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Design and Implementation of In-Building Solution for LTE (4G and 5G) Network

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ABSTRACT

Blend of telecommunication with business, finance and battlefields makes it enhance to govern the future of prosperity. This slogan depicts modern era of wireless communication which is fundamentally beyond any financial limits with idea 'stay connected anywhere anytime'. Due to huge infrastructure many of us find difficult to connect with the RF range while using mobile phones in certain areas like high rise skyscrapers, metallic lifts, basement (Parking Zone), hotels, stadiums and tunnels. So there is need to troubleshoot this coverage holes as user demands high data rate. The primary objective of this paper is to provide solution for mentioned problem by implementing network quality enhancer having matching capability 4G and 5Gmobile network.

KEYWORDS: *RF range, troubleshoot, coverage holes, network enhancer, 4G, 5G.*

1.INTRODUCTION

The number of mobile phone users is growing, and so their demand is for high quality service. People spend a large part of their time inside buildings, and increasingly rely on mobile phones to communicate. Whether it's a crowded convention centre or a remote railway station, users expect their mobile phones to perform. Since building material such as concrete and steel attenuates the incoming RF signal by some dB value, hence the RF strength is reduced, if we move in remote area inside building which degrades the performance of the network.

Due to increases in cellular phone, and data usage, the demand for more capacity in urban areas is ever increasing. Operators must increase the number of available cells to these areas to meet these capacity demands. With the increased number of cells, each cell is required to support a smaller area to minimize interference between adjacent cells. The service providers need a solution that will enable them to increase the number of cells, while minimizing costs on equipment, real-estate, and human resources.

In-Building Continuity is a solution that covers and connects different indoor (in-building) public spaces. It allows more consumers to utilize mobile services, especially bandwidth-intensive data services, in and around high-traffic indoor locations or facilities.

A well-engineered indoor solution allows mobile service providers, site owners and alternative service providers with comprehensive solutions that can be configured with various combinations of network elements to address the specific site needs. Components include access products and services, as well as end-user applications that often leverage location as an attribute.

In-Building continuity can be illustrated through the "islands of life" concept: From work to home, from the mall to the train station, voice and data continuity is there when you need it. Fig1 depicts some of the islands of life that In-Building Solutions help cover. As we move to an island like a mall, one or a mix of access technologies should be available based on size and business justification. The challenge is then to provide the right solution at the right time[3].

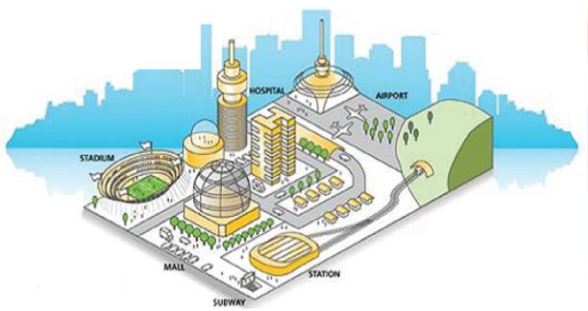

Fig. 1 Islands of Life

Generally, we find the some issues in following parts of building refer fig. 2 below ground level i.e. in basement we have coverage issue now as we move towards higher floor we are lagging in regards with capacity & also quality issue at high rise buildings. To overcome all this challenges in-building solution is the best system.

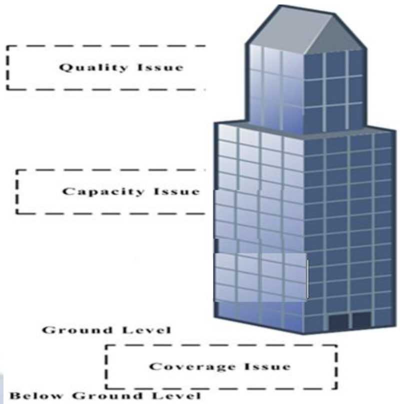

Fig. 2 Issues at Different Heights of Building

2. DESIGN METHODOLOGY

. A building may not receive adequate mobile coverage from outdoor cell sites. This is because in most cases the signals present outside the building are unable to penetrate the building material, thus resulting in poor coverage. A typical problem in high rises is the problem of interference.

