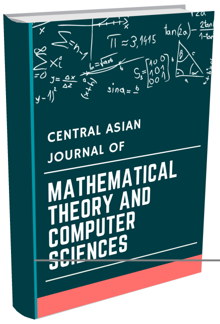

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A DETAILED SUMMARY OF OPTIMIZATION ALGORITHMS FOR MOBILE-WSN

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Abstract

Mobile wireless sensor networks (MWSN) are a result of recent advancements in wireless telecommunications. The sensor nodes that make up these networks are mobile in addition to being inexpensive and having a short battery life. Numerous applications have been developed for these networks because of their inherent properties. Rescue efforts in the impacted areas, surveillance, and surveillance systems are all possible with it. Traffic signals are transmitted using it. Movable equipment that has energy limits and is energy-conserving is a considerable tool in its design. According to the needs of the aforementioned applications and taking into consideration the wireless sensor nodes. The MWSN allows the sensor nodes to move autonomously and communicate with one another, doing away with the need for centralised control. These networks can outperform static wireless sensor networks due to their longer network lifetime, reduced power consumption, more bandwidth availability, and better targeted capabilities. Given that the sensor nodes in MWSN are resource-constrained, low-cost mobile devices, the routing process is frequently challenging in mobile networks. Many problems, including maintaining network access, reducing energy consumption, and providing enough sensing coverage, to name a few, remain unresolved despite the development of a variety of efficient routing techniques for MWSNs as a consequence of contemporary research. This paper presents the sophisticated routing protocols in the MWSN, which addresses many routing issues. The communication network, information state, power proficiency, and mobility of the routing protocols are categorised. The

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categorization shown here encompasses the core components of a number of theories that have been proposed in the literature for efficient routing in MWSN and also sheds light on potential upgrades to the existing routing protocols.

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I. INTRODUCTION

Sensor nodes that may relocate throughout the network make up a mobile wireless sensor system (MWSN) [1]. A sensor node is an element of technology that consists of three basic modules: a sensing component for gathering data from the physical environment, a processing component for processing and storing data locally, and a wireless communication component for transmitting data [2]. Initial research indicates that such as portability into a WSN is advantageous [3]. The sensors can be made to self-incite using spirals [5] or swivels [6], to be attached to trailers like cars, mammals, or robotics [7], or they can be supplied with mobilizers to alter their locations [4].

With the goal of increasing the precision and stability of disease spot segmentation, authors in [6] developed an adaptive segmentation method for crop disease photos based on K-means clustering. Improvements to the FCM model have been looked into for both the assessment of the intensity inhomogeneity and segmentation of magnetic resonance image data [7] since the FCM method is susceptible to noise and selection to the initial cluster centres. Particle swarm optimisation and kernel FCM clustering were used by authors in [8] to create a fast level set model for global region-based image segmentation. An adaptive kernel-based FCM clustering with spatial restrictions model was put out by authors in [9] to automatically regulate the impact of the surrounding pixels on the core pixel. The sensor nodes may move depending on the atmosphere (air or water) in which they are placed [8]. Recent studies have found that MWSN beat static WSN because they offer the following advantages [2].Figure 1 depicts the MWSN's design. The sensor nodes are randomly distributed throughout the network. These nodes are attached to one another and are capable of communicating with agents on the move. Data collected by the mobile agents can be transmitted to the stationary network of access points.

Everywhere, at any time, they can relocate. The MWSN's dynamic topology is reflected in the choice of additional distinguishing characteristics including connection, MAC level protocols, and physical characteristics. In a static WSN, an earlier interconnected network can disintegrate into a collection of disconnected subnetworks due to hardware failure or energy depletion. With MWSN, the nodes can be utilised to reorganise the network. Mobile sensors can be moved after initial implementation to fill energy gaps in the network and achieve the necessary density [9–11]. You can conserve energy while speaking while being mobile. The channel capacity of MWSN is more than that of static WSN. Data fidelity is achieved by MWSN by reducing the number of hops, which reduces the likelihood of error.

