Enhancing the Efficiency of Cluster-based Networks through MISO Techniques

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***Abstract*—Towards the realization of the Internet of Things (IoT), cellular networks are expected to play a fundamental role, providing the ubiquitous coverage and global internetworking. However, due to the physical limitations, namely energy consumption or hardware complexity, of many of these objects, the direct communication with the cellular infrastructure is hindered. In this sense, cluster-based networks have been introduced as an efficient solution, offering coverage extension and energy savings. The energy efficiency and performance of these networks can be further enhanced if the devices can choose between two or more cluster-heads towards their connection to the infrastructure.**

In this paper, we propose a novel cluster-head (CH) selection algorithm, where the nodes can switch between different CHs, according to the corresponding signal strength, in order to maintain a predefined quality of service constraint. We show that the network reliability significantly increases, especially when considering mobile scenarios, where the connection to a CH may be not feasible, due to shadowing. In addition, the CHs are equipped with multiple antennas for enhanced performance. The performance of this scheme is theoretically investigated over correlated Nakagami-m multipath fading channels, subject also to shadowing. By considering Gamma distributed shadow effects, convenient expressions for important statistical metrics are obtained. The theoretical analysis is accompanied by representative performance evaluation results, complemented by equivalent computer simulated ones, which validate the accuracy of the proposed analysis.

***Index Terms*—Cluster-based networks, correlated statistics, internet of things, Nakagami-m fading, multiple-input-single-output (MISO), shadowing.**

I. Introduction

The vision of the Internet of Things (IoT) is based on the global infrastructure assumption of everyday smart objects that are networked. These objects are usually equipped with sensors, which enables them to sense their environment and interact with each other or human users. The realization of this meticulous and demanding vision is related with some critical features and requirements, such as the need for ubiquitous reliable connectivity in ad-hoc and energy limited scenarios. In recent years, several research activities have been dealing with these important issues, proposing novel architectures and technologies towards a dynamic global platform of seamless networks and networked objects [1]. While a new architecture is required to satisfy the demands of these future systems, it is also essential that their development goes through the enhancement of today's communications networks and standards. In this sense, cellular systems are expected to be a fundamental part of the IoT, providing them with crucial benefits, such as ubiquitous coverage and global internetworking [2]. However, most of the connected objects (e.g., sensors) are subject to physical limitations, including power consumption or hardware complexity, hindering the direct links to the cellular infrastructure. Towards this problem, cluster-head (CH) based networks have been introduced, providing coverage extension, which facilitates the connectivity of those objects [3]–[5].

The energy efficiency, the reliability and the performance of CH networks can be further enhanced if the cluster nodes are able to switch between different CH [6], [7]. In [7], the authors proposed a protocol to build multiple independent CHs *overlays* on top of the physical network, which allows the nodes to switch to another CH in case of a CH failure. The CH switch is based on the node's residual energy and a cost parameter related with the node's degree of connectivity.

Following a similar concept and by extending the research framework of cooperative communications, relay nodes can be placed in a network topology to serve as CHs. Following such an approach, we propose a communication protocol for CH-based networks, where the nodes can switch between different CHs, according to the corresponding signal strength, in order to maintain a predefined Quality of Service (QoS) constraint. More specifically, a node is connected to a CH as long as the corresponding signal-to-noise ratio (SNR) is above a predefined threshold; otherwise, this node connects to another CH within the same CH overlay. This could be the case of an intelligent transportation system where some mobile nodes-machines are trying to communicate to the CH that satisfies a certain QoS level. Hence, the network reliability significantly increases, especially for these mobile scenarios, where the connection to a CH may be not possible, due to shadowing effects. In particular, we consider the case where a message is broadcasted to the nodes with the assistance of a number of CHs. In contrast to previous works, we relate the CH failure with the wireless channel between the infrastructure (e.g., base station), the CH and the node, which is subject to multipath random fading and shadowing. Both these link quality impairments may cause a severe degradation to the system performance, while the former is also responsible for irreducible bit error rate. Moreover, we assume that the CHs are equipped with multiple antennas, further enhancing the performance and the reliability of the network.

Following a thorough theoretical analysis, we show how the reliability of such CH-based networks can significantly increase, especially when operating in severe fading and shadowing conditions. The results, which are presented in terms of critical performance metrics, have been validated through extensive simulations.