Crowded areas like malls, airports, large commercial complexes need a dedicated system to handle the capacity requirements for the large number of calls at such locations. Further with 3G quickly getting popularity amongst these above mentioned demo graphics, network strength, quality and capacity etc are becoming a cause of major concern

A. IBS Design & Implementation

For actual design it is essential to focus on interior of the dedicated site. Also judge the area from where calls are frequently generated. Keeping this high profile area into consideration makes sure that evaluating EIRP which is acronym of "Effective Isotropic Radiated Power", must be higher than other locations. The whole system is called as DAS (Distributed Antenna System).

For implementation of in-building solution we have 6-phases

i. Site Survey.
ii. Planning of DAS .
iii. Implementation of DAS.
iv. Network Planning
v. Walk Test to test the coverage.
vi. Network optimization (as per the feedback by walk test) / KPI monitoring

Fig.3 Implementation In-Building Solution

3. DAS-Distributed Antenna System

With exploding wireless data use, network infrastructure, both in-building and outdoors, must offer adequate coverage and bandwidth to handle and transport this huge amount of data. According to a research carried out by Cisco, smart phones require 24 times the amount of data bandwidth of regular phones, and tablets are even more demanding. They require on average, 122 times more data compared to a regular phone. Future predictions draw a picture of triple digit data increases. To make the task even more daunting, use of data is becoming increasingly localized to areas with a high user density, many of them using multiple devices at the same time. Large office buildings, concentrated residential areas, public buildings like subway stations, airports, sport arenas or convention centers require infrastructure solutions that provide best efficiency, while at the same time resolving coverage and capacity challenges. Signals of different wireless operators with different frequencies have to be accommodated and re-distributed to provide best coverage without mutual interference. Public safety signals often share the same wireless infrastructure with commercial signals. Clearly, networks must guaranty sufficient bandwidth and interference-free operation for these services. Furthermore, in-building and outdoor infrastructure has to be scalable and open for emerging wireless networks and future technologies. To make the most of the benefits of coaxial DAS systems, it is very important to minimize loss at every stage and have the bandwidth to cover present and future needs. For economic reasons, both send and receive signals share the same cable. The system must be designed for the optimal Transmit and Receive levels at every antenna location. This requires very careful planning. A combination of equal and unequal signal splitters establishes the same path loss between base station and each antenna.

B. Steps to design DAS

To deign distributed antenna system refer following steps

i. Link Budget (For EIRP calculation)

It is mandatory to calculate Effective Isotropic Radiated Power by using required component such as type of cable, connector, jumper, coupler, splitter, BTS, suitable antenna.

Here losses due to cable, connector, jumper, coupler, splitter all are considered in dB and should be subtracted from EIRP wherein BTS power, gain of antenna should be added. Record the EIRP of antenna. Above process is represented in following table & process to be followed for rest of the antennas.

Table I DAS - Link Budget

FLOOR		**1st Floor**	
Antenna ID		**AN1F001**	**AN1F002**
Antenna ID		**PN01**	**PN02**
Cable length 1/2" (m)	0.1100	5	5
Cable length 1/2" (m)		60	60
Cable length 1/2" (m)		8	8
Cable length 1/2" (m)		15	15
Cable length 1/2" (m)		5	5
Cable length 1/2" (m)		10	10
Cable length 1/2" (m)			
Total Cable length 1/2" (m)		**103**	**103**
Total Cable loss 1/2" (dB)		**-11.3**	**-11.3**
Cable length 7/8" (m)	0.0600		
Cable length 7/8" (m)			
Total Cable length 7/8" (m)		**0**	**0**
Total Cable loss 7/8" (dB)		**0.0**	**0.0**
Cable length 1 5/8" (m)	0.0371		
Cable length 1 5/8" (m)			
Total Cable length 1 5/8" (m)		**0**	**0**
Total Cable loss 1 5/8" (dB)		**0.0**	**0.0**
Total Cable Loss (dB)		**-11.3**	**-11.3**

