Applicability Analysis of LTE in Long-distance Maritime Communication

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Abstract. With the development and evolution of communication technology, maritime communication methods still lag far behind developed land. This paper first introduces several existing long-distance communication methods from communication speed, communication distance and application fields. Compared with the existing maritime communication methods, the applicability of LTE in long-distance maritime communication is analyzed, and an effective method is proposed to solve the problem of long-distance communication at sea.

Keywords: communication method; LTE; long distance; maritime communication.

1. Introduction

With the development and evolution of communication technology, the methods of maritime communication lag far behind the land methods, but it has met the basic needs of security assistance, business liaison and personal communication [1]. However, long-distance maritime communication has always been a problem which plagues people for a long time. Optical fiber communication and satellite communication are the popular ways in long-distance maritime communication. In recent years, LTE has been increasingly used in close-range maritime communications with its unique advantages. This paper first compares the communication rate, communication distance and application field of optical fiber communication and satellite communication, and then analyzes the applicability of LTE in long-distance maritime communication, providing an effective method for long-distance maritime communication.

2. Comparison of Long-distance Communication Methods

2.1 Optical Fiber Communication

Optical fiber communication is a new communication technology that uses optical waves as a carrier to transmit information and optical fiber as a transmission medium to achieve information transmission purposes [2]. Wavelength division multiplexing technology has greatly improved the transmission capacity of optical fiber transmission systems, and has broad application prospects in future cross-sea optical transmission systems. Another way to increase transmission capacity is to use optical time division multiplexing (OTDM) technology. OTDM technology improves transmission capacity by increasing the single channel rate. It achieves a single channel with a maximum rate of 640 Gbps. Fiber optic communication has many significant advantages:

(1) Large communication capacity and long transmission distance.
(2) The signal interference is small and the security performance is good.
(3) Anti-electromagnetic interference and good transmission quality.
(4) No radiation, and difficult to eavesdrop.
(5) The optical cable has strong adaptability and long service life.

But at the same time, there are some shortcomings:

(1) Expensive, the price of submarine cable is about 100,000 yuan, and the cost of laying 1 kilometer is 200,000-300,000 yuan.
(2) Cutting and joining of optical fibers requires certain tools, equipment and techniques.
(3) The branching and coupling are not flexible, and the bending radius of the fiber optic cable cannot be too small (>20cm).

(4) There is a problem of power supply difficulties.

2.2 Satellite Communication

Satellite communication refers to the use of artificial earth satellites as relay stations to forward radio waves, thereby enabling communication between two or more earth stations [3]. Compared with microwave relay communication and other communication methods, satellite communication mainly has the following characteristics:

(1) The communication coverage area is large and the communication distance is long: the communication distance of one hop in the satellite beam coverage area is up to about 13000km.

(2) The communication quality and the system reliability are high.

(3) It is suitable for broadcast type and user type services.

(4) It has great flexibility and can provide medium and high-speed data channels of tens of megabits (Mbit/s) or even 120Mbit/s.

(5) It is easy to implement multiple-access transmission and has the function of transmitting multiple services.

Satellite communications also have some drawbacks:

(1) The delay of transmission of the satellite link is large: a delay of 500 milliseconds to 800 milliseconds.

(2) The attenuation of satellite link transmission is very large.

(3) It is difficult to achieve satellite communication in high latitudes.

(4) The phenomenon of Japanese Ling and Star Food in space will interrupt and affect satellite communications.

2.3 LTE

LTE is a global common standard developed by the 3GPP organization based on OFDMA technology [4, 5], including FDD and TDD modes for paired spectrum and unpaired spectrum. In general, LTE is also called “4G”, and people regard LTE technology as an advanced technology that transforms from 3G to 4G. The most obvious feature of LTE is that it has higher sound quality, higher frequency utilization, larger traffic transmission, and higher transmission efficiency than traditional communication technologies. LTE has the following technical features:

(1) High rate: LTE can achieve a downlink peak rate greater than 100 Mbit/s in a 20 MHz bandwidth, and an uplink peak rate greater than 50 Mbit/s.

(2) High efficiency: downlink 5bit/s/Hz, uplink 2.5bit/s/Hz.

(3) Low delay: The control plane delay of the LTE system is less than 100ms, and the service plane delay is less than 10ms.

(4) Large capacity: The maximum number of active users per cell is 400, and the number of online users is 1200.

(5) Support multiple cell bandwidths: 1.4MHz\3MHz\5MHz\10MHz\15MHz\20MHz.

(6) Good coverage and mobility: different formats, covering distances from 1.4 to 100km.