The remainder of this paper is organized as follows. In Section II, the system model along with the basic assumptions are presented. Moreover, a useful approximation for the probability density function (PDF) of the sum of exponential correlated Nakagami-m random variables (RV)s is used to represent the instantaneous SNR between the CHs and the nodes. Furthermore, assuming random variations for the average powers of the Nakagami-m RVs, caused by the shadowing and modeled here by the Gamma distribution, a generic expression for this PDF is obtained. Capitalizing on these results, in Section III, the PDF, cumulative distribution function (CDF), moments generating function (MGF) and moments of the mobile nodes' SNR are extracted, in most cases, in closed form. These results are used in Section IV to study important performance criteria such as the average bit error probability (ABEP) and the outage probability (P_{out}). In Section V, using the above mentioned performance metrics several numerical evaluated results are presented, while in Section VI the concluding remarks of this paper are provided.

II. System Model and Mode of Operation

We consider a communication network, where an access point (e.g., a base station in a cellular network) broadcasts a message to a set of mobile nodes (Fig. 1). The nodes are divided in M CH overlays, each consisting of N CHs [7]. The CHs are equipped with a single antenna for the link to the access point and L_n antennas for the link to the mobile nodes. The CHs receive the broadcast message, via an error free channel, and then retransmit it to the mobile nodes, using the maximal ratio transmission (MRT) technique, assuming that perfect channel state information is available at the CHs.

The mobile nodes are monitoring the SNR of each CH and are able to switch between different CHs, according to the corresponding signal strength, in order to maintain a predefined QoS constraint. More specifically, a node is connected to a CH as long as the SNR is above a predefined threshold; otherwise, this node connects to another CH within the same CH overlay.

Let $X_{\ell,n}$, with $1 \leq \ell \leq L_n$ and $1 \leq n \leq N$ denote the instantaneous SNR per symbol at the link between the ℓth antenna of the nth CH and the mobile node. Assuming Nakagami-m fading channels, the PDF of $X_{\ell,n}$s is given by

$$f_{X_{\ell,n}}(x) = \frac{m_{\ell,n}^{m_{\ell,n}} x^{m_{\ell,n}-1}}{\overline{x}_{\ell,n}^{m_{\ell,n}} \Gamma(m_{\ell,n})} \exp\left(-\frac{m_{\ell,n} x}{\overline{x}_{\ell,n}}\right), \quad x \geq 0 \quad (1)$$

where $0.5 \leq m_{\ell,n} < \infty$ is distribution's shaping parameter related to fading severity, $\overline{x}_{\ell,n} = \mathbb{E}\left\langle X_{\ell,n}^2 \right\rangle$, with $\mathbb{E}\langle\cdot\rangle$ denoting expectation, and $\Gamma(\cdot)$ is the Gamma function [8, eq. (8.310/1)].

Let γ_n representing the sum of $X_{\ell,n}$, i.e., $\gamma_n = \sum_{\ell=1}^{L_n} X_{\ell,n}$ and $\rho_{i,j}$ denoting the exponential correlation among the fading signals of the each CH antenna, given as $\rho_{i,j} = \rho_n^{|i-j|}$, $0 < \rho_n < 1$, with $[(i,j) \in (1,\ldots,L_n)]$. Considering also identical distributed parameters for each CH, i.e., $\overline{x}_{\ell,n} = \overline{x}_n$ and $m_{\ell,n} = m_n$, the PDF of γ_n is closely approximated by [9]

$$f_{\gamma_n}(\gamma) = \frac{\mathcal{A}_{x_n}^{\mathcal{B}_n} \gamma^{\mathcal{B}_n - 1} \exp\left(-\mathcal{A}_{x_n}\gamma\right)}{\Gamma\left(\mathcal{B}_n\right)} \quad (2)$$

where

$$r_n = L_n + \frac{2\rho_n}{1-\rho_n}\left(L_n - \frac{1-\rho_n^{L_n}}{1-\rho_n}\right)$$
$$\mathcal{A}_{x_n} = \frac{m_n L_n}{r_n \overline{x}_n} \text{ and } \mathcal{B}_n = \frac{m_n L_n^2}{r_n}.$$

