Research on IP Address Allocation of Tactical Communication Network

Wang Huitao¹, Yang Ruopeng¹, Wufan¹ and Zou Xiaofei¹

¹College of Information and Communication, National University of Defense Technology, Wuhan 430010, China
81445785@qq.com

Abstract: According to the IP address allocation problem of tactical communication network, the structure and IP address requirements of tactical communication network are analyzed in paper. A tactical communication network IP allocation method based on Classless Inter-Domain Routing (CIDR) addressing technology and without network-wide routing configuration is proposed. The allocation principle, addressing method and allocation process of the method are analyzed in detail. Based on this, the algorithm and model of IP address allocation in tactical communication network are given. Finally, the model and algorithm are analyzed and verified with examples.

1. Introduction
The tactical communication network is a layer-by-layer communication network that uses wireless communication as the main means to interconnect various communication user terminals and channels in the network, and realizes interconnection and intercommunication between units at all levels to meet the needs of information and communication support of troops. Due to the adoption of IP interconnection technology, various types of communication terminals in a tactical communication network are required to uniformly allocate and address their IP addresses to meet the needs of the communication network for IP addresses. The IP address allocation of the existing tactical communication network is mainly carried out by network planning software. However, from the perspective of distribution, the following problems still exist: First, manual allocation is dominant, randomness is easy, and error is easy. Second, each unit is separately allocated and lacks systematic distribution strategies. The third is the separation of communication and allegations, lacking integrated design and distribution. In view of the above problems, this paper proposes a tactical communication network IP address allocation model and algorithm, and carries out verification analysis to improve the tactical communication network IP address utilization and network opening time.

2. Tactical communication network structure
The tactical communication network is mainly composed of a variety of routers, switches, computers, communication terminals, etc., and interconnects numerous devices through a tactical communication platform to improve stable and reliable information and communication support for the troops. Its network structure is shown in Figure 1.
The tactical communication network mainly consists of a public communication platform, a command post network and various wireless subnets, and each network is interconnected by an IP interconnection protocol. In each network, the used IP address resources mainly include an IP service address and an IP management address. The IP service address mainly includes the switch core address, the switch port address, various mobile communication device addresses, computer terminals, and the like. The IP management address mainly includes an IP address used for device management, such as a node management device, a communication device, and a computer terminal device, etc.

2.1 Command post network
The command post network is mainly used to ensure the communication of the command post. It is mainly based on various types of communication and accusation vehicles. The IP address used by each communication vehicle mainly includes the terminal address of the command post user, device management address, and Interconnection address and reserved address of the communication platform within the command post. Among them, the terminals of the command post’s user at all levels are mainly connected by Ethernet interfaces. Device management addresses are mainly network switch interfaces; the interconnection addresses of the communication platforms of the command post are mainly switches, communication terminals and communication interconnection devices.

2.2 Public communication platform
The public communication platform is mainly used to build a public communication network covering the entire operational area, and to ensure access to users at all levels of the command post. The IP addresses required for each public platform communication vehicle mainly include the switch address, the in-vehicle device management address, the communication platform address, and the user terminal address.

2.3 Wireless subnet
The wireless subnet is mainly used for the communication between various users to access the superior command post or the command post of the same level.

It is mainly composed of various VHF Radio stations to build a hierarchical radio subnet, whose IP address is mainly the tactical radio port address.
3. IP address allocation and addressing

3.1 Distribution principle

According to the actual application and technical requirements of the tactical communication network, the following principles must be followed when assigning IP addresses:

- **The principle of uniqueness.** The uniqueness of the IP address is the basis for the tactical communication network user terminal to correctly carry the service. To avoid the IP address conflict of the entire network, the IP address of each device should be unique to the entire network.

- **The principle of aggregation.** Due to the large scale of tactical communication networks, the large number of equipments, and the existence of a large number of heterogeneous networks, in order to reduce the number of router entries, the principle of router aggregation should be considered in planning.

- **The principle of autonomy.** For tactical communication networks, they are usually divided into different autonomous regions according to the force preparation. Each autonomous region can be divided into different small autonomous regions, and each autonomous region is relatively independent, which can effectively reduce the difficulty of IP allocation.

