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Soil Nutrition Analysis with Modified Multi-drop HART Protocol in Internet of Things

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ABSTRACT:-The Internet of Things (IoT), the idea of getting real-world objects connected with each other, will change the way users organize, obtain and consume information radically. Internet of Things (IoT) enables various applications (crop growth monitoring and selection, irrigation decision support, etc.) in Digital Agriculture domain. Wireless highway addressable remote transducer (HART) is modern network protocols in wireless sensor networks (WSNs) which system of multiple small sensors (nodes), limited energy sources, used to sense any given sensing region (environment) of interest. Nodes in HARTs are provided with low power and are employed in a hazardous environment where replacement of the battery or any fault evaluation in the sensor network is impossible. With the help of this approach which provides real-time information about the lands and crops that will help farmers make right decisions.

KEYWORDS:-Internet of Things, Wireless Sensor Network, Highway Addressable Remote Transducer (HART)

I. INTRODUCTION

Soil is the main source of nutrients for crops. Soil also provides support for plant growth in various ways. Knowledge about soil health and its maintenance is critical to sustaining crop productivity. The health of soils can be assessed by the quality and stand of the crops grown on them. However, this is a general assessment made by the farmers. A scientific assessment is possible through detailed physical, chemical and biological analysis of the soils. Essential plant nutrients such as N, P, K, Ca, Mg and S are called macronutrients, while Fe, Zn, Cu, Mo, Mn, B and Cl are called micronutrients. It is necessary to assess the capacity of a soil to supply nutrients in order to supply the remaining amounts of needed plant nutrients (total crop requirement - soil supply). Thus, soil testing laboratories are considered nerve centres for nutrient management and crop production systems.

Soils may have large amounts of nutrient reserves in them. All or a part of these reserves may not be of any use to crops because they may not be in plant-available form. For the purpose of estimation or analysis of plant-available soil nutrients, such methods are to be used that have been tested/verified for the correlation of nutrients extracted and their plant availability. This guide describes internationally accepted and widely used methods. Apart from nutrients, soil pH estimation is also critical in the assessment of soil health. Generally, plants prefer soils that are close to either side of neutrality. However, there are acid-loving crops and also crops that can withstand high soil alkalinity. Hence, good crop yields are possible in acid and alkali soils. With proper amendments, still higher yields can be obtained in acid and alkali soils. Soil pH also has a considerable influence on the activity of soil microflora and on the availability of soil nutrients to crops. It is also important to estimate physical properties such as soil texture and soil structure.

The methods and procedures for obtaining soil samples vary according to the purpose of the sampling. Analysis of soil samples may be needed for engineering and agricultural purposes. This guide describes soil sampling for agricultural purposes, i.e. for soil fertility evaluation and fertilizer recommendations for crops.
Information is the sign and key of agricultural modernization. Agricultural information can significantly change small scale of agricultural production, great temporal and spatial variation, low scale merit and other industrial weakness. Moreover, it plays an important role in the development of agriculture and the full realization of a well-off society [1, 2]. The Internet of Things (IoT) is defined as things connected to things in the Internet [3]. The agricultural Internet of

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Things is a new trend in world agricultural development, a new type of agriculture which combines the Internet of Things and agricultural production [4]. It will bring agriculture into the digital information age. Agricultural Internet of Things is able to implement digital design, intelligent control, precise operation and scientific management for various agricultural elements. So it achieves a comprehensive perception, reliable transmission and intelligent processing, and ultimately achieves high yield, high efficiency, high quality, ecological and safety purposes [5].
The emergence of wireless sensor, data fusion and internet technology, can achieve the remote automatic monitoring on the citrus water, nutrient and temperature of growth environment. And through the model analysis and data processing, expert decision-making system can give effective measures of citrus management. Practice has proved that single-point multi-layer detection technology can effectively expand the detection range of citrus growth environment, and it is helpful to construct a more accurate expert knowledge base. At the same time, the system can effectively guide fruit growers to scientific management of citrus orchards and significantly improve the yield of citrus.