Using [8, eq. (3.351/1)] the corresponding CDF can be obtained as

$$\mathcal{F}_{\gamma_n}(\gamma) = \frac{\gamma\left(\mathcal{B}_n, \mathcal{A}_{x_n}\gamma\right)}{\Gamma\left(\mathcal{B}_n\right)} \quad (3)$$

where $\gamma(\cdot,\cdot)$ is the lower incomplete gamma function [8, eq. (8.350/1)]. Furthermore, the radio communication links, at each CH, are considered to be affected by fully correlated shadowing. This is the case where the different paths exhibit identical shadowing affects simultaneously and has been studied several times in the past, e.g., [10], [11]. When the multipath components are also subject to shadowing, $\overline{x}_n$ become RVs and the PDF of γ_n is conditioned on $\overline{x}_n$ as $f_{\gamma_n|\overline{x}_n}(\gamma|y)$. In most cases the slow variations in $\overline{x}_n$ are modeled with the lognormal distribution and thus the derived expressions are mathematical very complicated. A mathematically more tractable approach is to employ the Gamma distribution, which has been found to be appropriate for modeling shadowing effects [12], [13], and its PDF is given by

$$f_{\overline{x}_n}(y) = \frac{\alpha_n}{\overline{\gamma}_n^{\alpha_n}} \frac{y^{\alpha_n - 1}}{\Gamma(\alpha_n)} \exp\left(-\frac{\alpha_n y}{\overline{\gamma}_n}\right) \quad (4)$$

where $\alpha_n \geq 0$ is the shaping parameter of gamma distribution, which is related to the severeness of shadowing (i.e., smaller values of α_n corresponds to stronger shadowing), while $\overline{\gamma}_n$ is the average power of $\overline{x}_n$. Hence, in order to remove the conditioning in $f_{\gamma_n|\overline{x}_n}(\gamma|y)$ the total probability theorem, [14, eq. (7.44)], can be applied as follows

$$f_{\gamma_n}(\gamma) = \int_0^\infty f_{\gamma_n|\overline{x}_n}(\gamma|y) f_{\overline{x}_n}(y) dy. \quad (5)$$

Substituting (2) and (4) in (5) and using [8, eq. (3.471/9)] the combined PDF can be mathematically expressed as

$$f_{\gamma_n}(\gamma) = \frac{2\mathcal{A}_{\gamma_n}^{\frac{\alpha_n+\mathcal{B}_n}{2}}}{\Gamma\left(\mathcal{B}_n\right)\Gamma(\alpha_n)} \gamma^{\frac{\alpha_n+\mathcal{B}_n}{2}-1} K_{\alpha_n-\mathcal{B}_n}\left(2\sqrt{\mathcal{A}_{\gamma_n}\gamma}\right) \quad (6)$$

where $K_\nu(\cdot)$ is the modified Bessel function of the second kind and order ν [8, eq. (8.407/1)] and $\mathcal{A}_{\gamma_n} = \alpha_n m_n L_n / \left(r_n \overline{\gamma}_n\right)$. Furthermore, starting from the definition of the CDF [14, eq. (4.17)], expressing $K_\nu(\cdot)$ in terms of the Meijer-G function [15, eq. (03.04.26.0006.01)] and using [16, eq. (26)] a generic

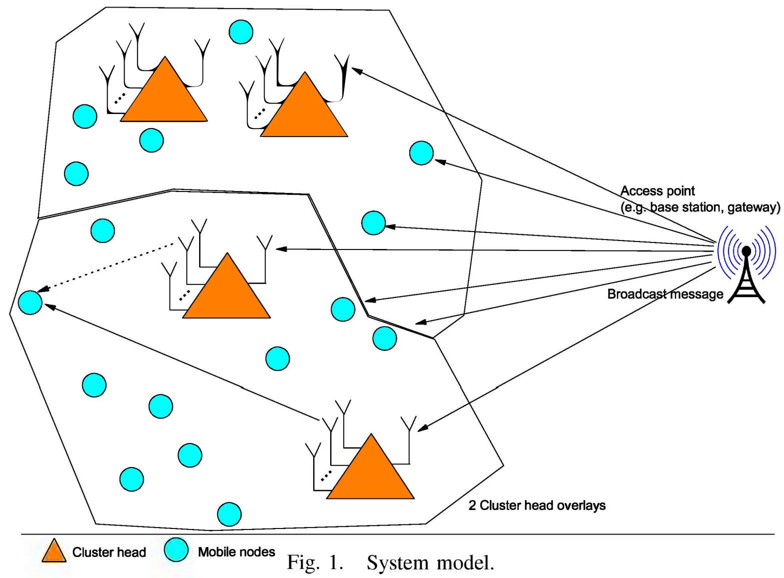

Fig. 1. System model.