Connector	-0.07	**12**	**12**
Connector Loss (dB)		**-0.84**	**-0.84**
Jumper	-0.5	**5**	**5**
Jumper Loss (dB)		**-2.5**	**-2.5**
Coupler C7-CPUS-N (thru)	-1.5		
Coupler C7-CPUS-N (coupling)	-7.0		
Coupler C10-CPUS-N (thru)	-0.7	1	1
Coupler C10-CPUS-N (coupling)	-11.0		
Coupler C15-CPUS-N (thru)	-0.4		
Coupler C15-CPUS-N (coupling)	-16.0		
Total Coupler Loss		**-0.70**	**-0.70**
Splitter 2-way (S2-CPUS-HN)	-3.0	5	5
Splitter 3-way (S3-CPUS-HN)	-5.0		
Splitter 4-way (S4-CPUS-HN)	-6.0		
Total Splitter Loss		**-15.00**	**-15.00**
Total Sum Losses		**-30.37**	**-30.37**
BTS Rack Top Power (dBm)		43.0	43.0
Combiner Nokia GSM 1800 Loss		-7.0	-7.0
Combiner/Diplexer Loss		0.0	0.0
BTS Jumper Loss		-1.0	-1.0
Antenna Gain (dBi)		7.0	7.0
Antenna EIRP (dBm)		**11.6**	**11.6**
Antenna ID		**PN01**	**PN02**
Antenna ID		**AN1F001**	**AN1F002**

ii. Trucking Diagram

Sample trucking is shown below, Design engineer as to follow same procedure for rest of the antennas. During physical implementation this diagram is advantageous.

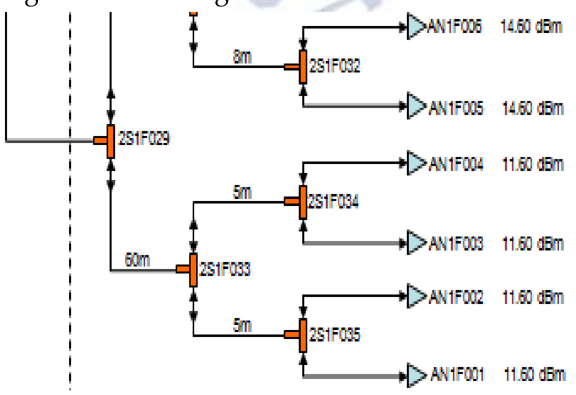

Fig.4 DAS - Trunking Diagram

Consequently, there is very little risk that the fields from the in-building antennas can cause electromagnetic interference in sensitive equipment.

4. RF Planning & Performance Testing

This section elaborates frequency planning and optimization for LTE network.

C. RF Planning

This is the very first step to design network by frequency planning. To plan a frequency for concern site this is different from nearby site so we can avoid both adjacent channel & co-channel interference.

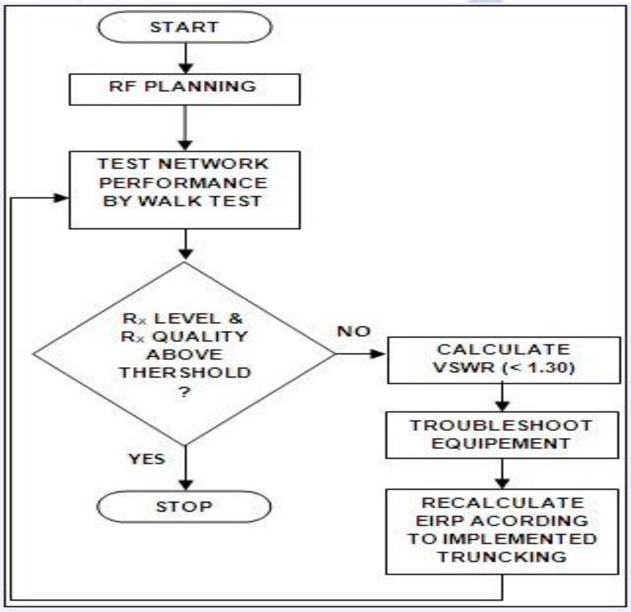

Fig.5 Flow Chart for RF planning & performance testing

D. Network Quality

Check all the parameters through walk test

i. BCCH (As per the planned value), Cell Id
ii. RX-Level
iii. RX-Quality
iv. UL Level ULRXQ
v. SQI-Speech Quality Index
vi. Short call
vii. Long call
viii. Cell selection and reselection (In Ideal Mode)
ix. Hand over
x. No Co and Adjacent channel interference

