Design of Networked Ammunition Network Communication Scheme Based on ESP8266

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Abstract. This paper analyzes the collaborative combat process of networked ammunition and forms a complete expression of the functional requirements and design constraints of the networked ammunition network communication scheme. Based on the requirements for the wireless communication function of the fuze by the network cruise missile in each process, the article proposes a network node communication networking scheme based on ESP8266, and conducts a hardware construction test. After testing and verification, the network system can realize stable information transmission between different nodes and between network nodes and the host computer. This networked ammunition system also has the functions of real-time reporting of node status, data encoding and decoding, and has low power consumption and stable performance. It is suitable for application in networked ammunition combat systems.

1. Introduction

Networked ammunition is a new type of ammunition that realizes distributed and coordinated strikes based on small and smart ammunition through networking communication between ammunition nodes. The networked patrol ammunition with strong air maneuverability, large combat area coverage, strong target confrontation capability, and high comprehensive strike effectiveness has attracted increasing attention.

At present, domestic and foreign researches have been carried out on topics related to networked ammunition, and certain results have been achieved.

In April 2015, the United States Naval Research Service. Reported on the US Navy’s "Low-cost Unmanned Aerial Vehicle Swarm Tactics (LOCUST)", which uses multi-tube launchers to launch a large number of "Coyote" cruise missiles with a cost of less than US$10,000 [1]. In January 2017, the U.S. Department of Defense Advanced Research Projects Agency (DARPA) issued a tender for the "Offensive Swarm Enabled Tactics (OFFSET)" project, seeking to develop urban operations as military needs, with a scale of more than 100 cruiser bombs. Group formation system architecture, game software design, system integration and algorithm.

During the "13th Five-Year Plan" period in China, China Electronics Technology and Aviation Industry Corporation have successively completed large-scale drone cluster releases and flight test verification of formation functions. All services and arms have arranged special research or background research projects with network coordination features. Such as the "Distributed Cooperative Attack System" released by the 3rd Air Force, the "Unmanned Aerial Vehicle Multi-aircraft Autonomous Cooperative Technology" released by the Army, etc.[2][3].

Based on the analysis of the operational process of networked munitions, this paper forms a complete expression of the functional requirements and design constraints of the networked munitions...
network communication scheme, designs the networked patrol missile network communication system scheme, and introduces related technologies to realize the functions. Conduct experimental demonstrations.

2. Analysis of Operational Profile of Networked Ammunition

The following analysis of the networked ammunition combat process, a detailed analysis of its typical combat mission process, and a brief summary of the communication interface requirements of the networked ammunition system.

2.1. Work flow of networked ammunition under various working conditions

The typical combat scenario of networked ammunition is shown in Figure 1[4]. Figure 2 shows the typical process of networked ammunition performing coordinated attack tasks.

Networked munitions are delivered by cluster launch, airdrop, and long-range sub-munitions. After each node has established a flight attitude, it completes the first networking and maintains a dense formation flight. After reaching the target area, completes network-based regional situational awareness and sharing, Target identification, attack plan formulation, attack path planning and task distribution, coordinated attack on the target under network coordination, in the case of a second attack, iterative attack mission, until the attack mission is completed, part of the remaining node ammunition or Self-destruction or recovery as planned. During this process, node ammunition that is disconnected from the network or falls should be harmlessly disposed of in accordance with the requirements of the Three Self.

2.2. Analysis of Communication Interface Requirements of Networked Ammunition System

The typical operational flow profile of networked ammunition is analyzed and the main information of fuze comes from the network terminal and the onboard computer. In the process of missile rendezvous, the on-board sensor should transmit the information of target blast height and vulnerable position to the fuze in real time and at high speed. Onboard network terminal need real-time transmission to the fuze various commands, and if necessary need to time benchmark between the nodes in the fuze synchronization, as a result, with reasonable planning and design of the communication interface, is to ensure that the information of low delay, high reliability of the transmission, the premise of more reliable network ammunition fuze, precisely to complete its complex the guarantee of safety and initiation control function[5].
3. Design of Network Ammunition Networking Scheme

3.1. Hardware system scheme design
According to the military needs of networked intelligent ammunition, its wireless network communication system is mainly composed of two parts: a system control module and a wireless communication module. For the system control module, the design is based on an embedded system. The embedded system is based on a computer system and is widely used in actual engineering. Its software and hardware can be flexibly tailored according to actual engineering requirements, which is more in line with the realization of intelligent ammunition Basic conditions for networking. For the wireless communication module, it is used as the transceiver of the network communication system to realize the transmission and reception of different commands, so as to realize the information sharing of networked munitions and neutron munitions.

According to the different fuze states during the networked ammunition cluster launch, formation flying, and coordinated attack, the control platform needs to send corresponding instructions to the cruise missile formation, including safety release instructions, resume cruise instructions, detonation instructions, and three-self processing Instructions etc. After the cruise missile receives a specific command string, the system control module performs the decoding operation to make the corresponding operation. The overall hardware design of the fuze system is shown in Figure 3:

![Figure 3. The overall hardware scheme design of the fuze system.](image)

A profile analysis of the typical combat process of networked ammunition, information sharing between ammunition nodes, task allocation and intelligent decision-making all rely on the establishment of a real-time and reliable communication network between ammunition. For the fuze hardware, the focus of research is the selection of wireless communication modules and the construction of communication networks. This article chooses the ESP8266WIFI module produced by Espressif, which works in the 2.4GHZ frequency band, follows the 802.11 b/g/n protocol, and has a built-in TCP/IP protocol stack. It can meet the requirements of low power consumption while having the largest integration level, including rich SPI interface and GPIO interface. At the same time, users can also develop secondary SDK based on their needs (this function is not required for this study).

