International Journal of Informatics and Communication Technology (IJ-ICT)
Vol. 12, No. 3, December 2023, pp. 293~299
ISSN: 2252-8776, DOI: 10.11591/ijict.v12i3.pp293-299

Quantum drones and the future of military warfare

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Article Info

Article history:

Received Feb 1, 2023
Revised Oct 2, 2023
Accepted Nov 10, 2023

Keywords:

Drone swarms
Internet of drones
Internet of quantum drones
Military warfare
Quantum well
Unmanned aerial vehicles
Wireless sensor networks

ABSTRACT

The advent of drones has significantly impacted military warfare, providing improved reconnaissance, surveillance, and target acquisition (RSTA), cost savings, increased convenience, safety, and flexibility. A layered network control architecture, known as the internet of drones (IoD), coordinates drone access to controlled airspace and offers navigation services. Various systems, including wireless sensor networks (WSN) and drones directed to an expanded controlling zone, integrate with IoD to improve connection performance. This paper provides an overview of the IoD and the internet of quantum drones (IoQD), highlighting key issues and potential solutions in applications and deployment. The IoQD provides primary features such as secure message exchange, fast communication processes, the viability of creating and deploying private IoQD, and enabling a new field of application, quantum well (QW). In conclusion, the advent of drone technology has significantly improved various aspects of military operations, including reconnaissance, surveillance, and target acquisition. The IoQD offers a promising solution for military networks, facilitating the safe and expedited transfer of data, ultimately benefiting the entire military network.

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1. INTRODUCTION

"Unmanned aerial vehicles (UAV)", more commonly known as "drones," are remotely operated and utilized in numerous sectors such as defense, commercial transportation, military operations, surveillance of the atmosphere, monitoring of architectural structures, and transportation [1]–[51]. Due to the ongoing enhancement of their affordability, they are extensively implemented in both the public and private sectors. Autonomous navigation in environments characterized by high intensity of change presents formidable obstacles for drones [34], [46], [52]. Aerospace and defense sectors initially produced drones with counterinsurgency and defense objectives in mind. In such conditions, these drones have demonstrated their utility. At present, drones find widespread application primarily within the military sector worldwide [53]–[56]. In addition to decoying targets, they are practical for an extensive range of purposes, including research and development. Moreover, software enhancing precision can be integrated into them.

Drones are an extraordinarily valuable asset on account of the plethora of applications in which they have demonstrated success. Drones possess the capability to be modified to serve a multitude of purposes, in addition to being an indispensable component of militaries [1], [5], [39], [49], [50], [57], [58]. Presently in operation with armed forces worldwide are a variety of drones belonging to the subsequent classifications [53], [54]:

- Presently, the fixed-wing drone stands as the most sophisticated and swiftest military drones in operation across the globe. Although designed to execute takeoffs and landings similarly to conventional aircraft, these unmanned aircraft derive their lift from wings as opposed to rotors.
- Comparable in durability to alternative drone types, single-rotor drones resemble helicopters in appearance. Although they might be more effective overall, they do require a greater amount of maintenance than other varieties of drones.
- The simplest option is a drone equipped with multiple rotors, which also provide the most accurate control over the camera's position and framing. As a consequence of this, they represent the most viable alternative in terms of conducting reconnaissance and surveillance.

This paper presents an overview of the literature on the internet of drones (IoD). It describes the primary applications that have been implemented in IoD systems in order to pique the interest of new researchers in the field. The primary critical issues discovered during the deployment and applications of the IoD are highlighted. This paper's information on IoD will help future academic research because it is unique in this burgeoning field. Finally, the impacts of IoD applications, deployments, and integration are discussed.

