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Reducing Call Drop in Mobile Cellular Communication by using MIMO Antenna

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Abstract— In this manuscript, we propose the solution of reducing call drop in mobile cellular communication by using MIMO (multiple input and multiple output) antenna. Call drop problem in mobile communication directly affects the customer requirement. The multiple reasons behind the call drop is handover failure call drops, LAPD (Link Access Protocol on D-channel) call drops and the radio frequency call drops (RF call drops). These are all common type of call drops occurring during the processing of calls in wireless communication. A novel approach to solving these problem of call drops has been discussed by using MIMO antenna. The solution proposed in this manuscript consists of theoretical concepts, accordingly suitable hardware needs to be selected.

Keywords— MIMO antenna, Call drop, Mobile station, BTS, Cellular communication, Beamforming, Handoff,

I. INTRODUCTION

Nowadays increased need of cellular radio service is growing rapidly, and in extremely populated areas the need arises to reduce the “scale” the clustering pattern and cell sizes. The extension of services into in-buildings and in pedestrian areas further enhances this style. Cellular systems incorporate micro and picocells for pedestrian use, with macro cells for roaming mobiles. The relation between call drops with handover and its effects on performance is completely conversed in [1]. The effect of user mobility on call drops in cellular mobile communication considering different patterns for user mobility was discussed in [2]. The impact on handover failures on call drops for different classes of calls are studied in [3, 4]. In case of [5], beginning from the statistical analysis of data in a real cellular communication, the lognormal assumption for scattering of the call holding time of both the normally terminated and the dropped calls has been verified. The phenomena which cause the conversation interruption have been classified, verifying that call drop failure become negligible in a well-established mobile telecommunication network. All the previous works indirectly consider that an appropriate radio planning has been carried out and there is no apparatus failure or network outage. Such assumptions lead to consider that calls are dropped mainly due to the failure of the handover procedure. The call drops due to lack of radio resources will be a rare event in a well-established optimized network. Hence new theoretical concepts to study the call dropping phenomenon as a function of call arrival rate, call duration, propagation conditions, equipment hardware faults and improper radio parameter settings are needed. The main objective of this manuscript is to solve the problem of call drops reasons in mobile cellular communication by using MIMO antenna in the mobile phones.

II. TYPES OF CALL DROPS

Some important common types of call drops that can be quantized from Base station subsystem (BSS) of GSM network are classified.

A. RF call drop due to uplink failure

The uplink failure factor observed by system is link fail. When the site cannot properly decode a SACCH (slow associated control channel) message due to severe uplink interference, the timer is decreased by 1; when the site correctly decodes a SACCH message, the timer is increased by 2. When the timer value is zero, the site stops transmitting downlink SACCH and starts the rr_t3109 timer (rr_t3109>T100). When T100 of MS is timeout, MS returns to idle mode and call drop occurs. The site releases the radio channel when the rr_t3109 timer is timeout and BSC (Base station controller) will send a Clear request message to MSC (Mobile Switching center). Either uplink failure or downlink failure will stop sending SACCH to the opposite end which results in radio link time out and call drops.

B. RF call drop due to downlink failure

According to GSM specification, MS (Mobile station) has a timer S (T100) which is allotted with an initial value called RLT (radio link timeout) through BCCH channel (Broadcast control channel). In the presence of severe interference in downlink, MS cannot correctly decode the SACCH which transfers system information message. S is decreased by 1 when MS fails to decode SACCH message and is increased by 2 whenever it decodes SACCH message. S will not exceed the initial value defined by RLT. When S value reaches zero, MS will release radio resource connection abruptly which will results in call drop.

C. ***Reasons for RF Call drop***

1. Unreasonable radio parameter settings.
2. Intra-network interference.
3. Existence of weak coverage area and weak radio signal.
4. Equipment hardware faults such as low output power of the power amplifier, large difference among different carrier transmission power, carrier transmitter fault, combiner fault and splitter fault.
5. Faults in antenna feeding system.
6. Weak battery power.