3.2 Addressing method\(^3\)[4]

The traditional IP address allocation mainly takes the IP address into a fixed class. The two-level addressing method is adopted. The IP address is in the form of "Network number + Host number". This addressing method can effectively save the IP address space. It is advantageous to divide the subnets. However, as the number of networks increases, the number of routing increases greatly, which reduces the forwarding speed of IP packets and is not flexible enough entries h. In order to improve the efficiency of IP address utilization, reduce the number of routing entries, improve the speed of network forwarding, and reflect the relationship between hierarchical management and unified planning, this paper uses Classless Inter-Domain Routing (CIDR) addressing technology for subnetting. A "CIDR address block" is composed of continuous IP addresses with the same network prefix, and the addressing method is "Network prefix + Host number". The IP address is divided into subnets with different network prefixes and assigned to each node. Each node divides the next subnet into the next subnet according to the assigned subnet and assigns it to the next subnet, and so on, until the IP address is assigned to each terminal device and user in the network. Because the prefix of the network is variable, the subnets of different lengths can be divided according to different situations, which fully meets the requirements of flexible and multi-level hierarchical division of battlefield network.

3.3 Assignment process

First, determine the total IP address allocation resources according to the operational requirements, network structure, and user scale of the tactical communication network. Take the bottom-up, level-by-level summary, and analyze the IP address requirements of each network layer by layer. When determining the requirements of each network, the network IP address segment requirements are determined according to the number of nodes and interconnections of each network platform, and then the seat address segment and the IP address segment of the internal and external subnet of the command post are clearly defined according to the number of seats in each command post and the internal and external network interconnection relationship of the command post. The IP address segment of each subnet is determined according to the number of wireless packet subnets and the number of users in the subnet.

The second is to analyze and determine the IP requirements. A unified planning and distribution method is adopted. According to the hierarchical division method, the CIDR technology is used for subnetting, and the bottom-up and level-by-level aggregation methods are adopted to analyze the IP address requirements of each node layer by layer. Continuous address block allocation and
hierarchical partition are adopted to implement route aggregation, ensure the relative independence of IP addresses between networks, and improve network stability. The basic idea is shown in Figure 2.

![IP layering diagram](image)

**Figure 2.** IP layering

The third is to specifically assign an IP address. According to the IP address requirements, IP addresses are allocated to each device and user in a segmented aggregation manner.

The fourth is to verify the allocation of IP addresses. It mainly checks the route aggregation and conflicts of IP address allocation.

### 4. Models and algorithms [5-8]

#### 4.1 Assumptions

- The IP address has the uniqueness of the whole network;
- The IP address adopts a layered manner, and each command post and public platform network adopts an independent IP address segment;
- The radio station interconnected by the Internet controller in the subnet uses the core IP address controlled by the Internet, and no longer allocates the address separately;
- The communication and accusation equipment IP addresses are uniformly planned, and the address segments are not separately divided.

#### 4.2 Assignment models and algorithms

**4.2.1 Assignment algorithm**

According to the CIDR addressing rules, CIDR usually uses a slash notation to indicate an IP address. If the number of bits occupied by the network prefix is \( m \), the IP address can be expressed as: IP address/\( m \) according to the CIDR rule. It represents that the prefix bit in the IP address is \( m \) bits, the default mask of the class A address can be represented by /8, the class B address can be represented by /16, and the class C address can be represented by /24.

Hypothesis \( m_1 \) —— The number of network prefix bits before the subnet is divided. \( m_2 \) —— The number of network prefix bits after the subnet is divided.

The number of subnets in a tactical communication network is \( N_2 \), the required number of subnets is \( n_1 \), then meet: \( 2^{n_2} - 2 \geq N_2 \), thus the number of required subnets is: \( n_2 \geq \log_2(N_2 + 2) \).

Similarly, the number of IPs used by devices in a subnet in a tactical communication network is \( N_2 \), the required number of users is \( n_3 \), then meet: \( 2^{n_3} - 2 \geq N_3 \), The required number of users is: \( n_3 \geq \log_2(N_3 + 2) \).

According to the above formula, the number of network prefix bits before the subnetting is known:
\[ m_1 = 32 - n_2 - n_3. \] The number of network prefix bits after subnetting is \[ m_2 = 32 - n_2, \] according to the number of network prefixes \( s_2 \). The corresponding subnet mask is available.

The above is a general allocation algorithm for IP address allocation. Next, the route aggregation algorithm is discussed.

First, find out the key bytes that are aggregated in the IP address, that is, the bytes with different values in each subnet address. Secondly, analyze the number of users in the subnet, analyze the number of bits used in selecting the subnet address, so that the number of subnet addresses is greater than or equal to the maximum keyword section minus the minimum key section, and find the appropriate subnet address block by calculation, so that: \( \text{Keyword Section/Address Block Size} = \text{Maximum Keyword Section/Address Block Size} \).

Again, the address block size is calculated, and it can be concluded that the user borrows \( n \) bits from the prefix for subnet aggregation.

Finally, the network routing address after aggregation = Keyword Section - Keyword Section / Address Block Size.