2. THE IMPACT OF DRONES ON MILITARY OPERATIONS

Despite their recent integration into the military-industrial complex, drones have already exerted a substantial influence on counterinsurgency and defense operations. While the concept of an drone is not entirely novel, the advantages it provides are immeasurable. The introduction of drone technology has resulted in numerous facets of military operations becoming more streamlined. Furthermore, the subsequent ways in which it will further transform the essence of military conflict are as follows [1], [5], [39], [49], [50], [53], [54], [57], [58]:

- Enhanced reconnaissance, surveillance, and target acquisition (RSTA) capabilities: Drones furnish real-time data regarding adversary movements, terrain, and target positions to ground commanders. In contrast to high-altitude aircraft, drones have the capability to capture images and videos at closer range while preserving their quality.
- Cost savings: Drones are less expensive to operate and maintain than traditional aircraft. Drones are unmanned, which reduces the possibility of pilot injuries in mid-flight.
- Increased convenience: Drones exhibit superior speed and ease of deployment in comparison to conventional aircraft. They are more user-friendly and necessitate less training compared to the majority of aircraft. In addition, a considerable number of drones do not necessitate a runway, while others can be conveniently stored within a backpack.
- Improved safety: Drone operators have the capability to deliver real-time data while minimizing personal risks. Additionally, this information provides commanders with guidance regarding the optimal placement of their troops in order to safeguard their well-being.
- Increased flexibility: Military troops must maintain constant readiness for any situation, regardless of the time. The military-industrial complex has developed technology that places a high emphasis on this requirement, with drones serving as a prime illustration. Drones have the capability to be fully automated as well.

Numerous military warfare firms are presently engaged in the advancement of drone technology with the aim of incorporating it into a wider range of military projects on a global scale. These entities provide a multitude of perks and advantages, rendering them well-suited for a diverse array of positions. Consequently, an increasing number of military units are contemplating the utilization of drones to enhance their combat and surveillance capabilities. The following are the most common functions of drones [1], [5], [39], [49], [50], [53], [54], [57], [58]:

- Reconnaissance: Drones have the capability to carry out surveillance missions by maintaining a prolonged hovering position over a designated area.
- Command and control: Drones provide the capability to transmit vital information pertaining to the movements, whereabouts, and strategic positions of adversaries. This data enables commanders to enhance their effectiveness and make more informed judgments in the operational environment.
- Military operations and assistance in combat: Drones are crucial components of both combat and support operations. Incorporated targeting software improves the precision and accuracy with which operators strike their targets.
- Target practice: Operators can utilize drones for target practice or training activities to enhance their precision. The targeting software integrated into drones can be tailored to autonomously identify and react to targets.

- Logistics: In the military-industrial context, drones have the potential to function as messengers, facilitating the movement of essential supplies and equipment. In addition, they can assist in the relief of injured individuals.

3. WHAT IS THE FUTURE OF MILITARY DRONES?

The development of drone technology was initiated by the military-industrial complex during the height of the cold war, and it has made significant progress since then. Drones are gaining broader usage and expanding their applications outside military contexts. The functions they execute in both commercial and civilian contexts are expected to progressively increase in complexity as time progresses. Here is a compilation of some of their existing capabilities [1], [5], [8], [10], [16], [34], [52]–[54], [59]:

- Fully automated flights: Employing traditional techniques can pose difficulties when attempting to chart and monitor extensive regions. Nevertheless, drones equipped with pre-programmed flight routes have the capability to perform this task without the need for manual intervention.
- Highly intricate cartography in three dimensions: Integrated software and built-in artificial intelligence can aid in a range of tasks, including 3D mapping and search and rescue missions. The processed data has the capability to be transmitted and exchanged in real-time.
- Thermal radiation detection and geotagging: Drones possess a remarkable array of uses in the agricultural industry owing to their capacity to tag, monitor, and predict the well-being of plants.