D. ***Handover failure Call drop***

If MS receives handover command or assignment message but fails to handover to the destination cell and does not return to the originated cell either, then it results in handover failure call drops. Here MS fails to occupy the originated cell channel and sends handover transfer complete message, neither does MS returns to the original cell channel and sends handover failure or assignment failure message. In this case MS is divided from the network. At this moment, the handover control timer of BSC will be timeout and notify MSC to clear release, and count this exception event as handover failure call drop. BSC handover control timers can be divided into: T8 timer timeout (inter-cell handover under different BSC), T3103 timer timeout (inter-cell handover under a BSC), T3107 timer timeout (intra-cell handover). The signalling flow of handover failure drop for different cases is shown in Fig. 1, 2 and 3.

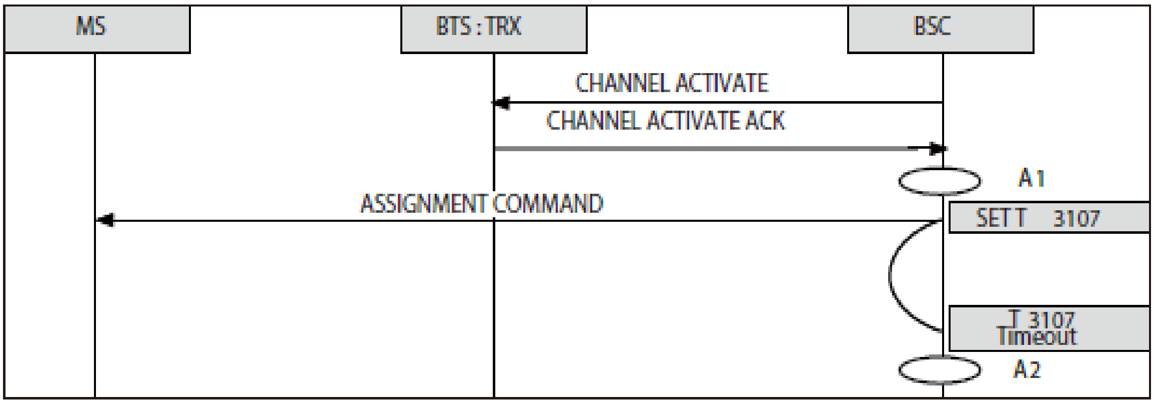

Figure 1. T3107 Timeout (intra -cell handover failure)

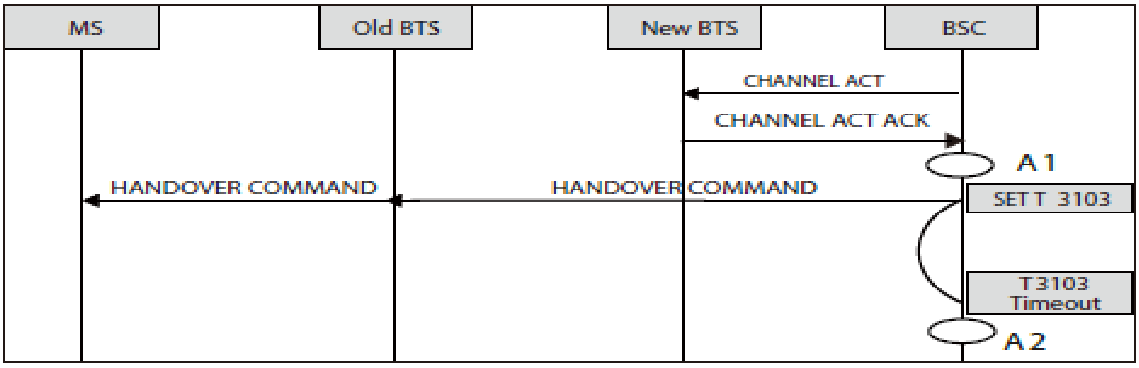

Figure 2. T3103 Timeout (inter -cell handover failure)

