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A Clustering System for Multi-Hop Underwater Cooperative Sensor Networks

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ABSTRACT: We propose the EOCA scheme designed for the multi-hop UWA-CSN, which is based on the CMDG scheme and is an improved energy optimization clustering something-rhythm. When selecting CH nodes, the EOCA scheme takes into account a amount of factor, including the number of nearby nodes, residual energy, also detachment toward the sink node designed for every join underwater. We also develop a reE-MECR power optimization mechanism for selecting the CH node which uses the curve characteristic of the Arctan function to establish a uniform relationship between the remaining energy of every subsequent sensor node. We also consider the mobility of underwater sensor nodes by incorporating the MCM model into the proposed energy optimization clustering scheme. The simulation results show that the system can effectively extend the lifetime of a multi-hop UWA-CSN power optimization clustering system, while achieving a high package delivery rate.

KEYWORDS: Energy optimization, clustering algorithm, underwater acoustic networks, cooperative communications

I. INTRODUCTION

In this paper, we propose an improved clustering scheme for energy optimization for multi-hop UWA-CSN with the aim of maintaining long-lived communication performance while optimizing energy use. The main contributions to this paper are: The next research was conducted as a first step in the development of a UWA-CSN clustering scheme to solve energy optimization problems: UWA-CSN multi-hop model, very prevalent in complex marine environments, introduces the motion of ocean current underwater sensor nodes. The model of the drifted node presented here is based on [41].

Inspired by the mobile data collection system for clusters [34], we proposed a UWA-CSN energy optimization clustering algorithm (EOCA). For each underground sensor node, we look for several factors, including number of adjacent nodes, residual energy and distance from the sink node in the proposed CH node selection process. Each cluster also developed the clustering algorithm with the cooperative mode of transmission in mind, because the cooperative strategy was designed to achieve a cooperative profit while energy consumption was reduced in each cluster. Our past work in the Taiwan Strait[37] has demonstrated the feasibility and benefits of an underwater acoustic cooperative strategy and has well recognized and adopted a cooperative underwater communication strategy[42][43].

We use the arctangent function for each sub-water node to create a waste energy-based maximum effective communications range (reE-MECR), which can adapt to each unconnected sensor to the appropriate maximum effective communication range (MECR). This system uses less energy than the current MECR [34] scheme. The presentation of the planned EOCA scheme be compare to open clustering algorithm, as well as the effects of network reporting area also number of underwater sensor nodes scheduled the projected scheme presentation.

The relax be divided interested in the subsequent section. Section II presents the associated UWA-SN clustering algorithm. Section III presents related models throughout this paper. Section IV presents the EOCA multi-hop scheme UWA-CSN. Section V presents simulation outcomes. in conclusion, segment VI conclude.

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II. RELATED WORK

In recent years, the network of underwater wireless sensors has made significant progress in developing advanced hardware and effective communication protocols, drawing attention to an increasing number of researchers [1]. Further over, the number of studies involving submarine wireless sensor networks is increasing gradually as a result of the increase in a wide range of applications, such as environmental monitoring, pollution control, catastrophic prediction and military activities[2][3][4]. Several underwater wireless networking applications were developed, including the U.S. Seaweb underwater acoustic network [5] and the Canadian underwater acoustic network NEPTUNE[6]. PLUSNet uses an underwater acoustic communication network to demonstrate multi-sensor and multi-vehicle warfare (ASW) by the United States Naval Research Office (ASW).