A few uses for a MWSN include the monitoring of the habitats of migrating birds by a group of ornithologists, a mobile worker (who may be a robot or a human) equipped with sensor(s) gathering and transmitting data to the base station about the agricultural sector, smart cities, electronic voting, smart transportation systems, fire crews attempting to pass through a burning house, and so on [12]. However, the frequent path breakage brought on by channel fading, shading, interfere, node movement, and node breakdown makes it challenging to implement mobility in a WSN. Frequent position changes from a moving node increase the risk of crashes and drain the sensor node's battery source. As a result, when building MWSN, factors such node mobility, bandwidth restrictions, and limited resources, among others, must be taken into account. Transferring a data packet from one place to another is the process of routing. The path that each message meant for the sink takes in a sensor network is crucial to the network's endurance. Reduced energy consumption is essential in a MWSN because sensor nodes have a limited supply of energy [13].

II. RELATED WORK

The interaction of movement and resource use in a WSN creates significant routing problems [14]. Routing is a significant issue in the MWSN due to its extremely dynamic nature and the ongoing changes in network design and networking devices brought on by mobile nodes or connection failures [15]. Mobile sensor nodes' capacity for storing and distributing power is insufficient. Due to the dynamic nature of the network configuration, a number of nodes will exhaust their energy and leave the network, dividing it. Numerous academics have created several routing protocols based on different design issues and requirements. MWSN routing protocols can be categorised based on the network architecture, information status, movement, and power-saving techniques.

Based on the network topology, they are further divided into Direct Communication Routing, Flat-based Routing, and Hierarchical Routing. A sensor node uses direct communication routing to provide data straight to the sink. When the network region is large, the power of the sensor node rapidly depletes and the frequency of collisions rises. Direct communication routing is therefore infrequently used in MWSNs. The flat-based routing system's nodes all have the same capabilities [16]. Network nodes are automatically combined by hierarchical protocols into smaller divisions known as clusters, which are subsequently combined into larger divisions known as super clusters, etc. The cluster heads aggregate the data, which lowers the amount of data and conserves energy [17]. Cluster leaders are responsible for maintaining control in clusters [18].

III. ROUTING PROCESS

Information routing from its origin to its endpoint is one of the most challenging problems in these networks since there is no defined topology. These routing techniques are generally influenced by two domains: MANETs and wireless sensor networks (WSNs). Since traditional routing protocols are unable to handle the higher frequencies of dynamic topology, WSN routing techniques fill this critical gap. On the other hand, MANET routing techniques can control network mobility, but they were designed for two-way communication, which isn't usually required in sensor networks. MWSN-specific protocols are frequently multi-hop variations of standard protocols. For instance, MWSN modified the wireless mesh network protocol to include (ADSR).

Using positional data, ADSR determines the angle between the transmitting node, potential relaying sensors, and the central station. Next, it is used to guarantee that packets are always routed to the central station. Additionally, (LEACH-Mobile) for mobile WSNs has been developed from the LEACH protocol for sensor networks [19]. Utilising location information from a GPS device attached to the sensors is a further frequent routing technique. This may be seen in protocols like (ZBR), which use location information to tell nodes about their cluster.

GOR [20] is a flat rule that divides the network region into nets before using the site information to transport data as efficiently as possible over each hop. Since they allow for a reliable means of routing, multi-hop protocols seem to be a good choice for MWSN routing protocols. Such a protocol is query-oriented (DCBM) [21]. Additionally, two protocols designed especially for quick MWSN applications, such as UAVs, are (RASeR) [22] and (LASeR) [23]. Both of them employ multipath movement, which is enabled via a technique called "blind forwarding," which only enables the transmitting node to disseminate a message to those in its immediate vicinity. It is then up to the receiving nodes to decide whether to accept or reject the message. The values of the transmitting and receiving sensors are evaluated to determine which is nearest to the central station, and a network-wide gradient measure is used to decide whether or not to advance a packet. How RASeR and LASeR track their gradient measures is the key difference between them: RASeR frequently broadcasts small beacon packets in which nodes send their current gradient. LASeR, on the other hand, is dependent on already-present geographic information on the mobile sensor, which is likely the case in many applications. According on their routing design, current routing protocols are categorised as flat, hierarchical, or location-centered. The two forms of hierarchical based routing are conventional and optimised hierarchically oriented routing. Additionally, path construction uses several routing techniques (proactive, reactive, and hybrid) to establish the route from the origin to the destination [24–25]. A categorization of MWSN-based routing methods is shown in Fig. 2.

