Research on Application Technology and Security of VoLTE in Power Wireless Private Network

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Abstract. Based on the wireless private network established by electric power, the application of VoLTE technology in power wireless private network is studied, and through the test scheme, test the performance index of wireless power network in three voice solutions based on multiple terminals and VOLTE. The performance index includes voice and video call quality under different wireless signal intensities, as well as call quality in the process of road movement. The analysis of Volte research in power wireless private network supports the application of power wireless private network in the future, provides technical support, and lays a solid foundation for the popularization and application of power wireless private network, and the security of the power network is guaranteed.

Keywords: VoLTE · Smart grid · Road test · Voice quality · Network security

1 Introduction

Energy Internet is a new type of power network node composed of distributed energy acquisition device, distributed energy storage device and various types of load, which combines advanced power electronics technology, information technology and intelligent management technology to realize energy peer-to-peer exchange and sharing network with two-way energy flow [1–5].

Wireless communication has the advantages of ubiquitous access, flexible deployment, fast construction and so on, it has unique advantages in meeting the information and communication needs of the global energy Internet [6–9]. It makes up for the problem that optical fiber communication can not cover all the business scope of power system because of the limitation of terrain, cost and so on [9–12].

VoLTE opens the way to mobile broadband voice, which brings two aspects of value to operators, one is to improve the efficiency of wireless spectrum and reduce the network cost, and the other is to enhance user experience [13–15]. In this paper, the deployment and networking scheme of VoLTE service in power wireless private network are studied, and a pilot verification project is established.

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According to the mobile characteristics and network coverage characteristics of the mobile terminal of the power wireless private network, the application model of the VoLTE in the power wireless special network is proposed, and the optimization direction is pointed out through analysis.

2 System Architecture of VoLTE

There are three solutions for LTE voice in the industry, which are VoLTE, CSFB and SGLTE, respectively [16]. The VOLTE and the CSFB are standardization scheme in 3GPP, and the SGLTE is the terminal implementation scheme, wherein the VoLTE is the ultimate scheme of the mobile 4G voice solution. SGLTE does not need to change the network, and both VOLTE and CSFB need to modify the network [16, 17].

In the VoLTE, it uses IMS as the business control layer system, and EPC only as the bearing layer [18]. The switching of SRVCC solves the problem of voice continuity, and the delay of call time is short. The network frame diagram of VoLTE is as follows (Fig. 1).

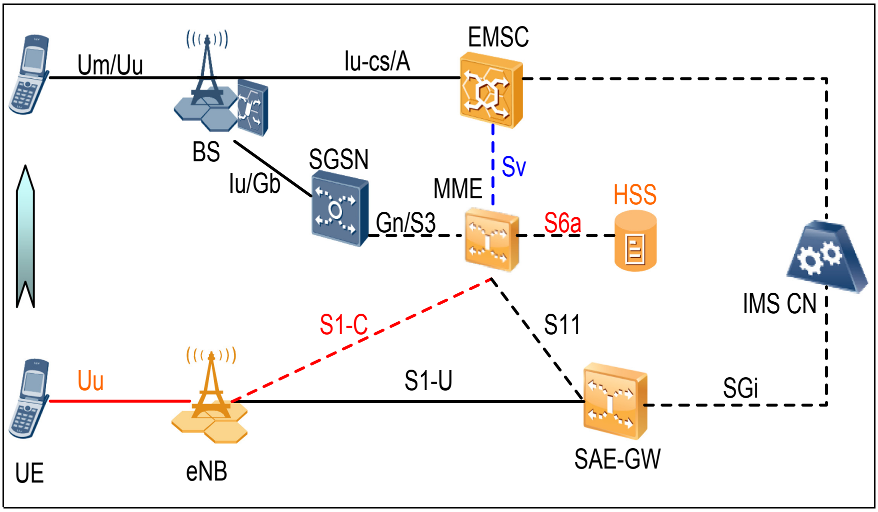

Fig. 1. Framework diagram of VoTLE network

The protocol architecture of VoLTE is as follows. As can be seen from the Fig. 2, the sip protocol only supports both the terminal and the IMS, and it's just a transmission function for wireless access networks.