The strong attenuation caused by the propagating medium is affecting the wave signal in the underwater environment. Fortunately, we can ensure reliable long-distance data transmission with the acoustic wave [8]. However, because of the high complexity of the underwater environment and the slow spread of the underwater acoustic wave, there are still several issues to address, such as the limited frequency range, long communication delays, etc. In addition, energy costs are high in order to maintain good communication performance for UWA-SNs (UWA-SN). In practise, however, the energy supply of underwater sensor nodes is limited and difficult to charge or replace, which requires significant staff and money[9][10]. UWA-CSN networks are using cooperative communication technology to increase the reliability of communication and support relay nodes for end-to-end long-distance communication [11]. UWA-CSN multi-hops need reasonable network topology to solve data transmission collisions and load balance problems. Some studies have shown that clustering technologies can improve performance and energy consumption of UWA Communication SN [12],[13][14]. The underwater sensor nodes of a network are divided into various sub-sets of clusters that are almost independent. Before transmitting CH nodes to the sink node or base station, the cluster head node (CH) is collected and combined with data in each cluster. The UWA-CSN multi-hop clustering algorithm was to our knowledge not a great deal of research. Optimizing energy use is one of the best ways to expand the UWA life of CSN. As a result, clustering technology is considered, as shown by previous work, to achieve energy optimization for UWA-CSN multi-hops.

III. DESCRIPTION OF RELATED MODELS

A. REPRESENTATION OF MULTI-HOP UNDERWATER SUPPORTIVE NETWORKS

This section covers multi-hop UWA and CSN. The UWA-CSN multi-shop used in the shallow sea is the subject of this paper, as shown in Fig. 1, where a large number of submarine sensor nodes are deploy to monitor the underwater environment and marine life. Each underwater sensor node and sink node communicates via the AUV. Figure 1. The multi-hop UWA-CSN is clustered as shown in Figure 1. CH nodes are represented by yellow subsea sensor nodes and other nCH nodes send their data directly or cooperatively to matching CH nodes. As shown in Fig. 1, S10 sends data directly to S4, and S11 sends data cooperatively to S4. A prior paper [37] provides details on the cooperative transmission model "S11-S4-S12." The AUV must then communicate with all nodes to collect data from all underwater nodes, but simply to correspond with CH nodes. This can help reduce data exchange between system components.

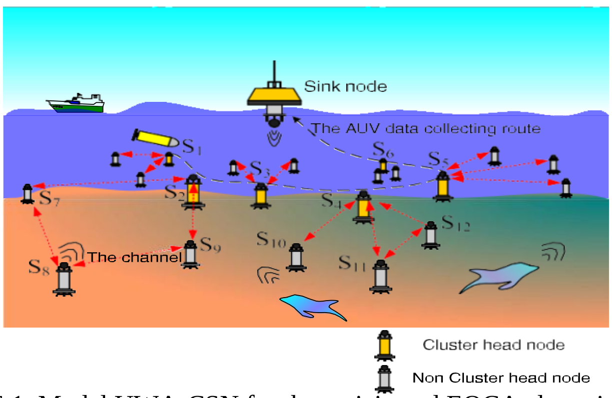

FIGURE 1. Model UWA-CSN for the anticipated EOCA clustering system.

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IV. PROPOSED OPTIMIZATION CLUSTERING SYSTEM

A. THE OPTIMIZATION CLUSTERING ALGORITHM

Designed for the multi-hop model UWA-CSN discussed in Section III, we suggest an enhanced circulated system called EOCA based on CMDG algorithm [34]. EOCA's proposed UWA-CSN clustering structure is decentralized, with only neighboring nodes per node underwater. This prevents the central controller from sending many global updates that would consume a lot of energy. Data collisions and long network delays complicate the situation, which cluster distribution can alleviate. Moreover, unlike a centralised clustering approach, the distributed clustering approach does not require the exact sites and locations of each submarine node to avoid localization problems in each submarine sensor node.