IV. HIERARCHICAL ROUTING PROTOCOLS

LEACH is one of the most used dynamic clustering methods for sensor networks with hierarchical topologies. It is designed specifically for dispersed environments and doesn't need access to a worldwide network. The cluster is produced after the sensor selects the cluster head (CH) based on the recorded signal strength and the threshold values. The cycle or topology updates interval, which is divided into defined time intervals, is utilised for data transmission. The sensor nodes in a network gradually degrade because each sensor has an equal probability of acting as a CH by selecting a random integer between 0 and 1 [26]. Although fixed LEACH is unsuccessful for large MWSN, dynamic LEACH should be investigated for vigorous networks since dynamic clustering increases longevity while fixed LEACH does not. Following are descriptions of LEACH versions for MWSN:

- T-LEACH: Similar to LEACH, T-LEACH [29] builds a hierarchical architecture for massive, lively, and unevenly dispersed moveable sensor networks. It uses a tree topology, an energy depletion mechanism, and a multi-hop transmits approach to balance the network's energy depletion and boost the packet delivery rate. T-LEACH is applied in two stages for the topology generation and topology maintenance stages. A data aggregation tree, a cluster organisation, and a multi-hop broadcast technique are originally created during the topology development process. Second, the topology maintenance phase employs the multi-hop transfer method, member node mobile response rate, and cluster mobile response rate to construct a stable network. Based on the results, when compared to LEACH and CBR, mobile LEACH, the T-LEACH protocol can successfully find and maintain the topology organisation of active and unevenly distributed large MWSNs in terms of packet delivery ratio (PDR) and average power depletion.
- Mobile LEACH is a movement-focused WSN protocol [27]. Mobile and static LEACH processes are very similar to one another. But with the mobile LEACH, it is possible to reposition the cluster so that it uses the least amount of energy and insert movable sensors without CHs during setup. After the cluster is formed, the CH assigns a time slot to each sensor in the cluster. In order to reduce the power consumption of the individual sensors, the cluster members turn off the radio when it is transmitting. The trials' findings show that Mobile LEACH performs better than LEACH at reducing data packet loss for mobile nodes. Mobile LEACH, as opposed to LEACH, has the disadvantage of increasing unwanted power consumption. Authors in [30] created mobility-based LEACH protocols to extend the life of the movable LEACH for mobile sensor networks. In mobile mono-hop LEACH, which is perfect for a compact indoor space, all mobile sensors can communicate directly with the BS. Nevertheless, the portable multi-hop LEACH is designed to support a variety of external applications. Based on simulation results, the suggested protocols improve the performance of mixed mobile sensor networks in terms of network lifespan, conveyed packet rate, suspension, and PDR.
- LEACH-ME: The mobile multiple-hop LEACH is designed to support certain significant outdoor applications. According to simulation results [28], the provided protocols improve the performance of heterogeneous MWSNs in terms of network lifespan, amount of packets delivered, deferral, and PDR. Additionally, LEACH-ME keeps track of details about sensor nodes, such as their job, mobility capabilities, list of cluster members, and TDMA scheduling. Even the sensor keeps track of everything; choosing which cluster head to employ depends heavily on the movement feature. Let's assume that the idea of remoteness and the total number of transitions control the movement feature. Using this knowledge, each CH can construct a cluster of cluster members with the lowest node mobility. When cluster heads are moving, LEACH-ME makes sure that clusters are dispersed as evenly as possible. According to simulation results, when it comes to the mobility element, LEACH-ME performs better than mobile LEACH in terms of average effective communiqué, standardised efficiency, calculating, and energy overrun.

V. MOBILE SINK-SETUP ROUTING PROTOCOL

The cluster-based WSN life is extended using the [31] approach. The nearby sensors to the washbasin must normally send a substantial number of messages when compared to the far-off sensors, and they can soon exhaust the last of their power. The challenge in question is a "hotspot" challenge. The identifying portion is composed of clusters to avoid these issues, extending the usefulness of the network. In MSRP, the moveable sink is used as opposed to the non-movable sink, and it travels to each cluster to compile the sensed data before uploading it to the CH. The remaining energy information from the CHs is now transferred to the higher energy CHs by the movable sink. The MSRP protocol consists of two phases: setup and steady state. During the setup phase, the entire network is divided into clusters, and the mobile sink advertises its location to CHs by disseminating the beacon message for the registration process. Additionally, it is divided into three stages: activation, announcement of movable sinks, and registration of CH. Once the setup phase is finished, the steady state phase starts. The sink receives data during the steady-state phase and delivers it to the registered CH, who subsequently collects information from the cluster members. The process is then divided into three stages: sink movement, sink forwarding, and TDMA scheduling.