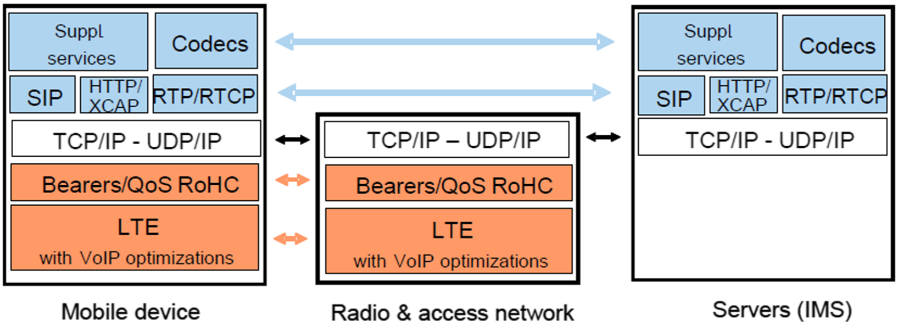

Fig. 2. Protocol architecture of VoLTE

3 Analysis of User Requirements in Power Network

The wireless special network can support the construction of smart grid, support distribution automation, marketing load control, power collection, smart home, new energy grid-connected communication, operation inspection and repair monitoring and other smart grid services, to meet the requirement of reliability, security, real-time (Tables 1 and 2).

Table 1. Demand analysis of power distribution automation services

	Department	Name of the service	Irish coefficient	Delay requirements	Quantity demand
1	Operation monitoring	Distribution automation	1	<500 ms	1000
2	Distribution transportation inspection room	Robot inspection	1	<2 s	30
3		Environmental monitoring	1	<2 s	15
4		Three-dimensional emergency repair	0.3	<2 s	15
5		Field remote management and visualization	0.3	<2 s	15

Table 2. Demand analysis of Smart grid extension service

	Department	Name of the service	Irish coefficient	Delay requirements	Quantity demand
1	Transformation and transportation room	Digitization and Informatization Management of Substation equipment	0.3	<2 s	15
2		Remote video monitoring and application of maintenance site	0.3	<2 s	15
3	Power transmission and inspection room	Intelligent Monitoring of Transmission Line Operation State	0.3	<2 s	10
4	Cable inspection room	Popularization and Application of Intelligent grounding Box for Power Cable	1	<2 s	60
5	Sales department	Intelligent building construction	0.1	<2 s	10
6		Scenery storage microgrid	1	<2 s	15
7		Smart home	1	<2 s	1000
8		Demand response information platform	0.1	<2 s	15
9		Electricity Information Collection	0.1	<2 s	5000
10		Power management service platform	0.5	<2 s	150
11		Electric automobile charging pile	1	<2 s	30
12		Shore charging pile	1	<2 s	15

(*continued*)

Table 2. (*continued*)

	Department	Name of the service	Irish coefficient	Delay requirements	Quantity demand
13		Electric load control	1	<2 s	100

4 Test Environment of VoLTE

The system is composed of wireless private network, IMS special network, administrative mobile background service and mobile soft terminal [19]. In which the IMS private network and the administrative mobile background service are deployed in the machine room, the wireless private network is deployed at the power company headquarters building, and the base station of wireless private network is in the substation. The deployed wireless private network is connected with the IMS private network and the administrative mobile background service through the SDH channel. The composition architecture of the system is as shown in the figure [20] (Fig. 3).

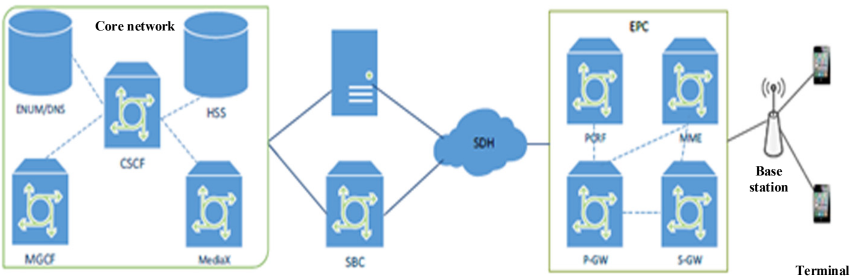

Fig. 3. Architecture of wireless private network system

The power wireless private network provides three voice solutions, the first is UC client;2, the second is administration client; the third is VoLTE. Scenarios 1 and 2 belong to the VoIP pattern, in this mode, the client software needs to be deployed on the mobile phone. The service platform is deployed on the IMS core network, and the terminal is accessed via wireless private network and registered to the service platform. Solution 3 does not need to deploy client software on power private network mobile phones. The performance indicators of voice and video under the three voice solutions are tested in this test.