The CH node selects clustering algorithms. CH node selection design affects system communication performance, load on each underwater sensor node, and even network topology stability. In the clustering algorithm, each subwater sensor node counts the number of neighboring nodes within d, the number of d-hop-based nCH nodes. Each location selects the highest d-hop-based nCH node potential. It means that the CH node becomes more likely if it can connect to more neighboring nodes within its effective communication range. Assuming N subsea sensor nodes can connect to neighboring nicknames I1, 2,.–, N) within their effective communication range, the subsea sensor coverage can be calculated as follows:

$$\rho_i = \frac{n_i}{N}$$

The higher the coverage ratio, the more likely it becomes CH (13). CMDG's disadvantage is that only the number of neighboring nodes is considered when choosing the CH node, and the submarine sensor node by means of the highest coverage ratio is forever chosen. However, due to data aggregation and relay operations, the CH node consumes more energy, resulting in premature death of subsequent sensor nodes with the UWA-CSN multi-highest shop's detection ratio and energy hole.

In the initial stage, we establish a uniform maximum communication hops d for each subwater sensor node, and each subwater sensor node must obtain related information from adjacent nodes, including hops and distances between each adjacent node and itself. If the same hops have more than two CH nodes, nCH nodes choose the shortest cluster distance. Every underwater node has a unique identifier.

The sink node sends each subwater sensor node a short time packet during the broadcast phase. All underwater nodes can receive this package. Consequently, each node can calculate its distance from the sink node through multiplying the transfer interruption:

$$l_{i,0} = vT_{i,0}$$

During the CH node collection phase, each underwater sensor node resolve struggle by way of its neighbors. In addition to the impending quantity of d-hop-based nCH nodes, we regard as the residual energy and communication expanse in each UWA-CSN multi-hop sensor node to achieve load balance and energy optimization. Each node calculates I = 1, 2, 3 and N) as follows: If any subsequent sensor knod's residual energy is Ri 1, 2, 3, N) and the unit is J and the transmission distance from each node to the sink is li,0 I 1, 2, 3, N) and each subsequent sensor kilometre is kilometre long, each node calculates the time of the subsequent sensor ti I = 1, 2, 3 and N) as follows:

$$t_i = \frac{\eta}{R_i} + \beta l_{i,0} + \gamma[(d_m - m_i)(DP/d_m)] \pm \lambda$$

An underwater sensor node may incessantly receive also store in sequence commencing its neighboring nodes until the timer expires, including its actual quantity of nCH nodes based on d-hop values, ID numbers and initial transmission times. If the number of hops di between a Si submarine node and a neighbouring Sn node with more nCH node potential is lower than the maximum hops of communication, the Si node transmits the Sn node. The Si node would also act as a cooperative node in the same communication cluster as the CH node. When an underwater sensor node does not receive information until its delay timer expires, it transforms into a CH node and notifies its neighbours, while other nodes transform into nCH nodes and receive and store CH nodes. Furthermore, nCH nodes will send information to these CH nodes about their own potential number of d-hop-based nCH nodes. The nCH node compares the CH node's d-hop to its local d-hop, and transmits CH node information if the CH node's d-hop exceeds the nCH node's local d-hop.

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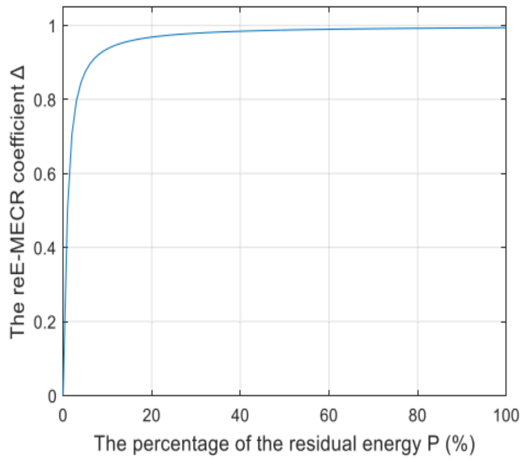
B. THE ENERGY OPTIMIZATION USED FOR UNDERWATER SENSOR NODES

In the majority associated studies, the effectual announcement variety of each sub water node is currently deposit to a steady worth and won't modify throughout process. This assumption is useful when all UWA-CSN sensor nodes have the best energy and transmission. However, some underwater sensor nodes fail due to constant energy consumption as the system runs. The low-energy underwater sensor node will die prematurely if there is still a large effective communication range, resulting in the UWA-CSN multi-hop energy pier. Maintaining a continuously effective communication range becomes difficult when a node falls below a certain threshold.