VI. CROSS-LAYER ROUTING

Based on the simulation results, the MSRP modifies the one-hop neighbouring sensors of the mobile sink to reduce power depletion among movable sensors and solve the energy holes problem. The creation of a single layer protocol will not be able to provide large-scale MWSNs with the best possible solutions. As a result, the authors developed the MACRO approach, which combines the application, transport, network, MAC, and physical layers of the OSI model into a single protocol. The MACRO protocol architecture incorporates path detecting, message advancing, and path controlling algorithms to guarantee stable quality linkages in the face of frequent topological changes. Additionally, it lessens node failure, flooding with unsolicited control packets, and extreme MWSN congestion. Massive MWSNs may experience substantial latency during the route finding process due to the higher number of mobile sensors and frequent topology changes. The results of the experiments demonstrate that MACRO outperforms the traditional CBR-mobile and LEACH-mobile in terms of PDR and end-to-end packet latency. Figure 4 depicts a WMSN cross-layer routing scenario.

VII. ENERGY MANAGING PROCEDURES

In order to improve the MWSNs' long-term power usage and data transmission prominence, the approach [32] has been suggested. The two phases of this method's operation for managing power in MWSNs with plenty of movable sinks are as follows: (i) Find the closed tours for all mobile sinks; the length of each closed tour is essentially the same. (ii) Complete the stopover sites for all mobile sinks on the discovered closed tour. Then, construct a routing tree for the mobile washbasin that is rooted at each stopover place and the stopover time. Every mobile washbasin has two different types of wireless communication interfaces. Wireless connection using little power: engage with sensor nodes in a sensor network; high-throughput wireless interface: communicate with a third network with the intention of transmitting data over long distances. Like LEACH, EMMS energy management processes are broken down into cycles. A routing tree is built during each cycle, sojourn periods are calculated at each sojourn point, and sensory input is collected and transmitted. Based on the remaining energy from the sensor nodes, the phase that creates the routing tree starts a routing tree at each stop along the mobile sink's closed tour. The sojourn time computation then starts by figuring out the components of the newly constructed tree and estimating a sojourn time at each stop along the closed tour of each washbasin. In the data gathering and recognising data transmission stage, the sensor nodes transmit their perceived data to the mobile sink via the established routing tree, and the mobile sink transmits the recognised data to the remote observing centre.

VIII. COLLECTORS OF DATA USING ARTIFICIAL BEE COLONY

The ABC technique, which examines three "bee" assemblies in the "colony" (i.e., spectators, scouts, and employed bees), was proposed by authors in [33]. The ABC technique uses a population of bees, each of which represents a location in the search domain, to choose the optimum route. An employed bee is one that repeatedly waits on the "dance" area to choose a honey source from a passerby, randomly hunts a scout, and then goes back to the honey source where it had previously been. Let's assume that one potential answer to the optimisation conundrum is the location of the honey sources. Additionally, the prominence (i.e., fitness) of the related issue is related to how much "nector" is produced by a honey source. Additionally, the first half of the ABC method represents the employed bees, while the second part represents the observer bees. The ABC algorithm's operation can be divided into four major phases: initialization, population renewal, bee source selection, and population eradication. The optimal moving route and the best routing path for data collection onto the mobile sensor nodes of large mobile WSNs were determined by authors in [34] using an optimization-oriented ABC approach that uses the mobile BS. The ABC technique also aims to investigate the data delay of the mobile sink from three angles: data collection optimisation, mobile route stretch reducing, and network integrity optimisation. Similar to LEACH, each round of the ABC procedure working has a preliminary step and a stage for gathering data. The moveable sink uses network topology data in the early stages to identify the optimal clusters of CH nodes and build a routing tree among them.

