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Design of Distributed Antenna System Deployment for 2100 Mhz

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Abstract: A lot of schemes are proposed to exploit the transmit diversity. Distributed antenna systems (DAS) constitute one of the most attractive schemes to efficiently achieve the stringent quality of service demands of next generation wireless networks. In this project, it is investigated MISO assisted different transmission techniques used in DAS and the performance of downlink multi-cell DAS in terms of capacity improvement using SINR for different transmission scheme. A system level simulation tool is used to analyze the performance [1].

The aim of this paper is to assess the applicability of a Repeater connected to a Distributed Antenna System (DAS) for improving indoor capacity in UMTS radio network (2100 MHz). A guarantee of sufficient coverage and capacity for In-building areas constitutes a considerable issue in topology planning, because in both links, indoor users produce high interference to the outdoor network due to significant indoor propagation losses. Presented configuration effectively exploits effectively a Repeater system that amplifies the signal from the outdoor network and delivers it for indoor locations through distributed antenna system. Implementation of the analyzed Repeater system is straightforward as it does not require usage of separate carrier. Moreover, any separate scrambling codes do not have to be dedicated either. Conducted measurement campaigns reveal improvement of radio conditions due to Repeater implementation that results in 35% gain of downlink capacity for indoor locations.

Keywords: DAS (Distributed Antenna System), RF transceiver Antennas, repeaters, UMTS (Universal Mobile Telecommunication System) 2100 MHz

I. INTRODUCTION

The Distributed Antenna system (DAS) usually use an external, directional antenna to collect the best cellular signal, which is then transmitted to an amplifier unit which amplifies the signal, and retransmits it locally, providing significantly improved signal strength. The more advanced models often also allow multiple cell phones to use the same Repeater at the same time, so are suitable for commercial as well as home use [2].

In cellular communication, Repeaters are classically used for providing coverage in dead spots, which mainly constitute hardly accessible areas for regular base station deployment. In most of the scenarios, utilization of Repeaters is very cost effective, as it decreases the number of required base stations. Moreover, in it was presented that properly deployed and configured Repeaters constitute an effective capacity enhancement in CDMA-based networks [2]. Hence, Repeater systems can provide flexible and inexpensive solutions for varying traffic conditions, for hotspots (i.e. Areas with high capacity requirements), and also for serving indoor users.

Typically, cellular networks providing service in majority of indoor locations must support high capacity requirements due to expected presence of active business subscribers using packet-based applications. Performance of the WCDMA (Wideband Code Division Multiple Access) network without specified approach supporting indoor traffic is limited, because high power required by indoor users produces interference that naturally limits the overall network capacity. Moreover, appropriate operation of HSDPA (High Speed Downlink Packet Access) in UMTS (Universal Mobile Telecommunication System) requires favourable radio conditions, which in indoor environment can be achieved only when dedicated antenna system is used. Therefore, from early stages of topology planning, indoor traffic with associated capacity requirements needs to be carefully considered [2].

A straightforward approach for improving indoor capacity constitutes a method of dedicating an additional carrier for indoor coverage in addition to the existing microcellular layer. However, in long term while the traffic of surrounding

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microcellular cells increases, operators prefer to retain this opportunity for immediate capacity enhancements. Alternative solution for supporting indoor traffic is an assignment of HCS (hierarchical cell structure) with a separate cell dedicated only to indoor environment. With this approach, indoor users that are served by an indoor cell do not cause that much interference to the other connections in surrounding network. Hence, the capacity of indoor and also neighbouring cells significantly increases, as presented in, where indoor Pico base stations are considered. The capability of an indoor cell for handling high load can be further enhanced by deployment of DAS (distributed antenna system). Due to high probability of LOS (line of sight) connections to indoor antennas, radio conditions are significantly improved resulting in, e.g., better code orthogonality. Moreover, favourable radio conditions improve HSDPA capacity, since it allows transmission with higher order MCS (modulation and coding scheme) [2].