To address these concerns, this paper proposes an energy optimization underwater sensor node. The projected mechanism aims toward create a suitable reE-MECR meaning allowing incorporated MECR control meant for each submarine node. On top of the one hand, if underwater sensor node residual energy is sufficient, it can maintain long, effective communication range. On the other hand, the underwater sensor node motivation adaptively reduce its MECR if its own residual energy falls below a threshold, which reduces also helps extend the underwater sensor node's lifetime.
To create reE-MECR based on the above concept, we use arctangent. Specifics of the function are: If the underwater sensor node's initial MECR is Rm, its initial energy is E0, and ts residual energy becomes E, it can be calculated as follows:



20 40 60

FIGURE 2. The highest effective communication range coefficient curve versus the residual energy percentage of the subsequent sensor node

IV. SIMULATION

A. THE RELATED PARAMETERS

Begin by overcoming UWA-CSN functionality. Cooperative UWA-CSN nodes can help transmit data to other nodes. When a cooperative gain is made, the recipient can receive sender and node signals. Longer distances of transmission, reliable communication. UWA-CSN and UWA-SN are the main differences. UWA-CSN has done past investigations. Jae et al. automatically asked for an efficient and cooperative performance improvement system[15]. We proposed a protocol for node cooperation, which looks at the efficiency of the various data collection routes[16]. The autonomous routing protocol[17] was developed by Yen-Da et al. to improve overall delays and package delivery.

The next section focuses on related UWA-SN research as there are no UWA-CSN clustering studies. LEACH, HEED, GAF, and other terrestrial wireless cluster algorithms demonstrated excellent performance in collision reduction and performance improvement[18]. [19],[20], [20]. [20]. Communication.delay in UWA-SN is however relatively long, and the submarine nodes have finite energy. Worse, it's difficult to find nodes underwater. The above clustering algorithms do not apply directly to UWA-SN for terrestrial wireless communication. A reliable and efficient algorithm of UWA-SN clustering is essential. Sundarameena and colleagues suggested the clustering algorithm for 3D grid structures[21], splitting up the whole network into several grids, and selecting the CH nodes through a regular dormant wake mechanism whereby the nCH nodes connect with the CH nodes through CH node transmission, which results in the

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clustering framework of the UWA. - In [14] Liu et al. proposed the GAF (BGAF) algorithm to solve an energy hole problem caused by CH nodes, which constantly transmits data in the selection process taking into consideration the residual power of each node, to ensure the GAF algorithm is suitable to the underwater environment. Zhang et al. developed an improved clustering algorithm based on the K-median algorithm to overcome the disadvantages of the original algorithm, such as cluster structure instability, high energy consumption and computational complexity taking into account UWA-SN node density and node depth. Two improved LEACH algorithms were proposed in [23] and [24] to resolve the major problem in terrestrial wireless network randomness and data transmission. The former reduce random selection of CH nodes by reducing the number of updated nodes in the status update and marking nodes before becoming CH nodes. The second method solves the transmission problem by creating a slot table for each CH node, thus preventing each nCH node receiving multiple transmission messages at the same time. In order to improve daily survival and delay performance[25], Wang et al. proposed the 3D mesh-based cluster algorithm. In order to prevent data loss, Bandita et al. have introduced a cluster head supporting each cluster[26]. Robert et al. suggested the whisper-inspired clustering algorithm in order to improve network life by reducing unnecessary overhead. UWA-SN security clustering protocol[28] has been developed by Yang et al. In practise, the submarine sensor node movement caused by ocean current is ignored, focusing mainly on the non-cooperative acoustic sensor network.