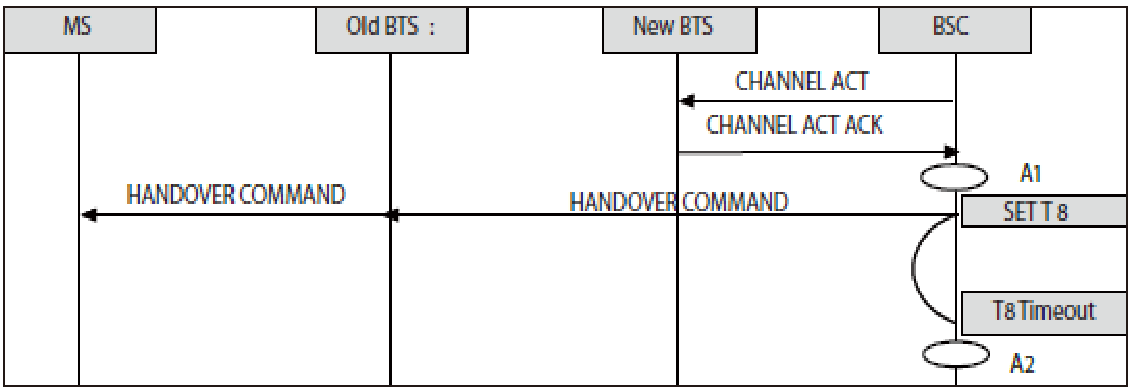

Figure 3. T8 Timeout (inter -cell handover failure under different BSC)

E. Reasons of Handover Failure Call drop

Optimization of handover calls drop need to be implemented together with optimization of handover success rate, especially the handover-out success rate.

The following are reasons of handover failure call drop:

1. Existence of interference such as intra-network interference due to unreasonable frequency planning and other external interference.
2. Equipment hardware fault, such as clock fault in destination cell or in source cell, low output power of the power amplifier, large difference among different transmitter's transmission power, transmitter fault, combiner fault, and divider fault.
3. Unreasonable radio parameter settings.

F. LAPD Call drop

The LAPD is a signaling layer 2 protocol which is defined in CCITT Q.920/921 and existed between BTS (Base transceiver station and BSC (Base Station Controller). LAPD works in the Asynchronous Balanced Mode (ABM). This mode is totally balanced. Each station may initialize, supervise, recover from errors, and send frames at any time. When LAPD link is broken, the call-in-progress on the carrier will be interrupted.

G. ***Reasons of LAPD call drop***

1. Site transmission problems, such as transmission interruption or unstable transmission (intermittent).
2. Site-side hardware fault, such as unreliable E1 cable, CMM (Control and Maintenance module) fault, and backplane connection fault, etc.
3. BSC-side hardware fault such as LAPD processing board fault may result in LAPD Call drop.

III. WHAT IS MIMO?

Multiple-input multiple-output (MIMO) is a wireless communication technology which is being noticed and is currently being used in various new technologies. MIMO technology uses an array of antennas to make use of reflected signals to provide return loss (in db) in channel robustness and throughput.

A. *Principle, working and proposed solution*

A channel may be affected by fading and this in turn will influence the signal to noise ratio. In turn this will influence the error rate, assuming digital data is being transmitted. The diversity techniques is to offer the receiver with multiple versions of the same signal. If these can be made to be affected in different ways by the signal path, the probability that they will all be affected at the same time is significantly reduced. Accordingly, diversity helps to stabilize a link and improves performance, reducing error rate. Distinct diversity modes are existing and offer a number of advantages:

- ***Time diversity:*** It means, a message may be transmitted at different times, e.g. using different timeslots and channel coding.
- ***Frequency diversity:*** Frequency diversity uses different frequencies. This may be in the form of using different channels, or technologies such as spread spectrum / OFDM.
- ***Space diversity:*** This used in the widest sense of its description is used as the basis for MIMO. It uses antennas located in different positions to take advantage of the different radio paths that occur in a distinctive terrestrial situation.