II. DAS STRUCTURE

A Distributed Antenna System, or DAS, is a network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure. DAS antenna elevations are generally at or below the clutter level and node installations are compact [3].

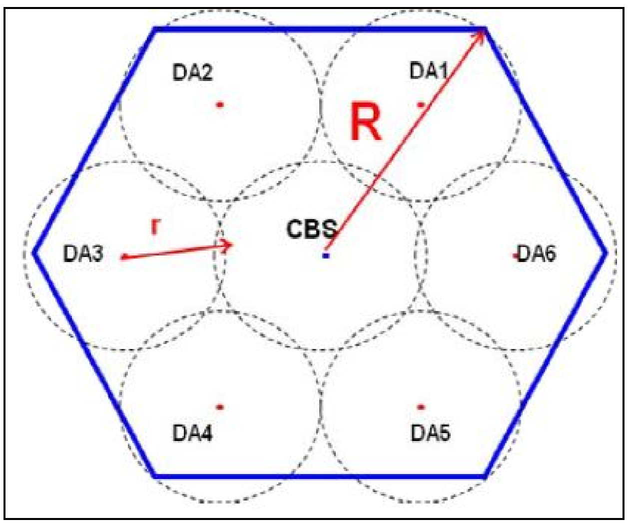

Fig.1. Structure of DAS in one CELL

In DAS, the main processing modules such as channel cards are centralized at a location (central unit) and are connected with distributed antenna modules. Each distributed antenna module is physically connected with a home base station via dedicated wires, fiber optics, or an exclusive RF link. As previously mentioned the dedicated connections do not construct the information-theoretic relay channel and thus differentiate DAS from cooperative communications. A general architecture of DAS in a multicell environment is given in Figure 1, where a cell is covered by a small base station and six distributed antenna modules. In contrast, the same area is covered by only a single high-power base station in traditional cellular systems. Alternatively, the small base station and 6 distributed antenna modules can be viewed as an alternative to 7 small traditional base stations (pico/micro cells) [4]. The actual number of distributed antenna modules would be determined by coverage, user densities, and other environmental factors but we only consider 6 distributed antenna modules as a reasonable example.

III.DAS DEPLOYMENT FOR 2100MHZ

A Distributed antenna system can be implemented using passive splitters and feeders, or active-Repeater amplifiers can be included to overcome the feeder losses. In systems where equalization is applied, it may be

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desirable to introduce delays between the antenna elements. This artificially increases delay spread in areas of overlapped coverage, permitting quality improvements via time diversity [2].

If a given area is covered by many distributed antenna elements rather than a single antenna, then the total radiated power is reduced by approximately a factor $N^{1-n/2}$ and the power per antenna is reduced by a factor $N^{n/2}$ where a simple power-law path-loss model with path-loss exponent n is assumed. As an alternative, the total area covered could be extended for a given limit of effective radiated power, which may be important.

In DAS, the main processing modules such as channel cards are centralized at a location (central unit) and are connected with distributed antenna modules. Each distributed antenna module is physically connected with a home base station via dedicated wires, fiber optics, or an exclusive RF link. As previously mentioned the dedicated connections do not construct the information-theoretic relay channel and thus differentiate DAS from cooperative communications. A general architecture of DAS is given in a multicell environment, where a cell is covered by a small base station and six distributed antenna modules. In contrast, the same area is covered by only a single high-power base station in traditional cellular systems. Alternatively, the small base station and 6 distributed antenna modules can be viewed as an alternative to 7 small traditional base stations (pico/micro cells). The actual number of distributed antenna modules would be determined by coverage, user densities [3],