The UWA-SN clustering algorithm is then used in various energy optimization studies. Vani et al. proposed geographical use of the clustering process[29] to establish the UWA cluster structure for the SN and to use the optimization of fluorescent logic and particulate swarm, respectively in the clustering process and the selection process for the CH node. The method proposed outperformed other methods of energy optimization, based on results. However, it is extremely difficult to obtain accurate location information underwater. Ahmed et al. suggested controlling the redundant transmission and energy savings system using the region node and CH node[30]. Research also considered the movement of ocean currents' underwater nodes. As an optimization particles swarm algorithm, Li et al. developed an improved cluster algorithm that reduces network energy consumption and increases network durability[31]. Wang et al.[32] proposed a soft-defined network-based clustering mechanism for selecting CH nodes based on the energy threshold information that is transmitted between subsequent nodes. Wan et al. established an energetic clustering algorithm in[33]. They considered several factors in this algorithm, including the residual energy and transmission loss of each node, and suggested calculating the efficient communication range of each node based on its residual energy and base station distance. The above studies only take into account single-hop transmission between CH and nCH nodes. Ghoreyshi et al.[34] proposed a mobile data collection (CMDG) multi-hop cluster in which the UWA SN structure is built by reducing each packet's hops of transmission and selection of CH nodes based on the number of neighbouring underwater nodes. Compared to the Autonomous Underwater Vehicle (AUV), the proposed system achieves better communication performance and less energy consumption compared to the AUV (AEERP)[35] and AUV visit-path nodes (AUV PN)[36]. Note that UWA-SN is not mentioned as a cooperative technology source in any of these studies.

B. THE PRESENTATION COMPARISON INVOLVING AND THE ACCESSIBLE SYSTEM

Compared to the current CMDG in this section, the proposed EOCA system includes system dynamics over time. Figure 7 depicts system residual energy performance as operating time. We can see that the energy consumption rates of both systems are initially similar, but the EOCA scheme's energy consumption rate is gradually decreasing compared to the CMDG scheme. Because the MECR underwater sensor node is dynamic in EOCA, while the CMDG is fixed. Underwater node energy consumption is more efficient than CMDG in the EOCA system. Considering only the potential large number of d-hop-based nCH nodes during the selection phase of the CMDG node, the underwater sensor node with the largest potential number of d-hop-based nCH nodes is frequently selected as the CH node, resulting in higher energy consumption than other nodes. This is the UWA-CSN energy gap. Since EOCA effectively avoids the energy hole issue, the proposed EOCA scheme gradually surpasses the current CMDG scheme.

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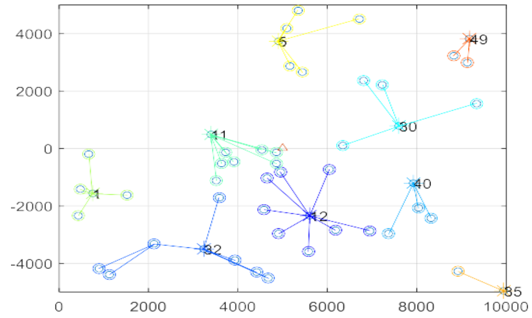

FIGURE 3. CMDG scheme network clustering result.

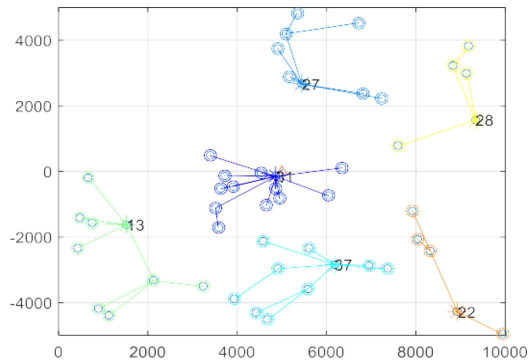

FIGURE 4. The network clustering consequence of the anticipated EOCA scheme.