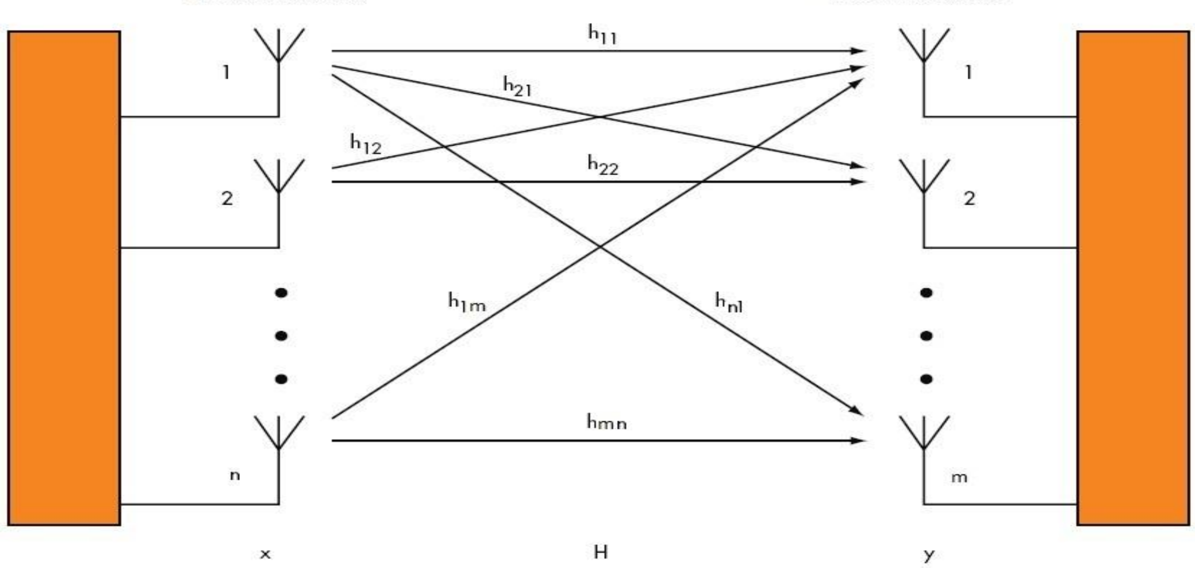

Fig. 4. A MIMO system consists of n transmit antennas and m receive antennas. Since the same channel is used, each antenna receives the direct component intended for it as well as the indirect components for the other antennas.

MIMO is efficiently a RF antenna technology using an array of antennas at the transmitter and receiver ends to permit a variety of signal paths to transmit the data, choosing separate paths for each antenna to enable multiple signal paths to be used. MIMO efficiently takes advantage of random fading and when available, multipath delay spread. Actually, the ability to turn multipath propagation, is considered as a downside of wireless transmission conventionally, into a benefit for the user is the significant feature of MIMO systems. For example in receive antenna diversity, in rich scattering environment, each receive antenna sees different versions of the transmitted signal and when these versions are combined in a proper manner the outcome has better quality (lower bit-error-rate (BER)) or higher data rate than a single version of the signal. Specifically, if the number of multipath components exceeds a certain value the channel capacity increase can be proportional to the number of transmit and receive antennas and no additional power or bandwidth is required.

Now, the array of receiver antennas will receive multiple signals transmitted by multiple antennas. The mobile phone will then identify the receiver antenna among the array of antennas with strongest received signal power. The mobile phone will then switch to that antenna if the received signal power by the current antenna falls below a certain threshold. The mobile station continuously observes the signal power received by each receiver antenna. This process continues at the time of call conversation also. In other case, when the mobile station is in idle state, then the MS will switch to the receiver antenna with the least signal power. This will help in reduction of battery power consumption. As soon as a call arrives, the MS switches to the antenna having strongest signal power.

B. *Functions of MIMO*

MIMO can be sub-divided into three main categories, precoding, spatial multiplexing or SM, and diversity coding.

Precoding is multi-stream beam forming, in the narrowest definition. In more general terms, it is considered to be all spatial processing that occurs at the transmitter. In (single-stream) beamforming, the same signal is emitted from each of the transmit antennas with appropriate phase and gain weighting such that the signal power is maximized at the receiver input. The benefits of beamforming are to increase the received signal gain, by making signals emitted from different antennas add up constructively, and to reduce the multipath fading effect. In line-of-sight propagation, beamforming results in a well defined directional pattern. However, conventional beams are not a good analogy in cellular networks, which are mainly characterized by multipath propagation. When the receiver has multiple antennas, the transmit beamforming cannot simultaneously maximize the signal level at all of the receive antennas, and precoding with multiple streams is often beneficial. Note that precoding requires knowledge of channel state information (CSI) at the transmitter and the receiver.