### 4.2.2 IP address calculation

**(a) Calculation of the IP address of the command post**

The command bases of tactical communication networks are mainly based on communication vehicles and are interconnected according to certain network topologies. Depending on the level of each command post, it is also different for the required IP address devices. For Class 1 command posts, which mainly include communication vehicles and command vehicles, the maximum IP address on each vehicle is no more than 64, and the mask is an address segment of /25. For the type 2 command organization, mainly the command vehicle, the maximum IP equipment is usually no more than 32, and its mask is /26 address segment. For the type 3 command terminal, the maximum IP equipment is no more than 16, and its mask is /27 address segment. The specific requirements are shown in the table.

| Device type           | Class 1 command agency command vehicle IP address requirements | Class 2 command agency command vehicle IP address requirements | Class 3 command agency command terminal IP address requirements |
|-----------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| User terminal         | 24                                                            | 16                                                            | 4                                                             |
| device management     | 16                                                            | 8                                                             | 4                                                             |
| communication device  | 8                                                             | 4                                                             | 4                                                             |
| Reserved              | 16                                                            | 8                                                             | 4                                                             |

**Table 1. the IP address demand table of the command post**

**(b) Calculation of IP address of public communication platform**

The public communication platform is mainly constructed according to various communication vehicles. The maximum number of IP addresses used by each communication vehicle is 64, and the mask is an address segment of /25.

**(c) Calculation of IP address of Wireless packet subnet**

The packet subnet address segment is mainly used for the VHF Radio network. Generally, the maximum number of subnet members is not more than 16, and the mask is /27. In order to facilitate route aggregation, the terminal IP address should be obtained from the reserved address of the troop (unit) of the nearest access point.

### 5. Examples

Assume that the IP address resource assigned by the superior to a tactical communication network type 1 command organization is a Class B address XXX.XXX.0.0/16, which is mainly used to secure the Class 1 command post network, the public platform network, and the wireless packet subnet. IP address is used. According to the tactical communication network allocation model and algorithm, the
IP address allocation scheme of the type 1 command organization is shown in Table 2. The following takes the command post network as an example, and assigns an IP address to it. The allocation is shown in Table 3.

Table 2. IP address allocation scheme for tactical communication

| Network                        | Address Resource Pool | 0: User terminal | 1: Device Management | 2: Communication platform | 3: Reserved |
|--------------------------------|-----------------------|------------------|----------------------|---------------------------|-------------|
| Command post network (max=8)  |                       | Number of node communication vehicles max=16 | Number of user terminals per vehicle max=64 | Each vehicle equipment max=16 | IP address of each device max=16 |
| Public communication platform (max=8) |                       | Number of node communication vehicles max=16 | Each vehicle equipment max=16 | IP address of each device max=16 | |
| Wireless subnet (max=32)      |                       | Number of node subnets max=8 | Each vehicle equipment max=4 | Number of members per subnet max=16 |

Table 3. IP address allocation table of command post network

| Command post network (XXX.XXX.0.0/16 ~ XXX.XXX.255.255/16) | Command organization 1 (XXX.XXX.0.0/19 ~ XXX.XXX.31.255/19) | User terminal (XXX.XXX.0.0/21 ~ XX X.XXX.7.255/21) |
|-------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------|
| Command organization 1 XXX.XXX.0.0/19                       | User terminal Equipmen t XXX.XXX.0.0/21 Car 1 XXX.XXX.0.1    |
| Command agency 2 XXX.XXX.32.0/19                             | Equipmen t managem ent XXX.XXX.8.0/21 Car 2 XXX.XXX.1.0      |
| Command organization 3 XXX.XXX.64.0/19                       | Communication platform XXX.XXX.1.0/21 Car 3 XXX.XXX.1.1      |
| Command organization 4 XXX.XXX.96.0/19                       | Reserved XXX.XXX.2.0/21 Car 4 XXX.XXX.2.0/25 Car 5 XXX.XXX.3.1 |
| Command agency 5 XXX.XXX.128.0/19                             | ... Car ..    |

6. Conclusions
The IP address planning problem of tactical communication network is an important part of tactical
communication network management planning, which plays an important role in ensuring the normal operation of the communication network. Based on the analysis of the structure of tactical communication network and the requirement of IP address, this paper proposes a tactical communication network IP allocation method based on Classless Inter-Domain Routing (CIDR) addressing technology and without whole network routing configuration, which achieves fast and automatic IP address allocation and configuration of communication devices of tactical communication network. The actual use effect shows that the allocation method and the allocation process can ensure the correctness of the IP address allocation, shorten the network startup time, and reduce the difficulty of network startup.

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