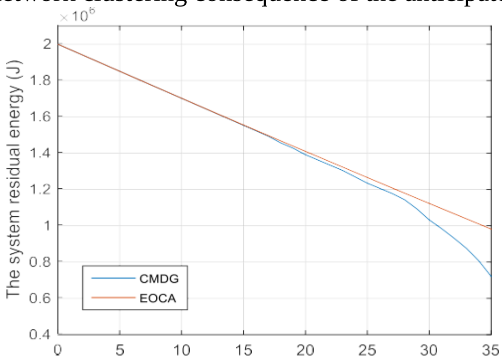

FIGURE 5. The residual energy system changes with runtime.

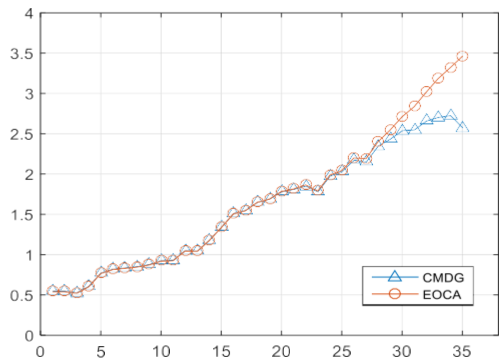

FIGURE 6. The residual energy system changes with runtime.

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Package delivery ratio is the proportion of packages successfully received by all underwater sensor nodes to total transmission packages. Figure 9 shows that the EOCA package delivery performance ratio is comparable to CMDG, both achieving a package delivery ratio of around 90%. UWA-CSN multi-hops can achieve good communication performance by implementing EOCA. Fig. 6 shows results of UWA-network-life CSN for both schemes. The first underwater sinnode is produced in CSN UWA's lifetime network. Fig. 7, with the average red line, shows the lifetime of CSN's UWA network using the EOCA scheme in each round. The blue line displays the average value, while the circular marker displays CMDG adoption effect. Clearly, the proposed EOCA scheme extends UWA-multi-hop CSN's network life over the current CMDG case, demonstrating the effectiveness of EOCA in extending UWA-multi-hop CSN's network life.

Figure 5 shows the UWA-CSN multi-hop supply relationship of underground sensor nodes. As the number of sub-water sensor nodes for both clustering schemes increases, the UWA-C SSN multi-hop delivery rate will gradually increase, while the network coverage area remains unchanged. Using the proposed EOCA system, multi-hop UWA-CSN can also achieve a higher packaging delivery ratio if the number of submarine nodes exceeds 110. Due to the proposed EOCA scheme, the UWA-CSN multi-hop package delivery rate will improve, and this performance will improve as the number of underwater sensor nodes grows.

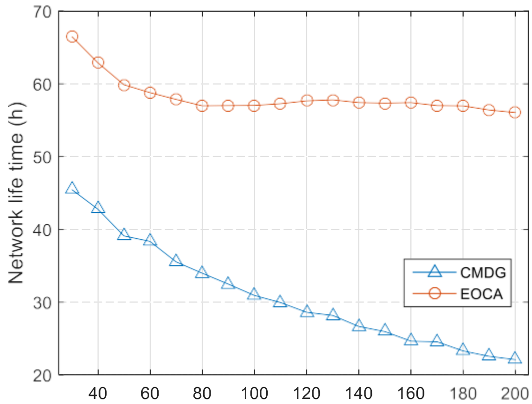

FIGURE 7. UWA-CSN multi-hop lifetime changes with the total number of underwater sensor nodes.

IV. CONCLUSION

We propose a UWA-CSN multi-shop EOCA scheme based on the CMDG scheme and providing better energy optimization clustering. The EOCA scheme considered several factors in the selection of CH nodes, including the number of nearby nodes, residual energy and the distance from the sink node at each underwater node. We also create a mechanism for optimising CH node selection reE-MECR energy with arctane to create a consistent link between the residual energies of every submarine sensor node. We will also consider node mobility underwater, by including the MCM model in the proposed energy optimisation clustering scheme. The results of a simulation demonstrate that the system can efficiently extend its life by using the proposed Energy Optimization Cluster of UWA-CSN and achieve a high delivery ratio of packages.