II. LITERATURE REVIEW

Pornchai Pongpipatpakdee et al. [1], Wire HART field device is connected to Wireless HART adapter (THUM) and Wireless HART device are assigned act as RTU(Remote Terminal Unit) in SCADA system. In system, THUM and Wireless HART device communicate to Wireless HART gateway that collects their data and send to master station with Modbus/TCP.
The paper presents the practices to install and configure the THUM with control valve wire HART device, Wireless HART transmitter, tags assignment, and so on that focus for HART parameters mapping in order to device operation and management.

Shylaja S.N. et al. [2], the agricultural yield primarily depends on soil fertility, the moisture level of soil and use of appropriate fertilisers. In the current scenario, the manual method of measuring the soil nutrients is less accurate because of the time difference of soil sample collected at the field and when it is measured in a laboratory. It becomes necessary to create a smarter agriculture practice through Internet of Things(IoT) to address this challenge. Soil nutrient analysis using wireless sensor networks (WSN) enables various application like remote monitoring of soil fertility, analysis, provide a selection of crop and build irrigation decision support systems.

Mo Sha et al. [3], Wireless sensor-actuator networks (WSANs) offer an appealing communication technology for process automation applications to incorporate the Internet of Things (IoT). In contrast to other IoT applications, process automation poses unique challenges for industrial WSAN due to its critical demands on reliable and real-time communication. While industrial WSANs have received increasing attention in the research community recently, most published results to date have focused on the theoretical aspects and were evaluated based on simulations.

F B· et al. [4], Internet of things (lOT) of agriculture is urgent to be developed to support precision agriculture. The lOT system in agriculture mainly consists of three layers, e.g., perception, transportation and application. In this paper, we researched and developed a set of agricultural Internet system with expert guidance. Specifically, we investigated the key sensors in the perception layer, the application mode of Bluetooth and 4G in the transportation layer, and an intelligent algorithm and an application framework for the application layer.

III. HART PROTOCOL

Wireless HART is the latest release of Highway Addressable Remote Transducer (HART) Protocol HART standard was developed for networked smart field devices.The wireless protocol makes the implementation of HART cheaper and easier.HART encompasses the most number of field devices incorporated in any field network.Wireless HART enables device placements more accessible and cheaper– such as the top of a reaction tank, inside a pipe, or at widely separated warehouses.Main difference between wired and unwired versions is in the physical, data link and network layers.Wired HART lacks a network layer.

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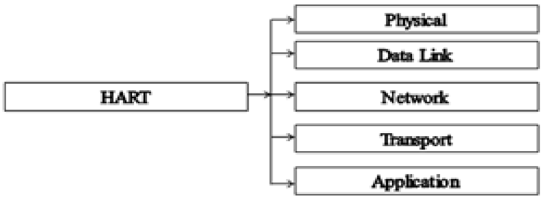

Figure 1: Protocol Layer

Physical Layer

- It operates only in the 2.4 GHz ISM band.
- Employs and exploits 15 channels of the band to increase reliability.

Data Link Layer

- Collision free and deterministic communication achieved by means of super-frames and TDMA.
- Super-frames consist of grouped 10ms wide timeslots.
- Super-frames control the timing of transmission to ensure collision free and reliable communication.
- This layer incorporates channel hopping and channel blacklisting to increase reliability and security.
- Channel blacklisting identifies channels consistently affected by interference and removes them from use.

Network & Transport Layers

- Cooperatively handle various types of traffic, routing, session creation, and security.
- Wireless HART relies on Mesh networking for its communication, and each device is primed to forward packets from every other devices.
- Each device is armed with an updated network graph (i.e., updated topology) to handle routing.
- Network layer (HART)=Network + Transport + Session layers (OSI)

Application Layer

- Handles communication between gateways and devices via a series of command and response messages.
- Responsible for extracting commands from a message, executing it and generating responses.
- This layer is seamless and does not differentiate between wireless and wired versions of HART.