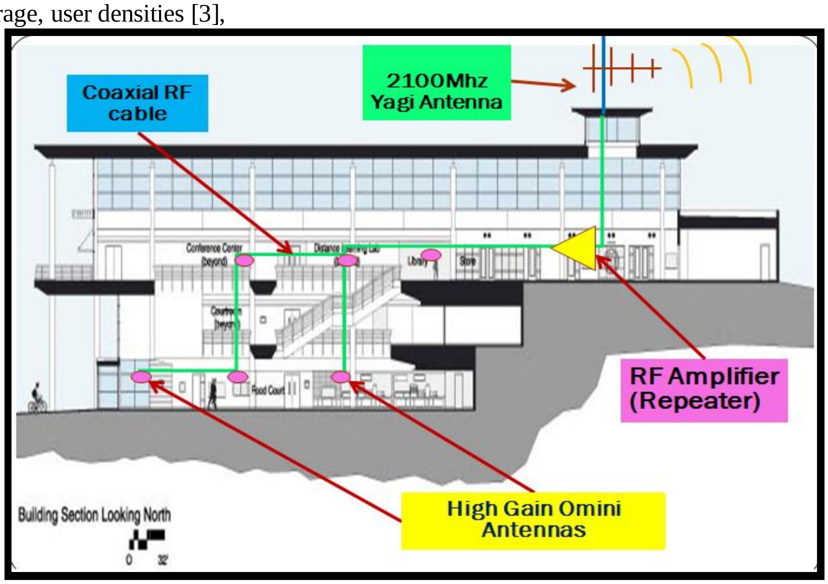

Fig.2. DAS implementation design with the RF elements

IV. ELEMENTS OF DAS

A. *RF Repeaters*

Repeaters are used to increase the range of a transmitted signal by re-transmission. For a conducted signal, an amplifier is used. Optical systems don't amplify but all these devices give the appearance of doing so. A Repeater is needed to secure sufficient isolation between donor and service antenna. When the isolation is lower than actual gain + reserve (typically 5-15 dB) then the Repeater is in loop oscillation. Also cheap models are equipped with automatic gain reduction in case of poor or weak isolation. In case of poor isolation the device works but with low gain, and coverage is poor.

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B. RF Antennas

The antenna is a vital part of any Repeater installation. Because the function of a Repeater is to extend the range of communications between mobile and portable stations, the Repeater antenna should be installed in the best possible location to provide the desired coverage.

1) External directional antenna: Generally the larger the external antenna the better the signal although even a small, correctly oriented external antenna should provide better signal than the internal antenna on any cell phone. These can either be fitted by professionals or will include a signal strength monitor for easy alignment.

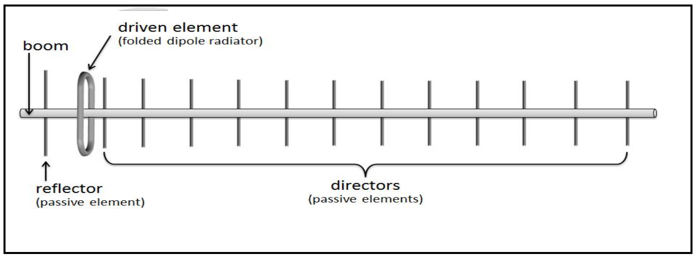

Fig.3. External directional Yagi Uda antenna

2) Internal rebroadcast antenna: The better systems will generally include an internal monopole antenna (although the type of antenna is far from standardised) for rebroadcasting the signal internally - the advantage of using a monopole antenna is that the signal will be equally distributed in all directions (subject, of course, to attenuation from obstacles). Because all radio antennas are intrinsically polarized, cell phones perform best when their antennas are oriented parallel to the booster's antenna - although within reasonable proximity the booster's signal will be strong enough that the orientation of the cell phone's antenna will not make a significant difference in usability.

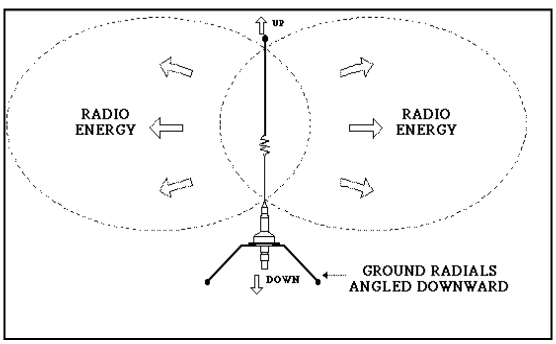

Fig.4. Internal rebroadcast Omni-directional antenna

C. RF Passive components

1) *Splitters*
2) *Combiners*
3) *Couplers*
4) *Duplexers*

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5) Terminators
6) Connectors
7) Feeder cables