IX. TREE TECHNIQUES

Authors have created a CIDT architecture in order to provide dependable, guaranteed, and comprehensive communication for large Mobile WSNs [35]. CIDT is a hybrid logical method technique that uses DCT communication for cluster and tree topologies, respectively, and intra-cluster communication for cluster topologies. The protocol design helps with QoS measures like data collection, battery depletion, latency, packet delivery ratio, throughput, and network lifetime for large scale mobile WSNs. Here, each sensor node chooses the CH with the quickest connection time, and the CH then collects the information messages from the cluster members for a predetermined time period. After choosing a CH, the BS starts the DCT to identify a one-hop neighbour DCN or present DCN. This CH is chosen because it has the highest coverage distance, fastest connection time, and least amount of network traffic. The protocol operation is divided into setup and steady-state phases. During the setup phase, a sensor selects itself as a cluster leader among them based on its threshold value (i.e., flag, remaining power, and movement). Depending on the evaluated linking time, RSS, and connection sturdiness, the cluster member also links with the one-hop CH during cluster building. After that, the base station starts DCT communication to create a data collection tree and select the DC node to cover the entire CH. The Data Collection Node does not participate in sensing for this round; rather, it gathers sensed data, adds data packets from the one-hop CH and the DC Node, and then sends the data packet to the sink via DCT. Different cluster leaders and DCNs are chosen for each round to ensure that the network's lifetime is distributed uniformly.

X. VELOCITY CONSERVATION

The purpose of VELCT [31], an energy-efficient routing technique based on a hybrid topology (cluster + tree), is to improve the network performance, data collection, and lifetime of massive MWSNs. Current network topology concerns, such as remaining power usages, coverage issues, the existence, movement, and network longevity, are successfully addressed by the CIDT upgrade known as VELCT. The designed VELCT system (DCT) is used to construct the data collection tree. Some sensor nodes in a network have been designated as data collection nodes based on the position of the CH and do not participate in sensing on this particular cycle in DCT. In this scenario, the DCN contemplation's objective is to gather and deliver data packets from the cluster head to the central station. The VELCT technique reduces residual power depletion, total latency, and traffic in CHs in large Mobile WSNs because it makes the best use of the DCT. The key benefits of the VELCT method are that it generates a basic tree architecture, prevents recurrent cluster creation, and maintains the cluster for an extended length of time. The strength of the suggested protocol is that it generates a straightforward tree design for each CH that maintains the cluster for an extended period of time, lowering power consumption and operating costs for control packets, and avoiding the blockage issue at the CH level and recurrent clustering in a mobile environment. Experimental results demonstrate that the proposed procedure can offer improved efficiency in terms of power usages, throughput, interruption, and Packet Delivery Ratio with condensed network traffic when compared to power-efficient data gathering protocols relying on tree structure, CREEC, CTDGA, MBC, and CIDT in a high motion environment.