closed-form expression for the CDF of γ_n can be obtained as follows

$$\mathcal{F}_{\gamma_n}(\gamma) = \frac{(\mathcal{A}_{\gamma_n}\gamma)^{\frac{\alpha_n+\mathcal{B}_n}{2}}}{\Gamma(\mathcal{B}_n)\Gamma(\alpha_n)} \mathcal{G}_{1,3}^{2,1}\left(\mathcal{A}_{\gamma_n}\gamma \middle| \begin{matrix} 1-\frac{\alpha_n+\mathcal{B}_n}{2} \\ \frac{\alpha_n-\mathcal{B}_n}{2}, \frac{\mathcal{B}_n-\alpha_n}{2}, -\frac{\alpha_n+\mathcal{B}_n}{2} \end{matrix}\right) \quad (7)$$

where $\mathcal{G}_{p,q}^{m,n}[\cdot|\cdot]$ is the Meijer's G-function [8, eq. (9.301)]. Furthermore, using [15, eq. (07.34.03.0727.01)], (7) can be expressed in terms of the regularized generalized hypergeometric function ${}_p\tilde{F}_q(\cdot;\cdot;\cdot)$ [15, eq. (07.32.02.0001.01)].

The results presented in this section will be used to study the statistics of the proposed communication protocol.

III. Statistics of the Received Signal at the Mobile Nodes

Assuming a two CH overlay (Fig. 1), the SNR of the received signal at the mobile node from ith CH, with $i \in (1, 2)$, is $\gamma_i = X_{1,i} + X_{2,i} + \cdots + X_{L_i,i}$. According to the protocol's mode of operation, the final instantaneous SNR, γ_{out}, at the node will have the following CDF [17, eq.(62)]

$$\mathcal{F}_{\gamma_{\text{out}}}(\gamma) = \begin{cases} \mathcal{C}\left[\mathcal{F}_{\gamma_1}(\gamma) + \mathcal{F}_{\gamma_2}(\gamma)\right], \gamma \leq \gamma_\tau \\ \mathcal{C}\left[\mathcal{F}_{\gamma_1}(\gamma) + \mathcal{F}_{\gamma_2}(\gamma) - 2\right] + \mathcal{D}, \ \gamma > \gamma_\tau \end{cases} \quad (8)$$

where

$$\mathcal{C} = \frac{\mathcal{F}_{\gamma_1}(\gamma_\tau)\mathcal{F}_{\gamma_2}(\gamma_\tau)}{\mathcal{F}_{\gamma_1}(\gamma_\tau) + \mathcal{F}_{\gamma_2}(\gamma_\tau)},$$

$$\mathcal{D} = \frac{\mathcal{F}_{\gamma_1}(\gamma)\mathcal{F}_{\gamma_2}(\gamma_\tau) + \mathcal{F}_{\gamma_1}(\gamma_\tau)\mathcal{F}_{\gamma_2}(\gamma)}{\mathcal{F}_{\gamma_1}(\gamma_\tau) + \mathcal{F}_{\gamma_2}(\gamma_\tau)}$$

and γ_τ is the predefined QoS threshold. Furthermore, in (8) $\mathcal{F}_{\gamma_i}(\gamma)$ is given for the shadowing case by (7) while for the non-shadowing case by (3). The corresponding PDF of γ_{out} can be easily obtained as

$$f_{\gamma_{\text{out}}}(x) = \begin{cases} \mathcal{C}\left[f_{\gamma_1}(\gamma) + f_{\gamma_2}(\gamma)\right], \gamma \leq \gamma_\tau \\ \mathcal{C}\left[f_{\gamma_1}(\gamma) + f_{\gamma_2}(\gamma)\right] + \mathcal{G}, \ \gamma > \gamma_\tau \end{cases} \quad (9)$$

where

$$\mathcal{G} = \frac{f_{\gamma_1}(\gamma)\mathcal{F}_{\gamma_2}(\gamma_\tau) + \mathcal{F}_{\gamma_1}(\gamma_\tau)f_{\gamma_2}(\gamma)}{\mathcal{F}_{\gamma_1}(\gamma_\tau) + \mathcal{F}_{\gamma_2}(\gamma_\tau)}.$$

Similar to the CDFs, $f_{\gamma_i}(\gamma)$ is given for the shadowing case by (6) while for the non-shadowing case by (2).

