Avoid Repetition in Intensive Indoor Coverage Construction

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一、Preface

Indoor coverage system is an indispensable part in wireless communications network. According to statistics, 70% percent of traffic is coming from indoors. Therefore, to provide excellent indoor wireless communications, eliminate indoor wireless signal “dead angle”. Improve indoor coverage communications quality, avoid repetition in construction, and to practice an intensive construction with co-construction and sharing are necessary and significant, and they are also feasible in technique and in engineering, now let’s discuss it from technique approach.

Mobile communications indoor distribution system is the main infrastructure of Telecom.’s. Early in October 2005, at the proposal of Shanghai Radio Administration, Shanghai municipal government decreed implementation rules of “Multi-network-in-one” intensive construction principle in indoor base station (indoor analysis system) construction. In response to this, Shenzen Linkwave Communications Technology Co.,Ltd. actively put it into practice, and has gained a certain technical and engineering experience. Now I will give your respectful leaders my report.

Since its opening in 2002, Shenzhen Linkwave has developed “multi-network combination indoor coverage system” on its own, and under the powerful supports of Shanghai Information Committee and Shanghai Radio Administrative Committee, Linkwave has deployed active research and experiment in overcoming interference in multi-network-in-one indoor coverage system, and our technique has been successfully applied in the following large projects.

- Multi-network-in-one indoor coverage system applied in Shanghai F1 international circuit (served 2 billion people)
- Multi-network-in-one indoor coverage system applied in Shanghai 125 key project buildings (total area is 1.12billion square meters)
- Multi-network-in-one core component “POI” applied in Beijing Olympics water cube.
- Multi-network-in-one core component “POI” applied in Macao stadium

These important and large projects use 2G+3G combination coverage, WLAN, Tetra800 and other systems are also contained in some projects.

These successful cases, set clear evidence that the mobile communications indoor coverage system in 2G+3G with multiple operators and multiple systems can definitely be achieved with high quality, strong scalability and low cost. They also prove that infrastructure co-construction and sharing is absolutely feasible in indoor coverage system.

二、Main Difficulties and Solutions in Intensive Multi-Network-in-One Indoor Coverage System

To establish a single indoor distribution system in one building to serve three major operators in the same time, and to realize excellent signal coverage. The main technical challenges we are facing are the interference among different systems and the equalization among different signal powers.

1. Interference type

In multi-network-in-one indoor coverage, to realize the full and even coverage of uplink signals and downlink signals from different networks, and to reject interference, the foremost thing is to eliminate interference.

In indoor coverage, network and channel taken by a certain user is the transmit channel of useful signal, whereas, other signals of this network and other networks are all interference signals which must be prevented from spreading to the useful channel. Interference in multiple operators and multiple network signal combination transmit is more than that of one operator transmit alone. Therefore, technical difficulties will be increased. The main interferences are analyzed as follows:

- **Spurious Interference**

Spurious emission of a transmitter from a certain network constitutes spurious interference to other receivers in other networks.

- **Blocking Interference**

Although a transmit signal frequency from a certain network is out of the band of other receivers, it is too strong, and the filtering function of the receiver been interfered is not adequate enough to resist, this causes the block of the receiver that it cannot work normally, that is a very serious problem.

- **Intermodulation Interference**

In indoor coverage, BS downlink strong signal in multi-network should be transmitted to distribution system after combination by filter. Although combining filter is a passive component, there is still tiny nonlinearity. Moreover, with multi-network downlink strong signal, there might be intermodulation frequency as well , f1±f2, 2f1-f2, 2f2-f1 and f1+f2-f3 are the most regular second order and third order intermodulation frequency components. When the intermodulation frequency is just between the uplink frequencies of a certain BS receiver, interference to the signals received by this certain network would be occurred. This kind of interference belongs to the same frequency interference which cannot be filtered by the receiver, and can pose serious damage to signal quality.

for example：

① f1=878.49MHz(China Unicom CDMA downlink 870～880MHz)

f2=957MHz（China Unicom CDMA downlink 954～960MHz）

f3=940MHz（China Mobile GSM downlink 930～954MHz）

third order intermodulation product：f 互=f1+f2-f3=895.49MHz

(network been interfered：China Mobile GSM uplink 885～909MHz)。

② f1=950MHz(China Mobile GSM downlink 930～954MHz)

f2=2112MHz[3G(FDD main) downlink 2110～2170MHz]

f3=2154MHz[3G（FDD main）downlink 2110～2170MHz]
third order intermodulation product：f 互=f1+f2-f3=908MHz
(network been interfered：China Mobile GSM uplink 885～909MHz).

2. Interference Solution

① High-performance "POI" equipment can effectively solve stray interference and block interference:

POI is the core equipment of multi-system combination. Using POI with over 80dB stop band suppression is the principal solution of mutual block interference and stray interference among multi-network signals.

For instance, DL pass band filter with high stop band suppression can effectively repress the stray interference generated by BS Tx signals on receivers of other networks. UL pass band filter with high stop band suppression can effectively repress the block interference generated by BS DL main Tx signals of other networks on receiver of the network itself.