IV. HART PROTOCOL

Wireless HART is a datalink protocol that operates on the top of IEEE 802.15.4 PHY and adopts Time Division Multiple Access (TDMA) in its MAC. It is a secure and reliable MAC protocol that uses advanced encryption to encrypt the messages and calculate the integrity in order to offer reliability. The architecture, as shown in Figure 2 consists of a network manager, a security manager, a gateway to connect the wireless network to the wired networks, wireless devices as field devices, access points, routers and adapters. The standard offers end-to-end, per-hop or peer-to- peer security mechanisms. End to end security mechanisms enforce security from sources to destinations while per-hop mechanisms secure it to next hop only.

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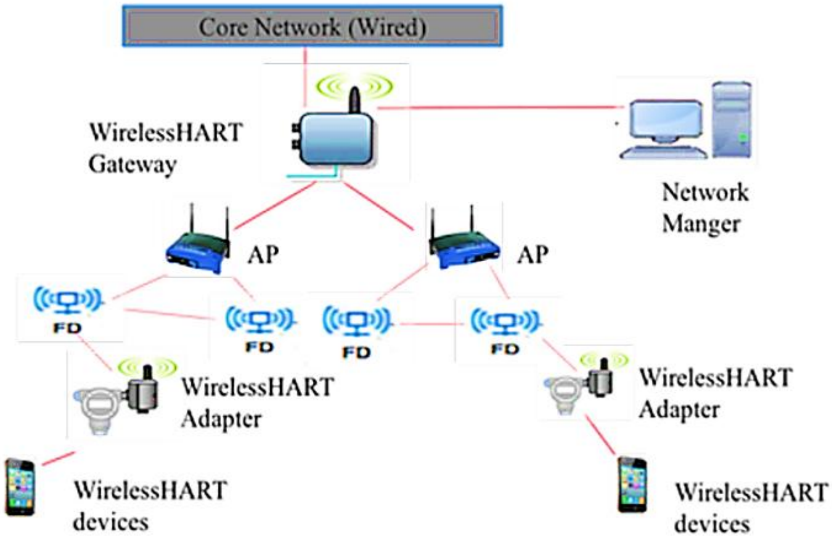
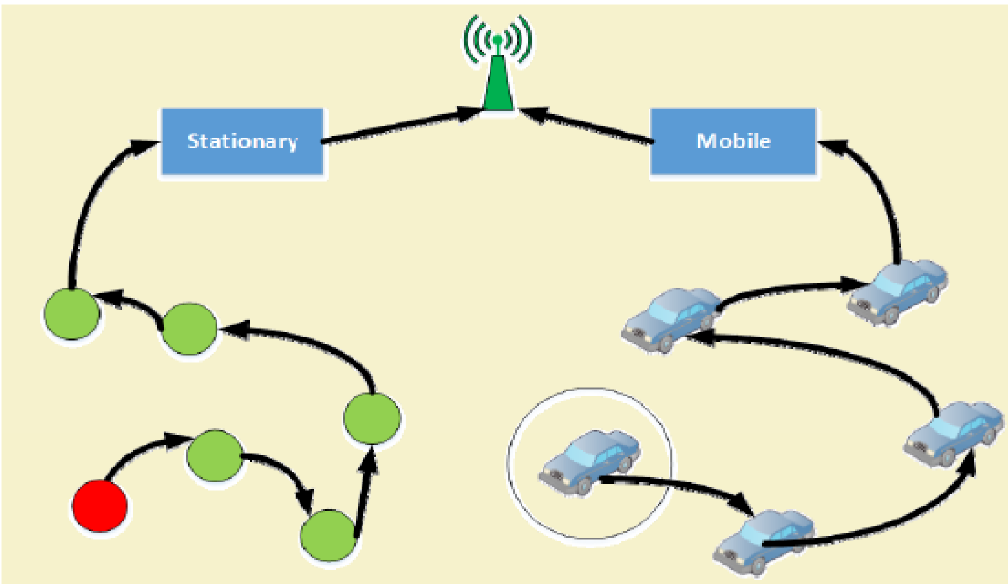