1) Moments Generating Function: Substituting (9) in the definition of the MGF [14, eq. (5.62)] and using (6) and [8, eq. (6.643/3)] the MGF of γ_{out}, for the shadowing case, can be obtained as

$$\mathcal{M}_{\gamma_{\text{out}}}(s) = \mathcal{C}\sum_{i=1}^{2}\left[\mathcal{M}_{\gamma_i}(s) + \frac{1}{\mathcal{F}_{\gamma_i}(\gamma_\tau)} \times \int_{\gamma_\tau}^{\infty} f_{\gamma_i}(\gamma)\exp(-s\gamma)d\gamma\right] \quad (10)$$

where

$$\mathcal{M}_{\gamma_i} = \left(\frac{\mathcal{A}_{\gamma_i}}{s}\right)^{\frac{\alpha_i+\mathcal{B}_i-1}{2}} \exp\left(\frac{\mathcal{A}_{\gamma_i}}{2s}\right) W_{\frac{1-\alpha_i-\mathcal{B}_i}{2}, \frac{\alpha_i-\mathcal{B}_i}{2}}\left(\frac{\mathcal{A}_{\gamma_i}}{2s}\right) \quad (11)$$

where $\mathrm{W}_{\lambda,\mu}(\cdot)$ denotes the Whittaker function [8, eq. (9.220)] and $\alpha_i, \mathcal{A}_{\gamma_i}, \mathcal{B}_i$ refer to the corresponding values of the parameters $m_i, L_i, r_i, \overline{\gamma}_i$. In (10), the definite integral cannot be obtained in closed form and hence numerical evaluation will be employed, by using any of the well-known mathematical software packages.

For the non-shadowing case, substituting (9) in the definition of the MGF and using (2) as well as [8, eq. (3.351/3)] and [8, eq. (3.351/2)], (10) simplifies to the following closed-form expression

$$\mathcal{M}_{\gamma_{\text{out}}}(s) = \mathcal{C}\sum_{i=1}^{2}\left(\frac{\mathcal{A}_{x_i}}{s + \mathcal{A}_{x_i}}\right)^{\mathcal{B}_i}\left\{1 + \frac{\Gamma\left[\mathcal{B}_i, (s + \mathcal{A}_{x_i})\gamma_\tau\right]}{\Gamma(\mathcal{B}_i)\mathcal{F}_{\gamma_i}(\gamma_\tau)}\right\} \quad (12)$$

where $\Gamma(\cdot,\cdot)$ is the upper incomplete Gamma function [8, eq. (8.350/2)].

2) Moments: Substituting (9) in the definition of the moments [14, eq. (5.38)], using (6), [8, eq. (6.561/16)] and following a similar procedure as for deriving (7), the nth order moment of $\gamma_{\rm out}$ for the shadowing case can be obtained in closed form as

$$\mu_{\gamma_{\rm out}}(n)=\sum_{i=1}^{2}\frac{\mathcal{C}/\mathcal{A}_{\gamma_i}^{n}}{\Gamma(\alpha_i)\Gamma(\mathcal{B}_i)}\left[\left(1+\frac{1}{\mathcal{F}_{\gamma_i}(\gamma_\tau)}\right)\frac{\Gamma(\mathcal{B}_i+n)}{\Gamma(\alpha_i+n)^{-1}} - \frac{(\gamma_\tau\mathcal{A}_{\gamma_i})^{\frac{\alpha_i+\mathcal{B}_i}{2}+n}}{\mathcal{F}_{\gamma_i}(\gamma_\tau)}\mathcal{G}_{1,3}^{2,1}\left(\mathcal{A}_{\gamma_i}\gamma_\tau\,\middle|\,{}^{1-\frac{\alpha_i+\mathcal{B}_i}{2}-n}_{\frac{\alpha_i-\mathcal{B}_i}{2},\frac{\mathcal{B}_i-\alpha_i}{2},\frac{-\alpha_i-\mathcal{B}_i}{2}-n}\right)\right]. \tag{13}$$

For the non-shadowing case, substituting (9) in the definition of the moments, using (2) as well as [8, eq. (3.351/3)] and [8, eq. (3.351/2)], (13) simplifies to

$$\mu_{\gamma_{\bullet\rm ut}}(n)=\sum_{i=1}^{2}\frac{\mathcal{C}/\mathcal{A}_{x_i}^{n}}{\Gamma(\mathcal{B}_i)}\left\{\Gamma(\mathcal{B}_i+n)+\frac{\Gamma(\mathcal{B}_i+n,\mathcal{A}_{x_i}\gamma_\tau)}{\mathcal{F}_{\gamma_i}(\gamma_\tau)}\right\}. \tag{14}$$

IV. Performance Analysis

In this section, using the previously derived expressions for the statistical metrics of the final SNR at the mobile node, important performance quality indicators are studied. More specifically, the performance is studied using the ABEP, the $P_{\rm out}$, the average output SNR and the amount of fading (AF). A basic assumption for deriving those results is that the communication link between the access point and the CHs is considered to be error-free [18].