4. INTERNET OF DRONES FOR MILITARY APPLICATIONS

The internet of drones (IoD) makes it possible to access drones without coordinating their use. Drones are able to be deployed for a number of reasons, including military operations, as a result of the continual reduction in the size of sensors, actuators, and computers, as well as the widely available wireless communication. Providing navigation services in addition to coordinating drone access to regulated airspace, the IoD is a layered network control architecture that is largely responsible for this function. Furthermore, IoD is used and integrated into a variety of systems, such as the integration of wireless sensor networks (WSN) with drones, which leads to an enlarged controlling zone and increased connection performance. WSN have the potential to be utilized in a broad variety of applications, such as the monitoring of traffic, the detection of landslides, the monitoring of pipelines, the monitoring of border patrol, rehabilitation, precision agriculture, laboratory tutoring, real-time soccer game monitoring, asset tracking, real-time healthcare monitoring, and military use. An authorized user, also known as an external party, is required to have direct access to real-time data from particular sensor nodes in order to function properly for all of these essential applications. Therefore, user authentication is required for WSN security. WSN refers to systems of spatially separated and applied sensors that govern and display the physical requirements of a scenario. Because WSN is application-specific, it is difficult to create bottleneck control rules that are appropriate for all types of IoD implementations. Crowding escape and restriction in WSN strive to reduce packet loss due to congestion while guaranteeing that all network flows are allocated equal capacity [33], [59]–[63].

A conceptual paradigm for the building of an IoD-based system was proposed before by previous studies. In order to create a one-of-a-kind architecture for drone traffic management, the notion behind three large-scale networks that already exist—namely, the Internet, the cellular network, and the air traffic control network—is utilized. A number of recent studies have also investigated the possibilities for enhancing the operations of commercial and public drones. There are two categories of drones: commercial drones and military drones. Both urban and rural areas might reap significant benefits from the IoD due to the fact that drones can be positioned or relocated at any time and in any location [33], [60]. The internet of quantum drones (IoQD) offers the following basic features [59], [62]–[65]:

- A safe and confidential messaging exchange: It is possible for the encrypted message to be transferred between any two entities in a secure manner thanks to quantum communication. Satellite or fiber optics are the most effective means of transmitting this message. When compared to communication through satellites in an open environment, the amount of data that is lost through fiber optics is substantially larger. Satellites, on the other hand, are quite expensive. As an additional point of interest, satellites are less adaptable to the ever-changing conditions on the ground.
- Fast communication process: Quantum encryption technology based on optical fibers has the potential to operate for hundreds of kilometers. Furthermore, the data transport rate is far quicker than existing long-distance demonstrations. In terms of distribution to cities and rural regions, an intercontinental successful data exchange experiment utilizing quantum mechanics was presented. This data sharing project is being carried out for picture exchange and was later expanded for videoconference. Similarly, local and long-distance communications may be evaluated to verify network service availability in cities and rural

locations. Fast and secure data exchange in a city network can help to build smart applications for traffic management, self-driving vehicles, transit networks, and healthcare services.

- Possibility of creating and implementing private IoQD: The formation of private IoQD is made possible by quantum drones, which give complete flexibility. A wide range of real-time applications, such as military surveillance, traffic monitoring, Internet services, and secure long-distance messaging, are all possible uses for these private IoQD networks which can be deployed.
- A novel area of utilization, specifically quantum well (QW): QW is a specialized domain within the realm of quantum technologies that leverages the Internet and quantum technologies for military objectives. This domain encompasses various aspects such as intelligence, protection, military and defense capabilities in diverse warfare contexts. It contributes to the formulation of novel military strategies, doctrines, scenarios, and attack capabilities, while also addressing concerns related to peace and ethics. The IoQD will augment existing military intelligence, surveillance, target acquisition, and reconnaissance capabilities through the facilitation of more precise navigation, highly secure communication, and processing. The IoQD also offers the potential to establish a private network for monitoring certain regions. This application holds significant importance within military networks. In contemporary circumstances, swarms of drones are employed to execute a diverse array of tasks inside the realm of military endeavors. IoQD facilitates expedited and enhanced data processing and transmission, hence aiding in the accomplishment of critical tasks, as shown in Figure 1.