Figure 2: Wireless HART Architecture

Consists of a large number of sensor nodes, densely deployed over an area is present.Sensor nodes are capable of collaborating with one another and measuring the condition of their surrounding environments (i.e. Light, temperature, sound, vibration). The sensed measurements are then transformed into digital signals and processed to reveal some properties of the phenomena around sensors. Due to the fact that the sensor nodes in WSNs have short radio transmission range, intermediate nodes act as relay nodes to transmit data towards the sink node using a multi-hop path.



Algorithm:-

The symbol in the algorithm: Node[n](n=1~n), represents the network node in wireless HART. Node [1] is the network AP. Node [2]~Node[n] express field device.

Step1: For the routing of node [2], the first path and the second one simultaneously point to the gateway, then n is equal to n+1;

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Step2: The hierarchy algorithm of node [n] is used to calculate the layer of node[n];

Step3: If node[n] is on the first layer, the first path points to the gateway and the link quality weight of the neighbor table of the node that is earlier to join network is calculated. Then the 2nd path points to biggest weight neighbor then it is switched to step 6. Otherwise, the upper node in neighbor table is put into the array and the next step is the step 4.

Step4: Sort node in the array according to the link quality.

Step5: The path whose link quality weight is the biggest is selected as the first path by the node. The second biggest weight one is the 2nd path.

Step6: n=n+1 and if n is a new node, you have to switch to step2. Otherwise it goes to the exit.

Algorithm Verification

In order to verify the effectiveness of the algorithm, the wireless HART network in figure 3 is selected as an example. Node 1 is AP and 2 to 11 represent field devices. The graph shown in figure 3 is acquired by the application of the hierarchy algorithm. The graph routings from node 2 to node 11 are obtained respectively by the application of the algorithm proposed. In the paper the graph routing for node 2, 3, 7 and 11 is taken as an example.

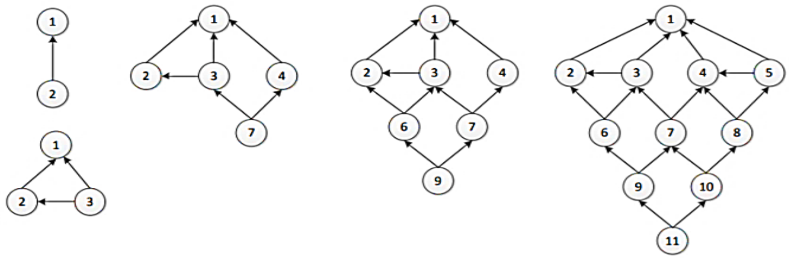

Figure 3: Routing in Wireless Hart Routing

V. SIMUALTION PARAMETER

Throughput (Kbps) analysis: To gauge the convention execution, throughput fills in as the better parameter. The throughput is characterized as the proportion of number of bundles got to the quantity of parcels transmitted and it is in a roundabout way corresponding to the overhead. The throughput is figured by utilizing the condition 1.

$$Throughput = \frac{x \times 8}{t \times 100} Kbps$$

Where x is number of bytes received and t is simulation time

Analysis of Packet Delivery Ratio (PDR):- To find the efficiency of the protocols, PDR is one of theimportant qualitative metrics. It is defined as the ratio ofdata packets received and packet sent, it is calculate as follows

$$PDR = \frac{x}{y} \times 100$$

Where x is the total number of packets received and y is the total number of packets sent at end of the simulation time.