A. Outage Probability

The $P_{\rm out}$ is defined as the probability that the final node's SNR falls below a predetermined outage threshold $\gamma_{\rm th}$. By employing (8), (7) for the shadowing case and (3) for the non-shadowing case, the $P_{\rm out}$ can be obtained by replacing γ with $\gamma_{\rm th}$ in these equations as $P_{\rm out}=\mathcal{F}_{\gamma_{\bullet\rm ut}}(\gamma_{\rm th})$. It should be noted that the optimal switching threshold γ_τ^* for minimum $P_{\rm out}$, can be obtained for $\gamma_\tau^*=\gamma_{\rm th}$ [17].

B. Average Bit Error Probability

Using (10) or (12) and following the MGF-based approach, the ABEP of the proposed scheme can be readily evaluated for a variety of modulation schemes, e.g., phase shift keying (PSK) and quadrature amplitude modulation (QAM), [19]. More specifically, the ABEP can be calculated: *i)* directly for non-coherent differential binary PSK (DBPSK), i.e., $P_{\rm be}=0.5\mathcal{M}_{\gamma_{\bullet\rm ut}}(1)$; and *ii)* via numerical integration for Gray encoded M-ary PSK, i.e., $P_{\rm be}=[1/(\pi\log_2 M)]\int_0^{\pi-\pi/M}\mathcal{M}_{\gamma_{\bullet\rm ut}}\left[\log_2 M\sin^2(\pi/M)/\sin^2\phi\right]d\phi$. Moreover, the optimum value of γ_T, i.e., γ_T^*, which minimizes the ABEP can be obtained by numerically solving $[\theta P_{be}(E)/\theta\gamma_T]|_{\gamma_T^*=\gamma_T}=0$ [19, pp. 428].

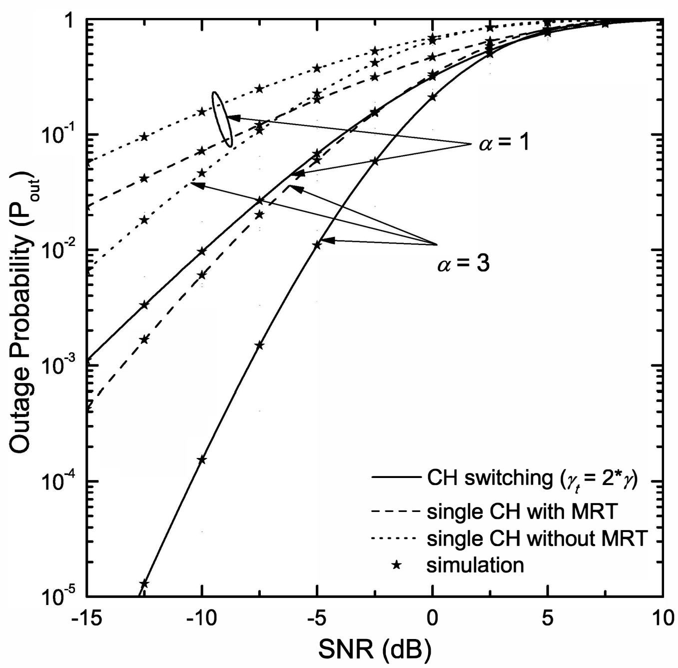

Fig. 2. The $P_{\rm out}$ versus the normalized outage threshold, $\gamma_{\rm th}/\overline{\gamma}$, for several values of α.

C. Moments

By employing (13) or (14), useful performance metrics, including the average output SNR and the AF, can be derived in closed form. More specifically, the average final SNR can be obtained as $\overline{\gamma}_{\rm out}=\mu_{\gamma_{\bullet\rm ut}}(1)$, while the AF can be expressed as $A_F=\frac{\mu_{\gamma_{\bullet\rm ut}}(2)}{\mu_{\gamma_{\bullet\rm ut}}(1)^2}-1$.

