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Advancing UAV Operations with Hybrid Mobile Network and LoRa Communications

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Abstract : Unmanned Aerial Vehicles (UAVs) have increasingly become vital tools in various applications, including surveillance, search and rescue, and environmental monitoring. One common approach to ensure redundant communication systems when flying beyond visual line of sight is for UAVs to employ multiple mobile data modems by different providers. Although widely adopted, this approach suffers from several drawbacks, such as high costs, added weight and potential increases in signal interference. In light of these challenges, this paper proposes a communication framework intermeshing mobile networks and LoRa (Long Range) technology—a low-power, long-range communication protocol. LoRaWAN (Long Range Wide Area Network) is commonly used in Internet of Things applications, relying on stationary gateways and Internet connectivity. This paper, however, utilizes the underlying LoRa protocol, taking advantage of the protocol's low power and long-range capabilities while ensuring efficiency and reliability. Conducted in collaboration with the Potsdam Fire Department, the implementation of mobile network technology in combination with the LoRa protocol in small UAVs (take-off weight < 0.4 kg), specifically designed for search and rescue and area monitoring missions, is explored. This research aims to test the viability of LoRa as an additional redundant communication system during UAV flights as well as its intermeshing with the primary, mobile network-based controller. The methodology focuses on direct UAV-to-UAV and UAV-to-ground communications, employing different spreading factors optimized for specific operational scenarios—short-range for UAV-to-UAV interactions and long-range for UAV-to-ground commands. This explored use case also dramatically reduces one of the major drawbacks of LoRa communication systems, as a line of sight between the modules is necessary for reliable data transfer. Something that UAVs are uniquely suited to provide, especially when deployed as a swarm. Additionally, swarm deployment may enable UAVs that have lost contact with their primary network to reestablish their connection through another, better-situated UAV. The experimental setup involves multiple phases of testing, starting with controlled environments to assess basic communication capabilities and gradually advancing to complex scenarios involving multiple UAVs. Such a staged approach allows for meticulous adjustment of parameters and optimization of the communication protocols to ensure reliability and effectiveness. Furthermore, due to the close partnership with the Fire Department, the real-world applicability of the communication system is assured. The expected outcomes of this paper include a detailed analysis of LoRa's performance as a communication tool for UAVs, focusing on aspects such as signal integrity, range, and reliability under different environmental conditions. Additionally, the paper seeks to demonstrate the cost-effectiveness and operational efficiency of using a single type of communication technology that reduces UAV payload and power consumption. By shifting from traditional cellular network communications to a more robust and versatile cellular and LoRa-based system, this research has the potential to significantly enhance UAV capabilities, especially in critical applications where reliability is paramount. The success of this paper could pave the way for broader adoption of LoRa in UAV communications, setting a new standard for UAV operational communication frameworks.

Keywords : LoRa communication protocol, mobile network communication, UAV communication systems, search and rescue operations
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