V. MEASUREMENT RESULTS AND ANALYSIS

A) Indoor environment

The presented capacity analysis is based on the method that exploits Ec/N0 statistics for reliable DL capacity estimation. The referred method is comprehensively described in. Ec/N0 is a function of RSCP (received signal code power) of the P-CPICH and RSSI (received signal strength indicator). Thus, it provides a feasible reference for evaluation of the DL interference increase as a function of DL throughput. Improvement in the level of the other-to-own-cell interference (iDL) in the Repeater scenario can be directly estimated from the difference in the IDLE mode Ec/N0 measurements conducted in an empty network. Measurement results of Ec/N0 observed with two different load situations in the same network configuration provide information about the sensitivity of the network configuration for increase of load. Hence, the maximum achievable (average) DL capacity can be estimated by an inverse load curve assuming certain allowed noise rise, see for load equations. In order to evaluate the capacity by the referred method, in addition to the other-to-own-cell interference (iDL), the average orthogonality factor (α) needs to be estimated. In performed analysis, the distance dependent orthogonality model is used for the estimation of α.

B) Outdoor environment

Achieved capacity gain in indoor location is mainly caused by lower DL transmit power to the indoor hotspot mobiles served through the Repeater. Logically, the interference produced to the neighbouring cells should be considerably lower resulting in higher capacity of the microcellular network surrounding the indoor hotspot, As expected, due to Repeater deployment, mean value of the *Ec/N0* observed over the outdoor route with presence of the indoor interference was improved from -5.81 dB to -5.32 dB. The measured average throughput was observed at the level of 296 kbps in the original configuration and 124 kbps for the scenario with the Repeater. The capacity estimation of the network surrounding the indoor hotspot was performed in a manner that each cell was analyzed individually. Based on *Ec/N0* and load measurements observed in particular cells, the capacity was estimated for each cell separately. The resulting average capacity for the entire network matches the value obtained from the network perspective analysis (not shown here). The capacity analysis shows that actual implementation of the indoor Repeater system decreases the interference produced to the surrounding network as well. Hence, the capacity of the whole network is improved from 900 kbps to 1050 kbps.

		Serving cell (#)	E_c/N_0 [dB]	Total throughput [kbps]
REPEATER OFF	*IDLE* mode, empty network	1 2	-6.91 -4.4	
	One served mobile	1 2	-7.45 -5	162 330
REPEATER ON	*IDLE* mode, empty network	2	-3.37	
	One served mobile	2	-4.17	314
	Three served mobiles	2	-5.18	623

Table1. Average *Ec/N0* and DL throughput in indoor environment for considered topology and load configurations

VI. Conclusion

In this paper, the feasibility of a Repeater-to-DAS configuration for indoor hotspots was evaluated by field measurements performed in UMTS network. In the considered system, properly deployed donor antenna of the Repeater delivered an amplified signal to the indoor users through DAS. Hence, superior hearability of the serving cell was ensured for indoor locations, and at the same time, the contribution of interfering cells was minimized. The measurement results indicate that the considered system is highly applicable solution for providing capacity for indoor hotspots. Based on the utilized DL capacity estimation method, the downlink capacity in the indoor environment with 3dB DL noise rise increases from 655 kbps in the original configuration to over 1 Mbps (35% capacity gain) when the indoor Repeater system is used. General improvement of indoor radio conditions was also observed by tracking SIR measurements. Due to Repeater implementation, SIR increases from 14.82 dB to 18.23 dB, which in turn might boost the capacity of HSDPA.

The results clearly indicate that users served through the Repeater do not require as high DL transmit power. Thus, the interference produced to the neighbouring cells is significantly lowered. This phenomenon naturally influences the radio capacity of the neighbouring cells that increases from 900 kbps to 1050 kbps (capacity gain 15%).

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