in the sleep mode most of the time, the number of transmissions is reduced, thus reducing the energy consumed. Both TEEN and APTEEN group the sensor nodes into clusters with each led by a cluster head. TEEN mainly focuses on time critical sensing applications. The soft threshold can be varied depending on the criticality of the sensed attribute and the target application. The user can change the threshold values at every cluster change time by broadcasting the new attributes. Although the hybrid protocol is more adaptive, it suffers from the additional complexity required to implement the threshold functions and the count time. However, this is a reasonable trade-off and provides additional flexibility and versatility.

d) Energy Aware routing Protocol (EAP)

EAP is a hierarchical cluster based protocol which achieves a good performance in terms of lifetime by minimizing energy consumption for in-network communication and balancing energy load among all nodes. It introduces a new clustering parameter for cluster head election which enables better handling of the heterogeneous energy capacities and it also adopts an efficient method known as the intra cluster coverage, which copes with the area coverage problem.

EAP uses the intra cluster coverage method, which selects some active nodes within cluster while maintaining the coverage expectation. The use of intra cluster coverage has two advantages, reduces power consumption in each round by turning redundant nodes off and reduces TDMA schedule overhead. After network is constructed, the cluster method is used for construction of routing tree.

iii) Location Based Routing Techniques

Routing algorithms based on geographical location is an important research subject in the WSN. They use location information to guide routing discovery and maintenance as well as packet forwarding, thus enabling the best routing to be selected, reducing energy consumption and optimizing the whole network. Through three aspects involving the flooding restriction scheme, the virtual area partition scheme and the best routing choice scheme, the importance of location information is seen in the routing algorithm.

a) Geographic Adaptive Fidelity (GAF)

GAF is a location based routing protocol for WSN. It is also an energy aware routing protocol. GAF works in such a way that, it turns off unnecessary nodes in the network without affecting the level of routing fidelity, this conserves energy. A virtual grid for the area that is to be covered is formed. The cost of packet routing is considered equivalent for nodes associated with the same point on the virtual grid. Such equivalence is exploited in keeping some nodes located in a particular grid area in sleeping state in order to save energy. By doing this the network lifetime is increased as the number of nodes increases. There are three states in this protocol and they are *discovery*, for determining the neighbors in the grid, *active* tells that the nodes are participating in routing and *sleep* when the radio is turned off. The load is balanced when nodes change states from sleeping to active in turns.

b) Greedy Perimeter Stateless Routing (GPSR)

GPSR is a routing protocol based on the position of routers and packets destination to make a forwarding decision for WSN. GPSR makes the forwarding decision which is actually transferring the packet from one node to another destination node using the minimum shortest path possible. Hence the routing protocol is associated with the term "greedy". The greedy forwarding decision for a packet is made using the information about a router's immediate neighbors in the network topology. If a packet reaches a region where greedy forwarding is not possible, then an alternative step is taken by routing around the perimeter of the region. Even though there are frequent changes made to the topology due to mobility, the GPSR protocol uses the local topology information to find correct new routes quickly. The scalability of GPSR routing protocol depends on two major factors like
the rate of change of topology and the number of routers existing in the routing domain.
GPSR benefits all stem from geographic routings use of only immediate-neighbor information in forwarding decisions.

c) Geographic and Energy Aware Routing (GEAR): Geographic and Energy Aware Routing algorithm or simply known as GEAR is a location based routing protocol for WSN. GEAR is an energy efficient protocol which uses the energy aware neighbor selection to route a packet towards a particular geographical region and then use either the recursive geographic forwarding or restricted flooding algorithms to disseminate the packet inside the destination region. GEAR shows considerably longer network lifetime than most non-energy aware geographic routing algorithms especially for non-uniform traffic distribution when compared to uniform traffic distribution.

II. RELATED WORK

In the sensor network, sensor node can communicate with the base station directly or through the cluster head. In the direct communication, each node communicates directly with the base station. The other scheme is the clustering; where the nodes are grouped into clusters and one node of the each cluster send all gathered data from the nodes in its cluster to the base station. In this section, number of related routing protocols has been proposed which try to maximize the lifetime of sensor networks
The aim is efficient transmission of all the data to the base station so that the lifetime of the network is maximized in terms of *rounds*, where a round is defined as the process of gathering all the data from sensor nodes to the base station, regardless of how much time it takes. Direct transmission is a simple approach for this problem in which each node transmits its own data directly to the base station. However, if the base station is far away, the cost of sending data to it become too large and the nodes will die quickly. In order to solve this problem, three elegant protocols LEACH [7] and PEGASIS [8] and GSSC [9] are proposed. In LEACH, the key idea is to reduce the number of nodes communicating directly with the base station. The protocol achieves this by forming a small number of clusters in a self organizing manner, where each cluster-head collects the data from nodes in its cluster, fuses and sends the result to the base station. LEACH also uses randomization in cluster-head selection and improvement in data transmission as compared to the direct transmission approach. PEGASIS takes it further and reduces the number of nodes communicating directly with the base station to one by forming a chain passing through all nodes where each node receives from and transmits to the closest possible neighbor. The data is collected starting from each endpoint of the chain until the randomized head-node is reached. The data is fused each time it moves from node to node. The designated head-node is responsible for transmitting the final data to the base station. PEGASIS achieves a better performance than LEACH by between 100% and 300% in terms of network lifetime. The GSSC[9] algorithm which employs sleep scheduling of sensor nodes with the help of their geographical information and then routes the data from active nodes to the base station using chaining (multi hop) concept. GSSC operates in three phases: (1) sleep scheduling phase i.e. to find out the active nodes in sensor field (2) chain formation phase in between active nodes (3) data transmission phase.
By using location information provided by GPS (Global Positioning System) and sensing range (the distance up to which a sensor node can sense information) of nodes, the sensor field is divided into several square virtual grids. Sensing range of nodes will decide the size of grid i.e. if sensing range is less, size of grid will be small. The sensor nodes which will come

under one grid will definitely sense same information. We are keeping diagonal of grids equal to maximum sensing range of sensor nodes. So we are fixing the maximum size of grid equal to 20m x 20m. Now if all the nodes in the same grid will send data to the base station then data redundancy will increase and also there will be unnecessary loss of energy in sending the redundant data.