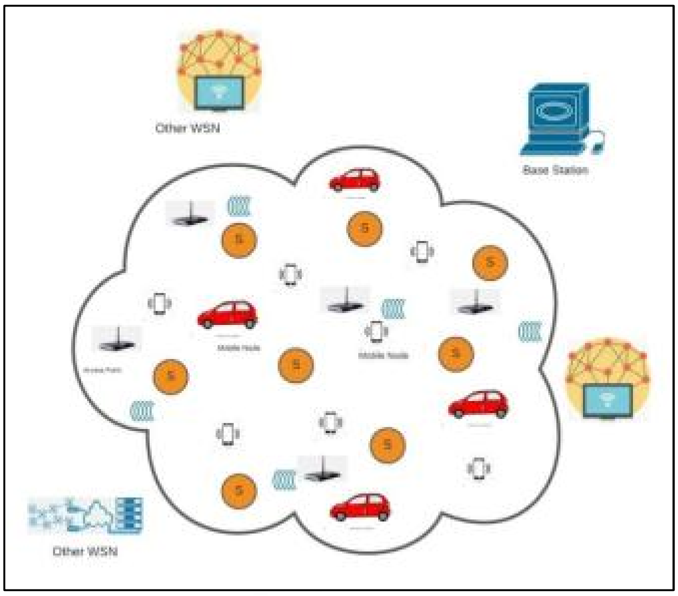

Fig 1: Mobile Wireless Sensor Network

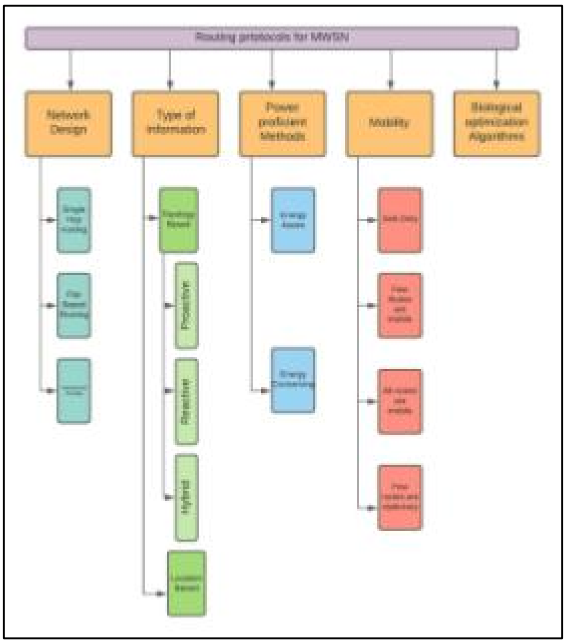

Fig 2: Classification of Routing Protocols of MWSN

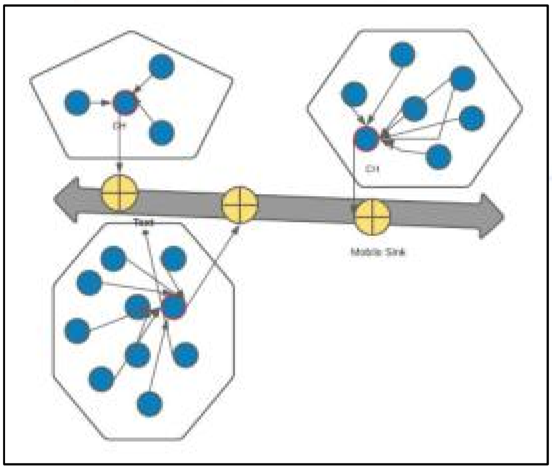

Fig 3. Mobile Sink Centred Clustering in MWSN

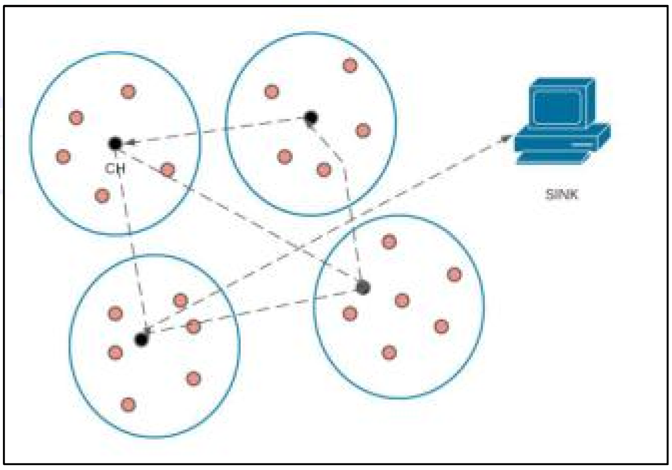

Fig 4. An instance of cross layer routing in WMSN

XI. CONCLUSION

Routing in a MWSN has become one of the trickiest challenges in recent years. Recent research developments have led to a promising evolution of MWSN routing. In this work, we provide a thorough overview of the most recent routing techniques suggested in the literature for mobile WSN. According to their network topology, information state, mobility, and power proficiency, we divided them into categories. Each of these routing protocols has its own set of benefits and drawbacks, the bulk of which are application-specific. Additionally, we discovered that a powerful solution for power-efficient routing in Mobile WSN may be achieved by combining an energy-aware routing strategy with an energy-saving mechanism at the cross-layer level. The flexibility of sensor nodes helps to lessen issues like hot spots, routing holes, and energy-hole issues, among others. We addressed the majority of the MWSN literature that is currently available, covering the design, mobility, topography, and routing protocols of mobile sensors. But there is still room for advancement in terms of effective node discovery and transmission planning.

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