V. Numerical Results and Discussion

In this section, selected numerical performance evaluation results are presented and discussed. These results include performance comparisons of several communication scenarios, employing various performance criteria and different fading and shadowing channel conditions. Per our previous performance analysis, the following criteria will be used: the ABEP (using (10)), and $P_{\rm out}$ (using (7) and (8)). It is noted that in all cases we have considered identical fading parameter, $m=2$, and when MRT is employed $L=2$.

In Fig. 2, we consider a communication scenario where a node is connected to a CH as long as its SNR is above $\gamma_{\rm th}$ otherwise it switches to another CH within the same CH overlay. The performance criterion employed is $P_{\rm out}$, while for comparison purposes the corresponding performances of a) a single CH connection supporting MRT and b) a single CH without MRT are also depicted. For the wireless communication link, we have assumed $\rho=0.2$ (weak correlation) and equal values for the shadowing parameter α. In this figure, it is depicted that $P_{\rm out}$ considerable improves when CH switching algorithm is employed, for both weak and strong shadowing conditions, meaning that the reliability of a CH-based network significantly increases if the nodes are able to choose between two CHs to connect to. We also observe that

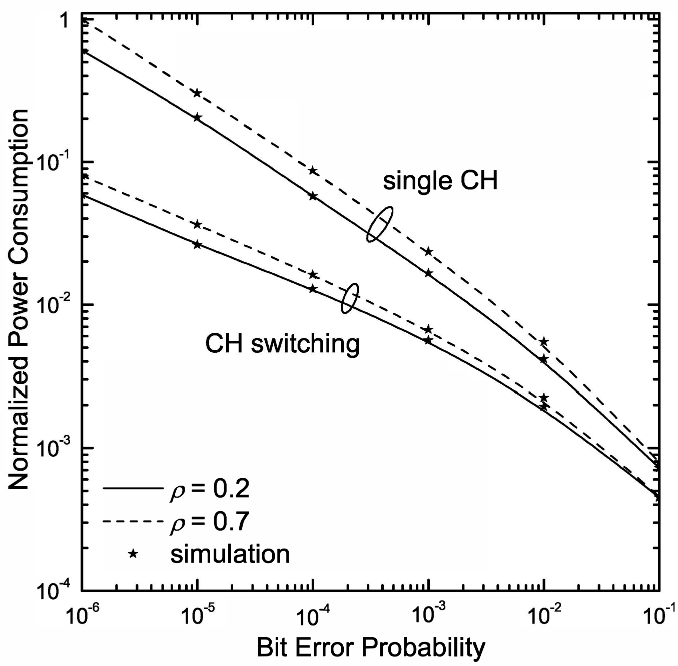

Fig. 3. The node normalized power consumption as a function of the ABEP, for several values of the correlation coefficient.

a non negligible $P_{\rm out}$ improvement is achieved even for the single (MRT supporting) CH case, as compared to CH without MRT. Finally, for the same $P_{\rm out}$ the proposed scheme requires up to 9dB less power, compared to the single CH scheme.

In Fig. 3, considering the same communication scenario as previously, and in order to investigate the energy efficiency that this CH switching algorithm induces to the nodes the normalized power consumption (NPC) is plotted as a function to a QoS target criterion, which is the ABEP of DBPSK. Furthermore, we have assumed $\alpha = 2$ for both CH communication link and several values of the correlation coefficient ρ. In this figure it is shown that for identical QoS target, the node NPC clearly decreases when CH switching is used, as compared with the single CH case. Another interesting observation in this figure is that the NPC also increases when the correlation coefficient of the multipath channel increases. For comparison purposes, computer simulation performance results are also included in both figures, verifying in all cases the validity of the proposed theoretical approach.

VI. Conclusions

In this paper, we proposed a novel CH selection algorithm, where the nodes can switch between different CHs, according to the corresponding signal strength, in order to maintain a predefined QoS constraint. Employing the proposed scheme, we showed that the reliability of CH-based networks significantly increases, while the power consumption decreases, especially when considering mobile scenarios, where the connection to a CH may be not possible, due to shadowing effects. The performance of this scheme was theoretically examined over correlated Nakagami-m multipath fading channels, which are also subject to shadow fading. The theoretical results were validated via computer simulations.

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