Performance index refers to the quality of voice and video calls under different wireless signal intensities. The specific performance indicators are shown in the following table. The test car runs at medium speed depending on the actual road traffic conditions, and the vehicle speed is about 30 km/hour (Table 3).

Table 3. Alternative condition

	RSRP	SINR
Test point in good condition	−85 ~ −95 dBm	16–25 dB
Test points in medium condition	−95 ~ −105 dBm	11–15 dB
Test points in poor condition	−105 ~ −115dBm	3–10 dB
Test points in very poor condition	<−115dBm	<−3 dB

5 Test Result

5.1 Test of Voice Quality

The test topology diagram shows that a pair of test terminals are attached to the power wireless private network and registered to the UC background and the administrative background respectively (Fig. 4).

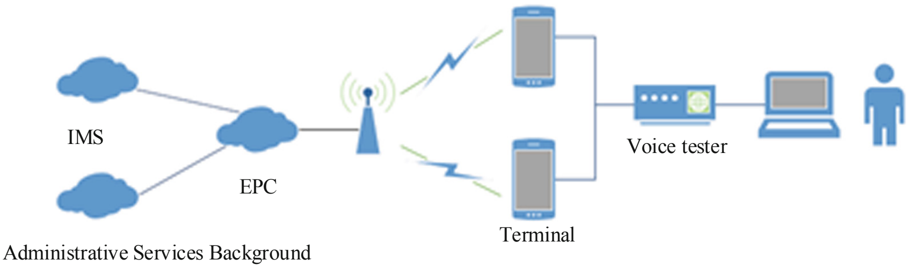

Fig. 4. Fixed-point voice test topology

Two test terminals are connected to the voice tester, and one test terminal acts as the caller and calls the other terminal. After dialing, sending the voice through the voice tester to the called terminal through the calling terminal, and returning the voice to the voice tester after being accepted by the called terminal. The test results are as follows.

(1) Voice test under good conditions

RSRP = −67 dBm and SINR = 28 dB, and the test site is 1 km from the base station by the side of the road (Tables 4 and 5)

Table 4. MOS value of speech quality (a good place)

Value of MOS / Terminal	Administrative communication	UC Client
Terminal1	4.01	4.37
Terminal2	3.43	4.06

Table 5. End-to-end call delay (a good place)

Delay / Termianl	Administrative communication （ms）	UC Client （ms）
Terminal1	430	400
Terminal2	530	420

(2) Voice test under medium conditions

RSRP = −98 dBm and SINR = 16 dB, and the test site is 3 km from the base station by the side of the road (Tables 6 and 7)

Table 6. MOS value of speech quality (a general place)

Value of MOS / Terminal	Administrative communication	UC Client
Terminal1	4.03	4.39
Terminal2	3.61	4.11

Table 7. End-to-end call delay (a general place)

Delay / Termianl	Administrative communication （ms）	UC Client （ms）
Terminal1	440	410
Terminal2	540	420

(3) Voice test under poor conditions

RSRP = −108 dBm and SINR = 11 dB, and the test site is 5.5 km from the base station by the side of the road (Tables 8 and 9)

Table 8. MOS value of speech quality (a bad place)

Value of MOS / Terminal	Administrative communication	UC Client
Terminal1	1.70	2.46
Terminal2	3.26	3.80

Table 9. End-to-end call delay (a bad place)

Delay / Termianl	Administrative communication （ms）	UC Client （ms）
Terminal1	720	680
Terminal2	590	430

(4) Voice test under very poor conditions

RSRP = −120 dBm and SINR = 0 dB, and the test site is 7 km from the base station by the side of the road (Tables 10 and 11)

Table 10. MOS value of speech quality (a very poor place)

Value of MOS / Terminal	Administrative communication	UC Client
Terminal1	无法接通	2.15
Terminal2	2.73	3.66

Table 11. End-to-end call delay (a very poor place)

Delay / Termianl	Administrative communication （ms）	UC Client （ms）
Terminal1	Unable to connect	930
Terminal2	770	560

6 Test of Video Quality

The test topology diagram shows that a pair of test terminals are attached to the power wireless private network and registered to the UC background and the administrative background respectively (Fig. 5).