② The solution of high-performance POI equipment + simplex can effectively eliminate IMD interference of multi-system combine indoor coverage in large buildings:

The transmission of multi-network strong signals are combined into one cable, while multi-network weak signals are transmitted in another cable. Since the two cables are separate, there is relatively high isolation between them. When the IMD component generated by the combination of multi-network strong signals can only be transmitted to BS receiver after passing through the high isolation of 2 cables, it will generate IMD but not interference. Therefore, the target of completely eliminating interference can be achieved.

The solution is especially suitable for large indoor coverage scenario. In such cases, there are many IMD interference frequencies formed by signals of various bands due to its heavy traffic and the large number of network signal carriers. It can eliminate all IMD components if UL and DL signals are transmitted respectively in two cables, that is, simplex transmission, besides that, the solution is also highly stable and reliable.

Simplex POI equipment is required to have over 80dB stop band repression to eliminate stray interference and block interference. On the other hand, the specification of IMD attenuation reflecting POI non-linear characteristics should reach over 80dBc for 2-order IMD, and over 120dBc for 3-order IMD, which can guarantee the complete repression of IMD component.

③ It can effectively solve the IMD issue in multi-system combine indoor coverage inside medium or small buildings using high-performance POI equipment and duplex transmission:

Duplex indoor coverage requires the designer to have analysis calculation of IMD interference. Moreover, the designer should also have IMD interference calculation of the network required by the property owner, including the calculation of IMD frequency and interference level. After that, the designer can determine the Spec. requirement of IMD attenuation indoor coverage components having to achieve according to the average IMD interference Spec.

Since transmission network and level are different, the frequency and level of IMD interference will be different, too. The Spec requirement of quality should be met through calculation.

Our analysis and measurement showed that, 3-order IMD attenuation of multi-carrier combine electrical bridge is commonly required to be over 150dBc, 3-order IMD attenuation of combine filter is commonly required to be over 142dBc, 3-order IMD attenuation of distribution system is commonly required to be over 120dBc, so it can really meet the requirement of duplex IMD attenuation requirement.

Therefore, using duplex design will result in more difficulty in component technology and designing, however, it can reduce construction cost.

Linkwave has successfully worked out mutli-system combine POI equipment, 3-order IMD attenuation of which has exceeded 145dBc. Up to now we have formed volume production, the test result is excellent through practical engineering application. It creates condition for the realization of duplex transmission.

3. Cell Coverage, Power Equalization

Indoor coverage system commonly requires that signals of different networks should have identical coverage area, it is just the foundation that multi-operator and multi-network signal can use one feeder line to achieve coverage with the same broadband antenna so as to avoid repetitious construction.

2G and 3G are two different systems, the difference of their operation frequencies（800～2200MHz） are great. Therefore, it should fully consider all the requirements of different networks in the indoor coverage design of the same building.

Coverage field intensity should be calculated in frequency bands to meet the requirements of different networks. Coverage field intensity of low-frequency 2G signals will have relatively large margin when satisfying the coverage field intensity requirement of high-frequency 3G signals. In practical application, repeaters of different networks are required to equalize coverage field coverage and make full use od signal power resources, that is, in some location, only 3G repeater needs to be installed, which can avoid the installation of 2G repeater.

In this condition, it is required to use band dividing filter to divide combined multi-network signals, then use repeater to amplify high-frequency 3G signals, while low-frequency 2G signals are processed by means of through, finally, use combiner filter to combine signals of different bands into signals of one band then to transmit or radiate.

The indoor coverage of large buildings requires to have repeaters in cells. Currently the superior way is to use optical repeater, which can effectively reduce long-distance loss of signals.

However, repeater will inevitably cause noise in transmission link. Especially in some super-large coverage area, it should have to use more repeaters to meet coverage requirements, which will probably result in the failure of meeting addmitted noise requirement, so it will also be hard to meet the requirement of signal quality. Under such circumstances, it is recommended to consider having other new base stations or micro cellular BS signals sources or remote base stations so that the contradiction between coverage and quality can be resolved.

三、Conclusion

《 Urgent Report of Promoting Co-operation and Sharing of Telecommunications Infrastructure Facilities 》 issued by Ministry of Industry and Information Technology (MIIT) and State-owned Assets Supervision and Administration Commission (SASAC) has promoted the co-operation and sharing of mobile communications indoor coverage infrastructure with great power, and its transmission quality can be as good as that of indoor coverage built respectively by operators. In addition, resources sharing can save the government hundreds of billion yuan (RMB) , which might have been wasted in repetitious constructions without the above governmental policy.

2.During the transformation of previous network or the newly-built multi-system combine indoor coverage of medium or small buildings, when 3-order IMD attenuation of core component-“POI” and relevant combine components can be over 142dBc～150dBc, it is recommended to adopt the design of sharing antenna feeder Rx&Tx co-cable to further reduce construction investment.

3.Multi-operator and multi-system combine indoor coverage of large buildings should adopt the the design of sharing antenna feeder Rx&Tx co-cable, the 3-order IMD attenuation of its core component-“POI” and relevant combine components should be over 120dBc, which can guarantee the transmission quality of signal, achieve the target of co-operation and sharing as well as decrease repetitious construction.

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