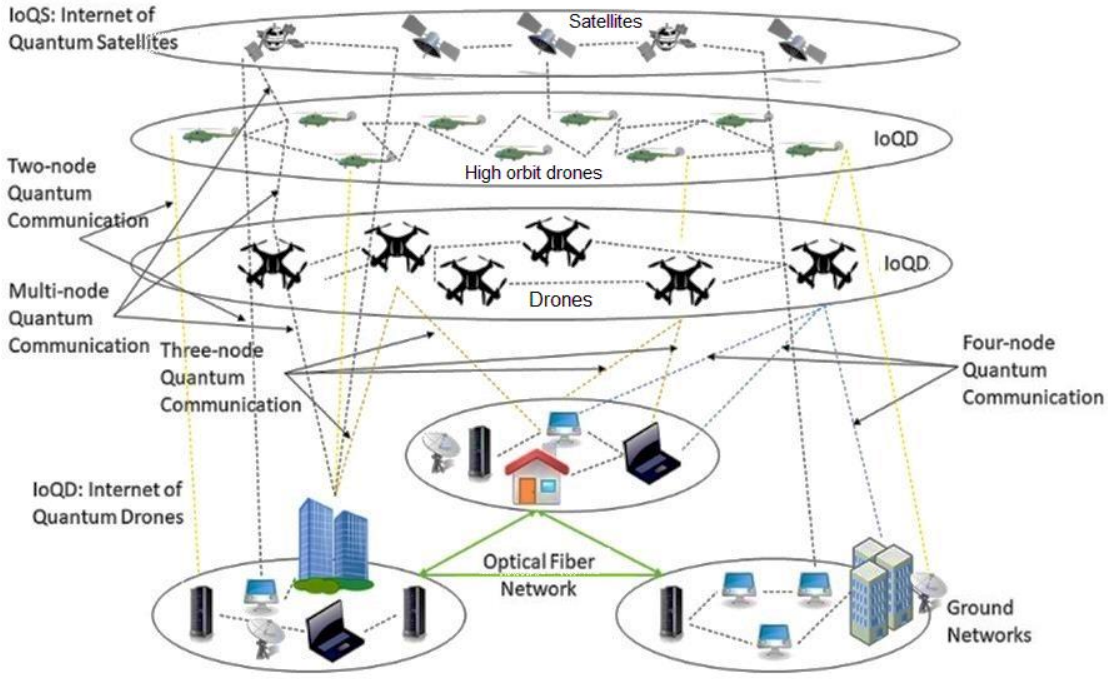

Figure 1. Internet of quantum drones (IoQD) [62]

Furthermore, IoD is used and integrated into many systems, such as the integration of WSN with drones, which resulted in a larger controlling zone and increased connection performance. WSN refers to systems of spatially separated and applied sensors that govern and display the physical requirements of a scenario. Because WSN is application-specific, it is difficult to create bottleneck control rules that are appropriate for all types of IoD implementations. Crowding escape and restriction in WSN strive to reduce packet loss due to congestion while guaranteeing that all network flows are allocated equal capacity. WSN has the potential to be utilized in a variety of applications, including but not limited to the following: traffic monitoring, pipeline monitoring, landslide detection, rehabilitation applications, border patrol, laboratory tutoring, precision agriculture, real-time soccer game monitoring, real-time healthcare monitoring, asset tracking, and military applications [1], [33], [66]. For all of these important applications, an authorized user (external party) need direct access to real-time data from specific chosen sensor nodes. Therefore, user authentication is required for WSN security.

5. CONCLUSION

This paper discussed the significant impact of drones on military warfare, highlighting their enhancements in reconnaissance, surveillance, and target acquisition. The paper also addressed the applications of the internet of things (IoD), encompassing topics such as faster communication processes, the establishment of private internet of quantum drones (IoQD), the protection of message exchanges, and the potential of quantum well (QW). The paper also emphasized the use of drone swarms in military operations to transmit and process data more quickly and securely. As part of a layered network control architecture, the IoD provides navigation services and coordinates drone access to controlled airspace. Integration of IoD systems, including drones and wireless sensor networks (WSN), results in an improvement in connection performance. In summary, the integration of drone technology into military operations has yielded substantial enhancements in surveillance, reconnaissance, and target acquisition. IoQD presents a potentially advantageous resolution for military networks by facilitating expedited and fortified data transmission and processing, thereby providing benefits to the vast majority of military networks.

ACKNOWLEDGEMENT

This research was supported by Universitas Ahmad Dahlan (UAD), and Embedded System and Power Electronics Research Group (ESPERG).

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