Spatial multiplexing requires MIMO antenna configuration. In spatial multiplexing, a high rate signal is split into multiple lower rate streams and each stream is transmitted from a different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signatures and the receiver has accurate CSI, it can separate these streams into (almost) parallel channels. Spatial multiplexing is a very powerful technique for increasing channel capacity at higher signal-to-noise ratios (SNR). The maximum number of spatial streams is limited by the lesser of the number of antennas at the transmitter or receiver. Spatial multiplexing can be used without CSI at the transmitter, but can be combined with precoding if CSI is available. Spatial multiplexing can also be used for simultaneous transmission to multiple receivers, known as space-division multiple access or multi-user MIMO, in which case CSI is required at the transmitter.[9] The scheduling of receivers with different spatial signatures allows good separability.

Diversity Coding techniques are used when there is no channel knowledge at the transmitter. In diversity methods, a single stream (unlike multiple streams in spatial multiplexing) is transmitted, but the signal is coded using techniques called space-time coding. The signal is emitted from each of the transmit antennas with full or near orthogonal coding. Diversity coding exploits the independent fading in the multiple antenna links to enhance signal diversity. Because there is no channel knowledge, there is no beamforming or array gain from diversity coding. Diversity coding can be combined with spatial multiplexing when some channel knowledge is available at the transmitter.

C. *Mathematical Description*

In MIMO systems, multiple antennas are used to transmit bunch of signals by the transmitter. The transmitted bunch of signals go through a matrix channel which comprises of all $N_t N_r$ paths between the N_t transmit antennas at the transmitter and N_r receive antennas at the receiver. Then, the receiver gets the received signal vectors by the multiple receive antennas and decodes the received signal vectors into the original information.

Consider a MIMO channel with N transmit antennas and M receive antennas as depicted in Fig. 4. The signal transmitted from the jth transmit antenna is $S_j(t)$. The time-varying channel impulse response between the jth transmit antenna and the ith receive antenna is denoted as $h_{i,j}(\tau,t)$. The MIMO channel response can be expressed as an NxM matrix:

$$\boldsymbol{H}(\boldsymbol{\tau}, \boldsymbol{t}) = \begin{bmatrix} h_{1,1}(\tau,t) & h_{1,2}(\tau,t) & \cdots & h_{1,N}(\tau,t) \\ h_{2,1}(\tau,t) & h_{2,2}(\tau,t) & & h_{2,N}(\tau,t) \\ \vdots & & \ddots & \vdots \\ h_{M,1}(\tau,t) & h_{M,2}(\tau,t) & \cdots & h_{M,N}(\tau,t) \end{bmatrix} \quad (1)$$

The signal received at the ith receive antenna is given by

$$yi(t)^n = \sum_{j=1}^{N} h_{i,j}(\tau,t) * s_j(t) + n_i(t) \qquad i=1,2,....,M \qquad (2)$$

where * denotes the convolution and $n_i(t)$ is the noise added in the receiver. The spatio-temporal signature induced by the jth transmit antenna across the receive antenna array is given by the vector

$$[h_{i,j}(\tau,t) \quad h_{2,j}(\tau,t) \ \ldots\ldots h_{M,j}(\tau,t)]$$

A narrowband flat fading MIMO system is modelled as

$$\mathbf{y} = \mathbf{H}\mathbf{x} + \mathbf{n}$$

Where **y** and **x** are the receive and transmit vectors, respectively, and **H** and **n** are the channel matrix and the noise vector, respectively. Referring to information theory, the ergodic channel capacity of MIMO systems where both the transmitter and the receiver have perfect instantaneous channel state information is