Delay: - The ratio of the total delay of each data packet to total data packet received for wireless sensor network.

$$Delay = \frac{Total\ Delay\ of\ Each\ Data\ Packet}{Total\ Data\ Packet\ Received} \times 100$$

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VI. SIMULATION RESULT

In this subsection we evaluate the performance dynamic cluster head selection using HART protocol in terms of:
Packet delivery ratio (PDR): The proportion of successful data packets delivered to the destination compared to the total generated data packets.

Table 1: Comparison Result of Previous and Proposed Algorithm for Throughput

Throughput (Kbps)			
Number of Node	Previous Algorithm	Proposed Algorithm	% Improvement of Previous Algorithm
8	1280.00	2133.33	39.99%
10	1163.63	1882.35	38.18%
12	1066.66	1600.00	33.33%
14	914.28	1422.22	35.71%
16	800.00	1280.00	40.00%
18	752.94	1280.00	41.17%
20	673.68	1066.66	36.84%
22	533.33	914.28	41.66%

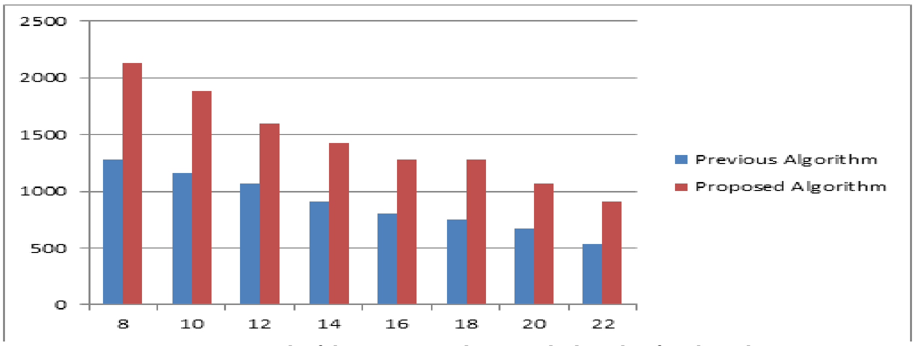

Figure 4: Bar Graph of the Previous and Proposed Algorithm for Throughput

Table 2: Comparison Result of Previous and Proposed Algorithm for Packet Delivery Ratio

Packet Delivery Ratio (%)			
Number of Node	Previous Algorithm	Proposed Algorithm	% Improvement of Previous Algorithm
8	96.8%	98.7%	1.9%
10	95.9%	98.3%	2.4%
12	96.7%	98.1%	1.4%
14	96.0%	98.0%	2.0%
16	96.0%	97.9%	1.9%
18	95.5%	97.6%	2.1%
20	95.4%	97.4%	2.0%
22	95.1%	97.2%	2.1%

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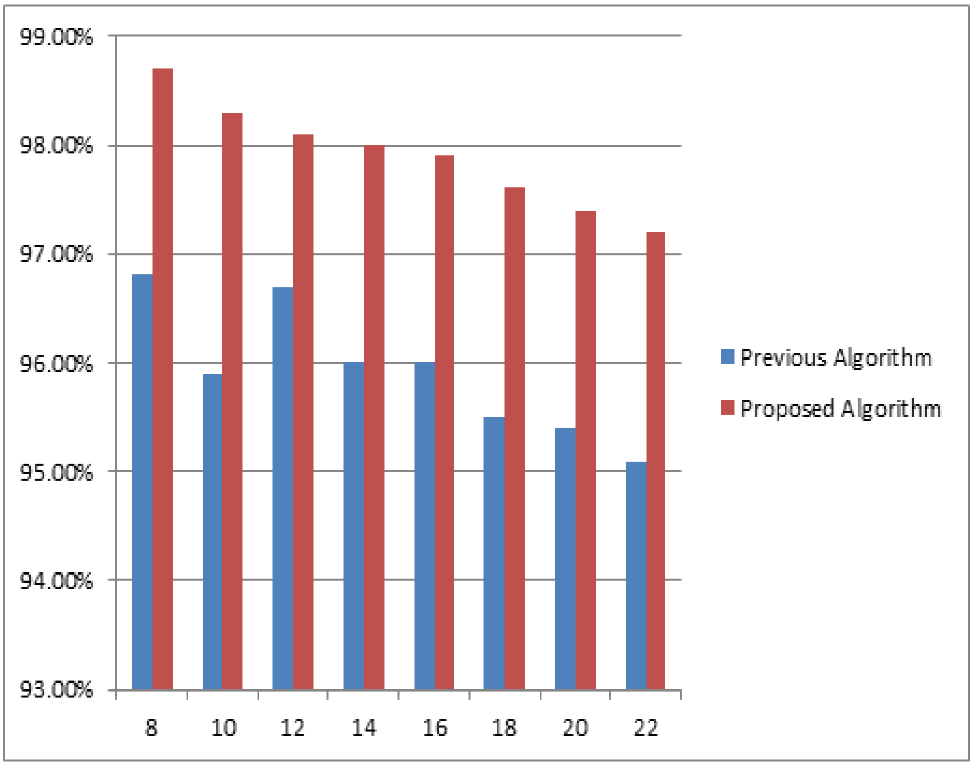