E. Walk Test

To know the performance of network the test is performed using laptop with either NEMO or TEMS software, mobile with SIM and a data cable. Test is executed in two modes ideal and dedicated.

i. Ideal Mode

Idle mode implies that the test mobile is kept in standby. In other words, no call or SMS is sent. This mode of walk test is usually done in order to determine the coverage of a particular network. The most important parameter to be monitored in idle mode is Rx Level it is measure in dBm

Table II Rx Level _Ideal Mode Statistics

Range	Remark
0 to 4	Good
5 to 6	Average
7 & above	Extremely Poor

ii. Dedicated Mode

Dedicated mode implies that a call has been established by the test mobile. This may either be an incoming call or outgoing call. The most important being call quality and continuity (i.e. handover success).

Table III Rx Quality _Ideal Mode Statistics

Range	Remark
10 to –70 dBm	Good
71 to –90 dBm	Average
-91 and lower	Extremely Poor

iii. Call Connectivity

a. Long Calls: (Coverage, Quality)

Referring to fig.5 indoor coverage verification test consists of several test calls in the indoor cell area along pre-defined measurement routes. The coverage footprint test includes the area where we have implemented antenna.

b. Short Calls (Accessibility/Call Completion)

Test can be performed by running script of Voice Calls per Cell at different locations with a Call Time of 20 sec followed by 10 sec break

iv. Data call test

Test can be performed by running script of Voice Calls per Cell at different locations to record data speed.

v. HOSR – Handover Success Rate

The HOSR is an important KPI assessed by telecom operators because the value of the HOSR directly affects the user experience[5].

$$HOSR = \frac{\text{Successful Handovers}}{\text{Handover Requests}} \quad (1)$$

5. Key Benefits and Limitations

i. Multi-band and multi-carrier transmission accommodate all carrier and Wi-Fi frequencies

ii. Better coverage brings more revenue.

Improving coverage & Capacity inside buildings will increase revenue and give operator an edge over the competition.

iii. Prepared for the future.

Forgot your worries about necessary upgrades. With this implementation we are already prepared for future i.e. for 5G & Wireless LAN.

iv. In-building networks are easily integrated with existing cellular networks, using one system for operation and maintenance. Advanced features ensure efficient use of network resources.

v. Isolated indoor cells yield greater capacity per cell Customized for every building type such as high rise buildings, tunnels, sports centers etc.

Before actual implementation building supervisor must consult to civil engineer for weight carrying capacity of building. Try to install all supportive equipment such as BTS-Base station subsystem, Battery bank & power plant at ground floor.

As antenna will radiate electromagnetic waves check EIRP of each antenna it should be in limits as per the norms of TRI.

6. Conclusion

We have presented effective system to design robust network which offers real practical benefits. The 5G technology can be enhanced using this technique.

Dedicated in-building solution will be implemented to ensure sufficient coverage and capacity at each premises which assures desired data rate.

REFERENCES

[1] VirenderKapoor and S.Tatke "Telecom Today Application and Management of Information Technology" Allied Publishers Pvt.Ltd
[2] www.ericsson.com/globalservices
[3] www.alcatel-lucent.com
[4] http://www.foxcom.com.
[5] Theodore S. Rappaport, "Wireless Communications: Principles & Practice", Second edition, Pearson Education (2002).
[6] Vijay K. Garg :"Wireless network Evolution 2G to 3G" , Pearson Education.
[7] www.anritsu.com

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