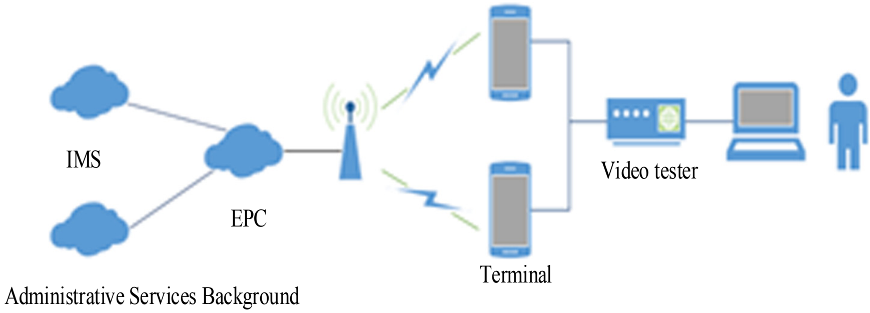

Fig. 5. Fixed-point voice test topology

Two test terminals are connected to a voice tester, and one test terminal acts as a caller and calls the other terminal. After dialing, the video stream is sent to the called

Table 12. Test results of video quality index (a good place)

Quality of video / Terminal	Administrative communication	UC Client			
		MOS	Video frame rate （fps）	Frozen rate （%）	Damage rate （%）
Terminal 1	The screen is not clear	3.1	19.0	0.2	3.5
Terminal 2	Nonsupport	2.6	17.8	0.1	10.4
Terminal 3	Nonsupport	2.1	13.8	0.2	10.6
Terminal 4	Average 10 seconds, disconnect.	1.1	13.6	0.2	29.3

terminal through the calling terminal through the video quality tester, and the called terminal receives it and returns it to the video quality tester.

(1) Video test under good conditions
RSRP = −67 dBm and SINR = 28 dB, and the test site is 1 km from the base station by the side of the road (Table 12)

(2) Video test under medium conditions
RSRP = −98 dBm and SINR = 16 dB, and the test site is 3 km from the base station by the side of the road (Table 13)

Table 13. Test results of video quality index (a general place)

Quality of video / Terminal	Administrative communication	UC Client			
		MOS	Video frame rate (fps)	Frozen rate (%)	Damage rate (%)
Terminal 1	Nonsupport	2.1	12.2	0.5	9.9

(3) Video test under poor conditions
RSRP = −108 dBm and SINR = 11 dB, and the test site is 5.5 km from the base station by the side of the road (Table 14)

Table 14. Test results of video quality index (a bad place)

Quality of video / Terminal	Administrative communication	UC Client			
		MOS	Video frame rate (fps)	Frozen rate (%)	Damage rate (%)
Terminal 1	Nonsupport	2.2	10.8	0	6.6

(4) Video test under very poor conditions
RSRP = −120 dBm and SINR = 0 dB, and the test site is 7 km from the base station by the side of the road (Table 15)

Table 15. Test results of video quality index (a bad place)

Quality of video / Terminal	Administrative communication	UC Client			
		MOS	Video frame rate (fps)	Frozen rate (%)	Damage rate (%)
Terminal 1	The screen is not clear	Easy to drop line			
Terminal 2	Nonsupport	Video communication is normal.			
Terminal 3	Nonsupport	2.1	12.9	0.4	7.8
Terminal 4	Average 10 seconds, disconnect.	Video communication is normal.			

7 Road Test

(1) Test terminal is terminal 1, and the call mode is administrative communication. The road test results are shown in the figure below (Fig. 6).

Fig. 6. Road test results

(2) Test terminal is terminal 2, and the call mode is administrative communication. The road test results are shown in the figure below (Fig. 7).
(3) Test terminal is terminal 1, and the call mode is UC Client. The road test results are shown in the figure below (Fig. 8).
(4) Test terminal is terminal 2, and the call mode is UC Client. The road test results are shown in the figure below (Fig. 9).