Figure 5: Bar Graph of the Previous and Proposed Algorithm for Packet Delivery Ratio

Table 3: Comparison Result of Previous and Proposed Algorithm for Delay

Delay (Sec)			
Number of Node	Previous Algorithm	Proposed Algorithm	% Improvement of Previous Algorithm
8	0.0005	0.0003	40.00%
10	0.00055	0.00034	38.18%
12	0.0006	0.0004	33.33%
14	0.0007	0.00045	35.71%
16	0.0008	0.0005	37.50%
18	0.00085	0.0005	41.17%
20	0.00095	0.0006	36.84%
22	0.00120	0.0007	41.66%

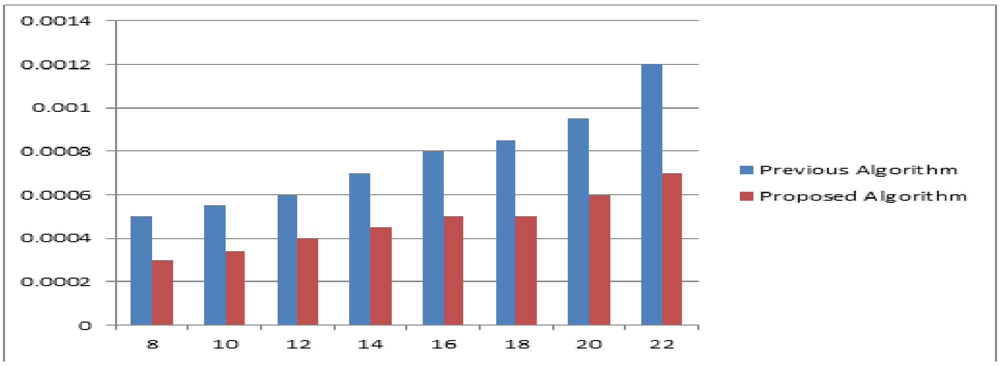

Figure 6: Bar Graph of the Previous and Proposed Algorithm for Delay

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VII. CONCLUSION

Farming will play vital role in next few years in country. Thus there is need of smart farming. Internet of Things will help to enhance smart farming. IoT works in different domains of farming to improve time efficiency, water management, crop monitoring, soil management, control of insecticides and pesticides etc. It also minimizes human efforts, simplifies techniques of farming and helps to gain smart farming. Along with these features smart farming can help to grow the market for farmer with single touch and minimum efforts.

The proposed algorithm gives a higher packet delivery ratio 98.7% for N=8 Sensor node as compared with 96.8% for previous algorithm. Similarly, proposed algorithm gives a higher packet delivery ratio for N=10, 12, 14, 16, 18, 20, 22 sensors node compared previous algorithm.

