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Efficacy of using a wireless relay node (WRN) to minimize total power dissipation in transmission of a layered video between two devices is presented. It is analytically shown that there is a feasible relay region that would have lower power consumption than direct transmission depending on both the encoding rate of each layer and received signal power level for provisioning required bit error rate.

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I. INTRODUCTION

One major technological trend in wireless applications is multicasting video on demand (VoD) to portable devices. A VoD system usually consists of servers and several proxy-servers distributed over an entire network. To deal with heterogeneous access rates each video stream is encoded into a constant bit rate base layer (BL) and multiple variable bit rate enhancement layers (EL) [1]. The BL is encoded at a much lower rate than the ELs. Therefore, if one layer is to be relayed through the proxy, it is more power efficient to relay the EL. Both layers may be relayed of course, if the proxy is not to be overloaded.

This paper is concerned with selecting proper locations for proxy servers in the network to minimize total power dissipation.

II. RADIO MODEL AND ASSUMPTIONS

We assume that a video is encoded into a BL and a single EL at average rates of R_b and R_e bps respectively. We denote by α_{R_e}, the required received signal power level for the EL, and $\alpha_{R_b} = \alpha_{R_e}(R_b/R_e)$ for the BL to provision certain BER. To model wireless transmission, we use a simple radio model analogous to the ones in [2,3]. We assume that the total power consumption of a communications node P_t in watts consists of power consumed by the transmitter/receiver radio circuitry, P_{circ}, the transmit amplifier, $P_{amp}(R)$, which is controllable to achieve a desired BER at transmit rate of R, and additional power to process received bits $P_{rec}(R)$. Also, different levels of clutter on the propagation paths are modeled as *lognormal shadowing* [4]. The shadowing effect between nodes i and j, x_{ij} in dB, is given as $10^{x_{ij}/10}$ in watts.

$P_{amp}(R)$ can be expanded as $P^{ij}_{amp}(R) = \alpha_R 10^{x_{ij}/10} d^{\gamma}_{ij}$, where d_{ij} is the distance between i and j, and γ is the path loss exponent. Antenna gain is assumed to be unity.

III. POWER ANALYSIS

Assume node A is a server, node B is a customer premises equipment (e.g., Access Point), and node C a proxy server. When both layers are directly transmitted from A to B, the total power expended in the system, P_t', is

$$P_t' = P^a_{circ} + P^{ab}_{amp}(R_b) + P^{ab}_{amp}(R_e) + P^b_{circ} + P_{rec}(R_e) + P_{rec}(R_b) \quad (1)$$

Without loss of generality, we can assume $P^a_{circ} = P^b_{circ} = P^c_{circ} = P_c$. Let P_t'' denote the power dissipated in the ABC triplet when A transmits only the EL to B over C.

$$P_t'' = P^a_{circ} + P^{ab}_{amp}(R_b) + P^{ac}_{amp}(R_e) + P^c_{circ} + P^{cb}_{amp}(R_e) + P^b_{circ} + 2(P_{rec}(R_e)) + P_{rec}(R_b) \quad (2)$$

The relative power saving with respect to the direct transmission is then $\Delta P_1 = P_t'' - P_t'$ provided that $\Delta P_1 < 0$.

$$\Delta P_1 = \alpha_{R_e}(-10^{x_{ab}/10} d^{\gamma}_{ab} + 10^{x_{ac}/10} d^{\gamma}_{ac} + 10^{x_{cb}/10} d^{\gamma}_{cb}) + P_c + P_{rec}(R_e) < 0 \quad (3)$$

III.1. Trigonometric Analysis (Excluding Shadowing Effect)

The Cartesian coordinates of A, B and C are denoted by, $(0,0)$, $(X_b, 0)$ and (X_c, Y_c) respectively. After rearranging (3), and substituting corresponding inter-node distances in terms of the coordinates, the test condition in (4) is obtained to find feasible power saving positions (FPSP) for the proxy device C.

$$(X_c^2 + Y_c^2)^{\gamma/2} + [(X_c - X_b)^2 + Y_c^2]^{\gamma/2} < X_b^{\gamma} - \frac{P_c + P_{rec}(R_e)}{\alpha_{R_e}} \quad (4)$$

The term $X_b^{\gamma} - (P_c + P_{rec}(R_e))/\alpha_{R_e}$ is a threshold to achieve power savings. If X_b^{γ} is less than $(P_c + P_{rec}(R_e))/\alpha_{R_e}$, there is no FPSP. Therefore, the direct transmission is always cost effective and preferred. On the other hand, any relay node at the coordinates, when entered into (4), resulting in a greater value than the threshold is not an FPSP. Figure 1 is a contour

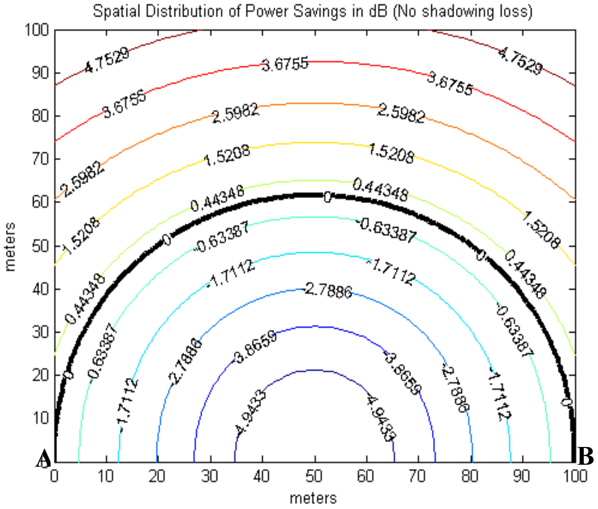

Figure 1 Feasible power saving positions and corresponding power saving values (no shadowing loss). Note: $(P_c + P_{rec}(R_e))/\alpha_{R_e} = 1/3$, γ=3, d_{ab}=100m.

plot of (4) normalized by $X_b^{\gamma} - (P_c + P_{rec}(R_e))/\alpha_{R_e}$ (in dB). Negative values show power savings for corresponding positions of the proxy node, while positive values indicate excess power consumption caused by relaying. When the proxy is located outside the 0 dB boundary, no power saving is achieved by relaying, but more power is dissipated in the network. The midpoint between A and B is the optimum relay location to have the maximum power saving (approximately 5dB under given parameter settings in Fig.1). For higher values of path loss exponent γ, the area under 0db boundary would expand. The ratio P_c/α_{R_e} is critical in a sense that when it increases for a fixed γ, the 0db boundary would shrink.

CONCLUSION

In this letter, we show that, for wireless streaming of layered video, a proxy server can be exploited as a relay for one or more layers to decrease total transmit power dissipated in the network. Future work and simulations would analyze error propagation through the relay node and power efficiency comparison of relaying and regenerating at the proxy under correlated lognormal shadowing. A scenario with more than three cooperative proxy servers will also be studied.

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