The main control module of the system adopts the STM32C8T6 type single-chip microcomputer based on the ARM CORTEX-M series produced by ARM, packaged as LQFP-8, with a clock frequency up to 72MHZ, on-chip integrated 32-512KB FLASH memory and 6-64KB SRAM memory, Its pin functions are rich, which can meet the control function requirements of the fuze safety circuit and its communication module.

3.2. Networking scheme design
The WIFI network topology mainly includes two forms: 1. Basic wireless network based on AP (basic network Infra). This type of network topology refers to a wireless network formed by APs and joined by many STAs. This type of network The characteristic is that the AP is the center of the entire
network, and all communications in the network are forwarded through the AP. 2. Wireless network based on ad hoc network (Adhoc): This type of network topology is composed of only two or more STAs. There is no AP in the network. This type of network is a loose structure. All STAs can communicate directly. Aiming at the whole mission process of networked ammunition, the communication traffic is large and the node information exchange is frequent. Although the network topology of the self-organizing network is stronger than the basic network, it has the advantages of network self-healing ability and multi-hop function, but it is used in cluster operations. The environment will bring greater electromagnetic interference, and the communication network is easy to be interfered or discovered. Therefore, this research is based on the basic network to build a wireless communication network. The schematic diagram of the networked ammunition system is shown in the figure 4:

![Networked Ammunition System Diagram](image)

As shown in the figure, the network construction chooses the star network topology. In networked ammunition cluster flight operations, a distributed coordinated control formation is adopted in which a lead plane drives multiple wingmen. During the patrol and reconnaissance period, the lead plane and the wingman rely on the sensors on the patrol missile to detect and search for targets. When the lead plane finds the target, the target information is identified by the onboard computer, and the combat command is encoded and wirelessly transmitted according to the corresponding target type. The wingman receives the information and performs corresponding actions; when the wingman finds the target, the onboard computer checks the target. The captured enemy information is identified, and the target information is sent to the lead plane through wireless transmission. The lead plane decodes the information and encodes the corresponding combat instructions according to the target type information, and then sends them to the wingman through wireless transmission to instruct them to make corresponding instructions. behavior.

As the lead plane in the cruise missile formation, its wireless communication module is configured in AP mode, the WIFI name and password established by it are customized, and the module transmission mode is configured as TCP transmission, and the configuration commands based on STM32 are written and burned. Automatic configuration after power-on. For the wingman in the patrol formation, configure its wireless communication module to STA mode, set the transmission mode to TCP CLIENT, write and program the configuration instructions based on STM32, and power on to connect to the wireless network established by the leader. Up to five network nodes can simulate wingmen joining the network at the same time. According to actual application scenarios, if the ground control platform is required to send instructions to the formation, one of the wingmen can be replaced by the network debugging assistant of the ground control platform, configure it in TCP CLIENT mode, and manually connect to the IP address established by the wireless communication module of the leader, You can send and receive data with the lead plane in the formation. The communication topology network is shown in Figure 5:
3.3. Hardware platform build test

The hardware construction of the networked ammunition wireless communication system is carried out according to the networking scheme in 3.2 above. Test process: Simulate the launch environment of the UAV combat cluster, using a host and four wingmen to build a topology. The network debugging assistant simulates and gives corresponding instructions in the combat process. The host receives the instructions and performs corresponding processing, and sends them to the wingman through the wireless network. The wingman can make corresponding actions, thus verifying the feasibility of the network system in the application of networked ammunition. The following figures 6 and 7 show a schematic diagram of information cross-linking between the central control platform and the host.

The test includes the following instructions: Connection test, Recovery insurance, Synchronous detonation, Delayed selfdestruction. (The above instructions are used as the host computer communication function test. In the battlefield communication, the data required by the fuze under different working conditions is encapsulated, the data is sent, and the ammunition network terminal
receives the data and decodes the data to realize different operations). The following Figure 8 and Figure 9 are the process of simulating information cross-linking between the host and the wingman.

The PC terminal uses the network debugging assistant as the host computer software to simulate the ground control platform, configure the AP mode network terminal to simulate the long machine, and configure the STA mode terminal to simulate the wingman. In the experiment, the network debugging assistant sends a test command to the AP. The AP can receive the data normally (as shown in the figure) and forward it to the STA terminal at the same time. After receiving the test command, the STA terminal will light up different colored signal lights (as shown in the figure). Represents different types of signal processing results. When a network node as a wingman joins the network, set a fixed period of data return, which can report the status information of the network node in real time.

4. Conclusion
Through the analysis of the networked ammunition combat process profile, the requirements of its communication interface information and other requirements are summarized, and the network topology hardware system built is tested. Experiments have proved that this networked ammunition networking topology based on ESP8266 has low power consumption and stable structure. In terms of information transmission, this system can meet the needs of long-term, high-frequency rate communication in networked ammunition combat scenarios, while ensuring a faster information transmission rate and lower communication errors.

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