$$C_{\text{perfect-CSI}} = E\left[\max_{\mathbf{Q};\,\mathrm{tr}(\mathbf{Q})\le 1} \log_2 \det\left(\mathbf{I} + \rho \mathbf{H}\mathbf{Q}\mathbf{H}^H\right)\right] = E\left[\log_2 \det\left(\mathbf{I} + \rho \mathbf{D}\mathbf{S}\mathbf{D}\right)\right]$$

where $()^H$ denotes Hermitian transpose and ρ is the ratio between transmit power and noise power (i.e., transmit SNR). The optimal signal covariance $\mathbf{Q}=\mathbf{V}\mathbf{S}\mathbf{V}^H$ is achieved through singular value decomposition of the channel matrix $\mathbf{U}\mathbf{D}\mathbf{V}^H = \mathbf{H}$ and an optimal diagonal power allocation matrix $\mathbf{S}=\mathrm{diag}(s_1,\ldots,s_{\min(N_t,N_r)},0,\ldots,0)$. The optimal power allocation is achieved through water filling [6], that is

$$s_i = \left(\mu - \frac{1}{\rho d_i^2}\right)^+, \quad \text{for } i = 1,\ldots,\min(N_t,N_r),$$

where $d_1,\ldots,d_{\min(N_t,N_r)}$ are the diagonal elements of $\mathbf{D}$, $(\cdot)^+$ is zero if its argument is negative, and μ is selected such that $s_1 + \ldots + s_{\min(N_t,N_r)} = N_t$.

If the transmitter has only statistical channel state information, then the ergodic channel capacity will decrease as the signal covariance $\mathbf{Q}$ can only be optimized in terms of the average mutual information as[15]

$$C_{\text{statistical-CSI}} = \max_{\mathbf{Q}} E\left[\log_2 \det\left(\mathbf{I} + \rho \mathbf{H}\mathbf{Q}\mathbf{H}^H\right)\right].$$

The spatial correlation of the channel have a strong impact on the ergodic channel capacity with statistical information. If the transmitter has no channel state information it can select the signal covariance $\mathbf{Q}$ to maximize channel capacity under worst-case statistics, which means $\mathbf{Q}=1/N_t\mathbf{I}$ and accordingly

$$C_{\text{no-CSI}} = E\left[\log_2 \det\left(\mathbf{I} + \frac{\rho}{N_t}\mathbf{H}\mathbf{H}^H\right)\right].$$

Depending on the statistical properties of the channel, the ergodic capacity is no greater than $\min(N_t, N_r)$ times larger than that of a SISO system.

IV. CONCLUSION

The proposed designed solution is helpful in reducing call drop in wireless communication. It also helps in saving bateery power consumption of the mobile station. MIMO antenna has been applied to a well- known international mobile phone manufacturer companies. This proposed solution will significantly help in reducing the call drop. Thus, the reliability of MIMO antenna used in mobile phone communication has been significantly improved. It brings great commercial and social returns for MIMO antenna built mobile phone in future and far-reaching impact to the development of mobile services.

REFERENCES

[1] Wahida Nasrin, Md Majharul Islam Rajib,"An analytical approach to enhance the capacity of GSM frequency hopping networks with intelligent Underlay-overlay" Journal of communication, Vol 4,No. 6, July 2009.

[2] A.G. Spilling and A.R. Nix, "Performance enhancement in cellular networks with dynamic cell sizing" IEEE PIMRC 2000

[3] D.Lam,D.C Cox and J.Widom "Teletraffic modeling for personal communication services" IEEE communications Magazine, Vol. 35, No. 2, Feb 1997,pp 79-87.

[4] H. Olofsson et al., " Interference Diversity as Means for Increased Capacity in GSM", in Proceedings of 1st EPMCC, Italy, 1995, pp.97- 102.

[5] Kolonits, "Evaluating the Potential of Multiple Re-Use Patterns for Optimizing Existing Network Capacity" IIR Maximizing Capacity Workshop, London, June 1997.

[6] Stefan Schindler, Heinz Mellein, "Assessing a MIMO Channel" (http:// www. rohde-schwarz. com/ appnote/ 1SP18. pdf,), Rohde & Schwarz, pg. 11.