Table 1. TD-LTE system communication coverage performance test table [4]

Distance(km)	Rate(Mbps)	Video service	Voice service
10	34	1.5Mbps Smooth	Clear smooth
48	17.8	1.5Mbps Smooth	Clear smooth
70	8.5	1.5Mbps Smooth	Clear smooth
75	4.5	1.5Mbps Smooth	Clear smooth
82	0.41	300kbs Smooth	Clear smooth
91.6	--	--	Voice available

The literature [4] pointed out that the theoretical coverage of TD-LTE can reach more than 100km, which can meet the coverage requirements of the sea surface far scene. At the same time, TD-LTE can also be used in buoys, wave gliders, drones, and unmanned vessels.

3. Choice of Long-distance Communication Methods at Sea

According to the previous analysis of various communication methods, this paper believes that LTE technology can meet the long-distance communication requirements of the sea surface. At the same time, with the popularization of 4G networks, the price of LTE equipment will gradually decrease, and the cost will also decrease.

This paper proposes a method for long-distance maritime communication based on LTE technology. In LTE communication, the maximum allowable spatial path loss is calculated as follows [6]:

(1) Uplink budget formula. Maximum allowable spatial path loss = mobile station transmits power (dBm) + mobile station antenna gain (dB) - human body loss (dB) - base station feeder loss (dB) + base station receive antenna gain (dBi) - building or vehicle body penetration Loss (dB) - Slow Fading Margin (dB) - Fast Fading Margin (dB) - Interference Margin (dB) - Base Station Receive Sensitivity (dBm).

(2) Downlink budget formula. Maximum allowable spatial path loss = base station transmits power (dBm) + base station antenna gain (dB) - base station combiner loss (dB) - human body loss (dB) - base station feeder loss (dB) + mobile station receive antenna gain (dBi) - Building or vehicle body penetration loss (dB) - Slow fading margin (dB) - Fast fading margin (dB) - Interference margin (dB) - Mobile station receiving sensitivity (dBm).

In the long-distance communication at sea, the shadow fading, penetration loss and human body loss are not considered in this paper. The maximum allowable spatial path loss of the uplink and downlink is 158.39dB and 163.41dB, respectively.

According to the maximum allowable spatial path loss, combined with the specific propagation model, the theoretical coverage radius is calculated in the open area such as the sea surface [7]:

$$d = 10^{[L-28.61-44.49\lg f+4.78(\lg f)2+13.82\lg h1+a(h2)]/(44.9-6.55\lg h1)} \tag{1}$$

Where f is operating frequency (MHZ), h1 is base station antenna height(m), h2 is mobile station antenna height(m), d is distance to the base station(km), a (h2) is mobile station antenna height gain factor(dB).

a (h2) = (1.1lgf-0.7) h2-1.56lgf+0.8(medium, small cities) =3.2[lg(11.75h2)]2-4.97(big cities) (2)

In the 2600MHz band, the height of the mobile station antenna is chosen to be 1.5m. When the base station antenna height is 25m, the theoretical coverage of the uplink and downlink obtained by the above equation is 50.012km and 69.105km respectively; when the base station antenna height is 16m, the uplink and the uplink are obtained by the above formula. The theoretical coverage of the downlink is 37.012km and 50.501km, respectively. In this paper, the coverage obtained by the uplink is used to calculate the coverage area of the base station.

Considering the influence of the radius of curvature of the Earth, the relationship between the limit direct viewing distance and the heights Ht and Hr of the transmitting and receiving antennas is as follows [8]:

Rmax=4.12*(sqrt (Ht)+sqrt (Hr)) (3)

When the base station antenna height is 25m, the ultimate direct vision distance can be obtained from the above formula is 25.646km; when the antenna height is 16m, the limit direct vision distance that can be obtained from the above formula is 21.526km.

In summary, it can be seen that in the 2600MHz frequency band, when the antenna height is 25m, the coverage can reach 25.646km; when the antenna height is 16m, the coverage can reach 21.526km.

The topology uses a regular hexagon and uses an omnidirectional station [9], as shown in the following Fig.1:

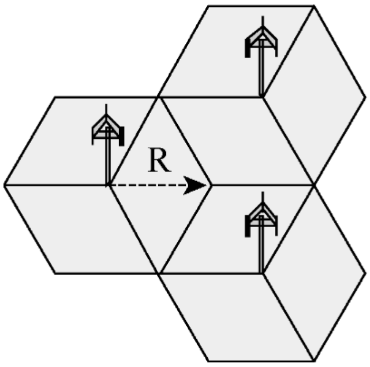

Fig. 1 Schematic diagram of a regular hexagonal topology

It can be calculated that to achieve maritime communication with a radius of 100 km, if the base station antenna height is 25 m, the number of regular hexagons required is 19; if the base station antenna height is 16 m, the number of required regular hexagons is 27.

4. Conclusion

This paper first compares the communication rate, communication distance and application field of optical fiber communication and satellite communication, then analyzes the advantages of LTE communication mode, and analyzes its applicability in long-distance communication at sea. An LTE-based maritime long-distance communication method.

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