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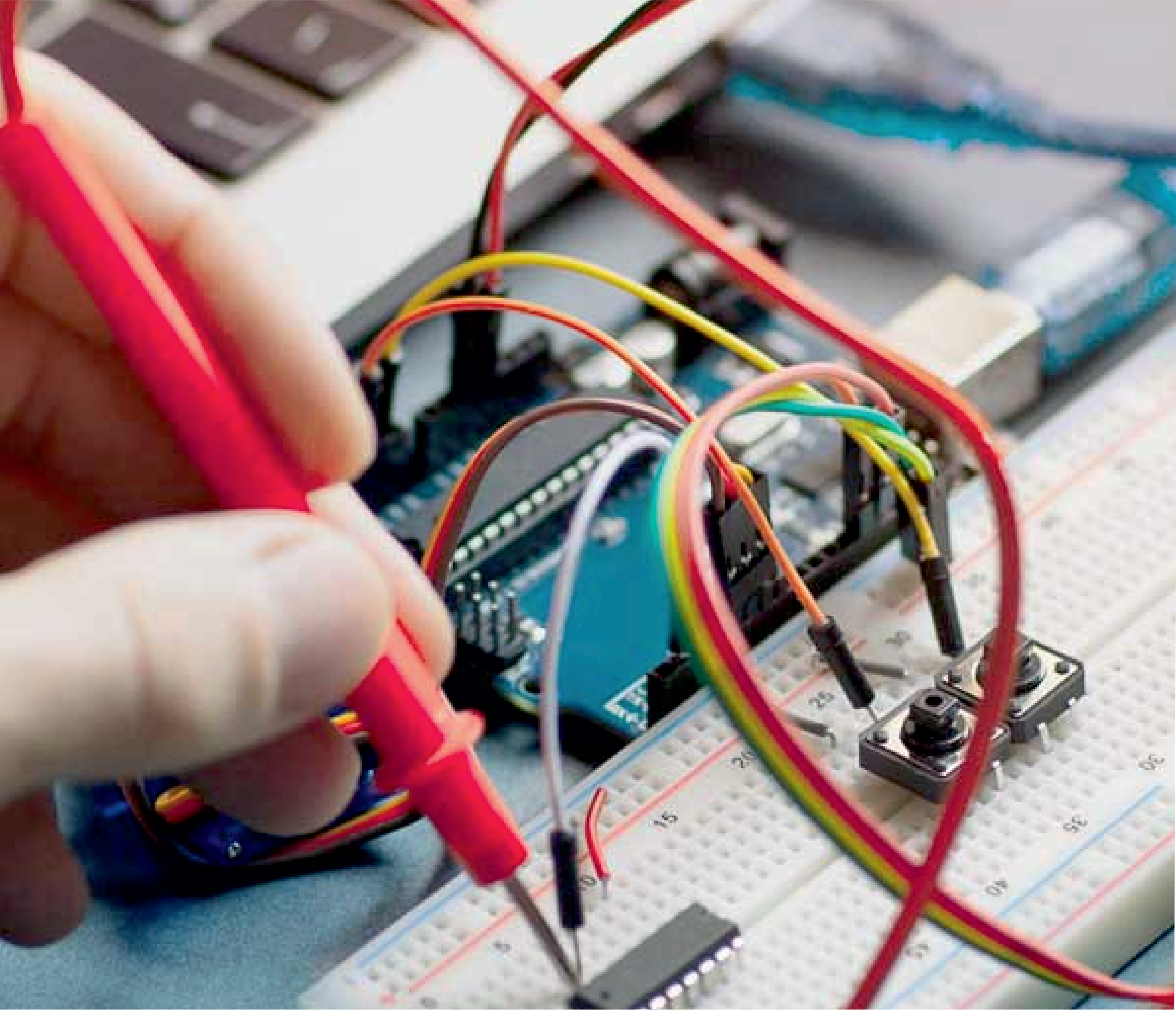

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