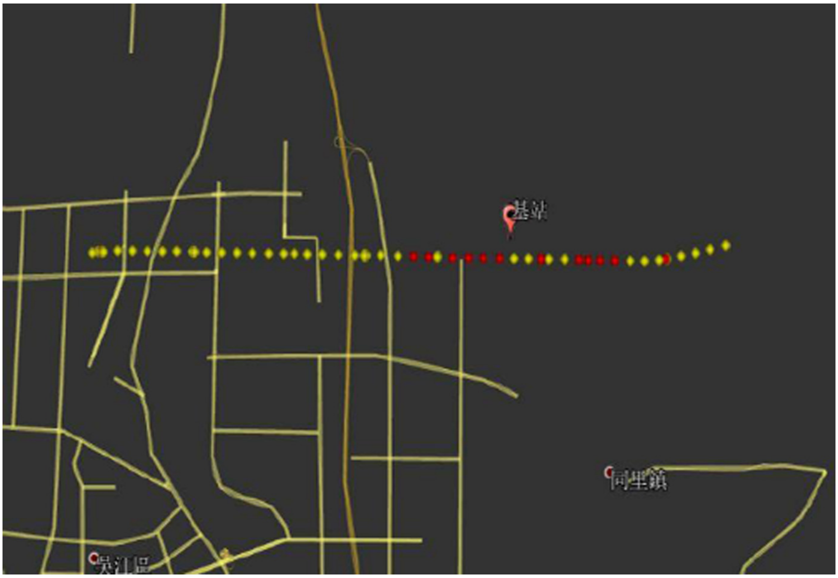

Fig. 7. Road test results

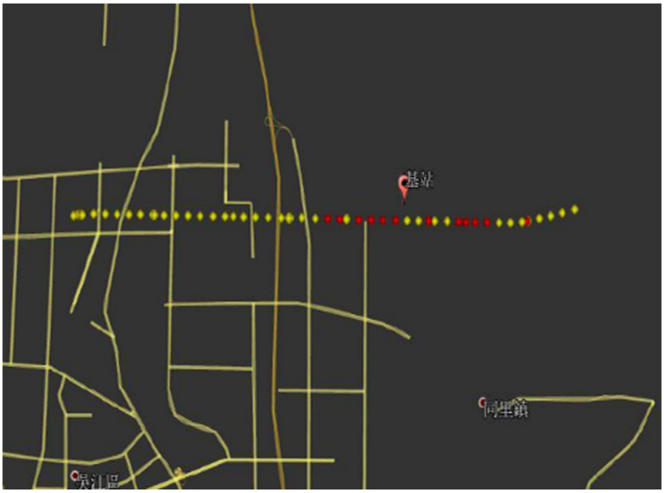

Fig. 8. Road test results

The green marker in the above test results indicates that the MOS value of voice is more than 4, the yellow marker indicates that the MOS value of voice is more than 3, and the red marker indicates that the MOS value of voice is less than 3. From the above test results, it can be seen that in the same call mode, the call performance of terminal 2 is better than that of terminal 1 at the edge far from the base station. In the UC mode,

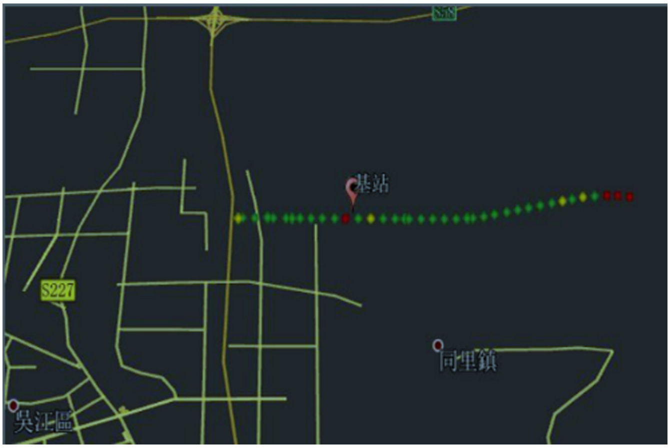

Fig. 9. Road test results

the MOS value of voice is mostly > 4, while in the administrative mode, the MOS value of voice is between 3 and 4.

8 Conclusion

In this paper, based on the wireless private network, the application of VoLTE technology in power wireless private network is studied, and the performance index of power wireless private network in three voice solutions based on multiple terminals and VOLTE is tested. The performance indexes include the voice, the video call quality under different wireless signal strengths, and the call quality in the course of road motion. The analysis of Volte research in power wireless private network supports the application of power wireless private network in the future, provides technical support, and lays a solid foundation for the popularization and application of power wireless private network.

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