To overcome this problem, from one grid only one sensor node i.e. active node will send data to base station and other nodes will be in sleep mode. In every periodic round the active node in each grid will be selected according to the maximum remaining energy of nodes.

2) Chain Formation Phase

_ Chain formation will get started from the active node in farthest grid and will continue with the active nodes in next grids in vertical direction toward the base station.

_ The distance between the active nodes will be calculated by using the distance formula

d=√((x2-x1)2+(y2-y1)2). Here using GPS system it is assumed that sensor nodes know their relative position in terms of X-Y co-ordinates with other nodes.

_ If there is no active node in all upper grids then it can send data directly to the base station i.e. communication should not stop till single sensor node is alive in sensor field.

3) Data transmission phase

In every round, each active node at the end of chain starts data transmission to the next active node along the chain. The node in the next position receives the data and fuses this data with its own and transmits it to the next active node. This is how data propagate from the farthest node in the chain to the base station. The energy consumption in transmission, reception and data fusion takes place according to the described energy model.

In this subsection we explain the weighted sum method scheme which employs sleep scheduling of sensor nodes with the help of their weighted sum method and then routes the data from active nodes to the base station using chaining (multihop) concept. Weighted Sum Method is used to elect the healthier Cluster Heads Having Battery Life and Sufficient Residual energy. It is used to select the Master Head Nodes and Cooperative Nodes for communication in Wireless Sensors Networks. Weighted Sum Method is evaluated the energy efficiency to improve the lifetime of sensor network**.**

In the network based on clustering, a cluster head is responsible for coordinating operations among member nodes in the cluster, collecting and fusing data, and then sending the resulted data to the master cluster heads. The cluster head consumes more energy than other nodes in the round. Thus, the location and the residual energy of node are introduced during the generation of cluster head to balance the energy consumption of all nodes in every cluster for prolonging the lifetime of network. All the cluster heads in first round are selected by minimum distance between sensor node to sink and their residual energy by using weighted sum method .In this method the maximum energy and distance are multiplied by weight parameter of residual energy and weight parameter of distance from the sink. The cluster head can be specified by following equation:

CH (i) = [Eres(i)*W1+D(i)*W2]max (1)

Where Eres(i) is its residual energy; D(i) is the distance from candidate node (i) to the sink, W1 is the weight parameter of residual energy and W2 is the weight parameter of distance from the sink.CH(i) is cluster heads for i number of rounds.[10]

The structure of the WSM routing scheme for wireless sensor network is shown in Fig. 3.

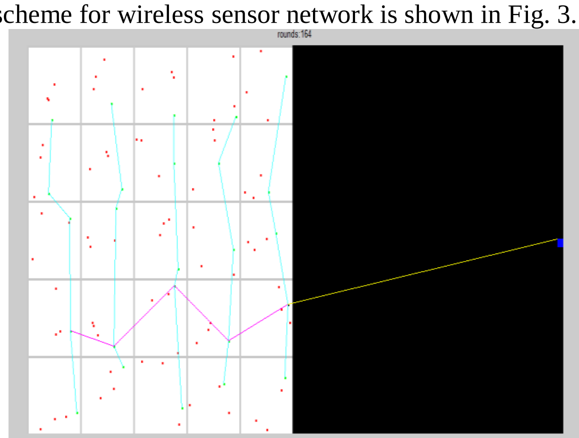

Figure 3: Data Transmission Routing According to WSM Algorithm

Table I: Simulation Parameters

Sr. No.	**Simulation Parameters**	**Values used**
1.	Numbers of nodes(N)	100
2.	Network area (M*M)	100*100
3.	Position of base station(x,y)	50,200

4.	Eelec (transmission & reception energy)	50 nJ/bit
5.	Eamp(Transmit Amplifier)	100 pJ/bit
6.	Eda (data aggregation energy)	5 nJ/bit
7.	K (number of bits in a packet)	2000
8.	Initial energy	0.5 J
9.	Weighted parameter of residual energy	0.998
10.	Weighted parameter of distance	0.002

III. CONCLUSION

This paper carries out a survey on Wireless Sensor Networks (WSN) based on their technologies and their routing techniques in WSNs comprises of a miniature sensor nodes with capabilities of sensing, computation, and wireless communications. The power consumption for the entire component of sensor nodes, processes and communication protocols for sensors and sensor networks has to minimize. The small requirement of power for sensor nodes makes the design of energy-efficient communication protocol necessary. They network architecture also influences the design of routing techniques. Weighted sum method for solving optimization which seeks solution by systematically varying weights among the objective condition under given constraints this is the to achieve high performance

In this paper we are comparing the very famous routing protocols like LEACH, PEGASIS, GSSC and weighted sum method this algorithm has achieved significant increment in network lifetime and the reliability of network.

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