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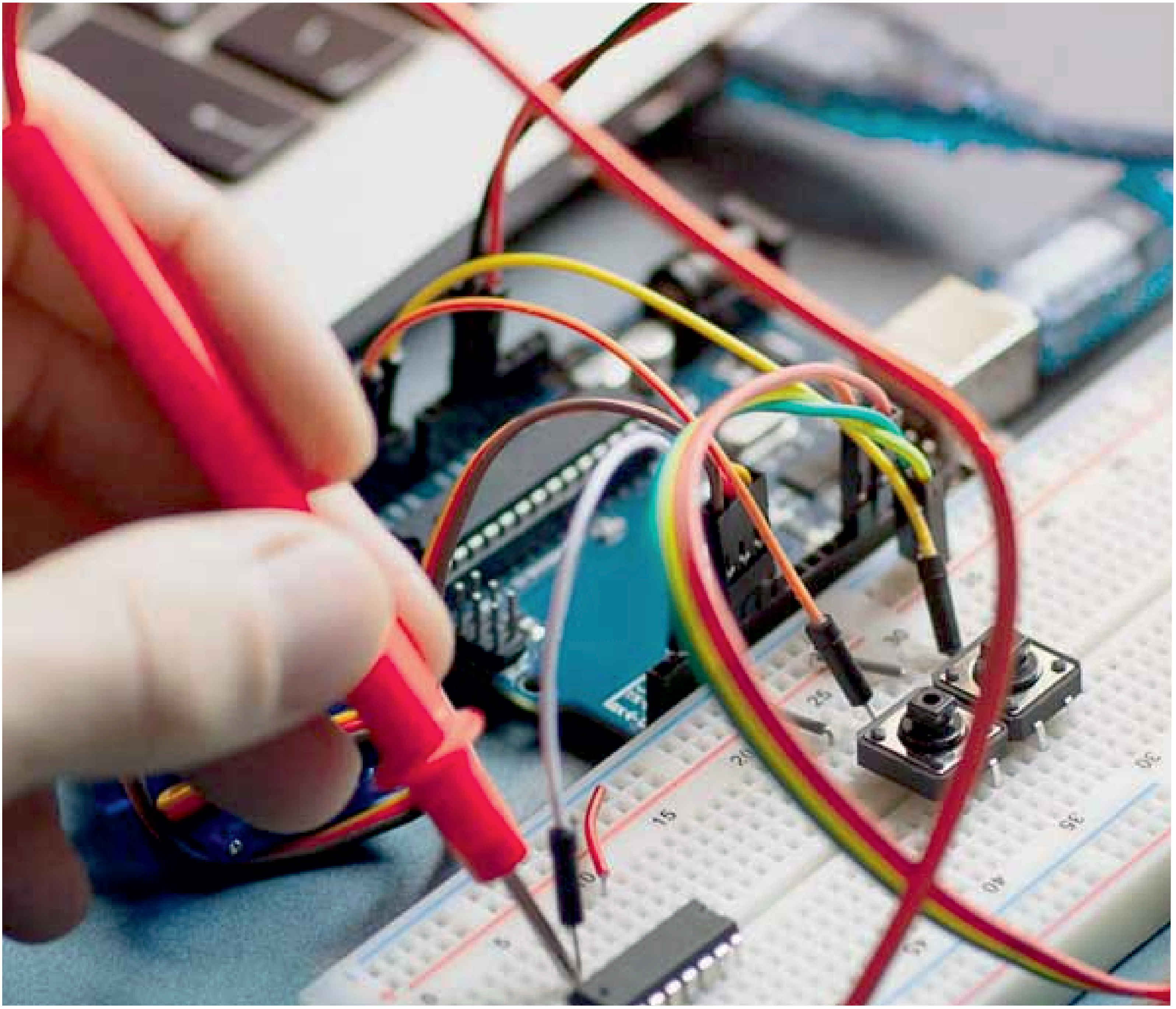

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