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A Simple Downlink Beamforming Strategy for GPS-Enabled Mobiles

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Abstract*—We propose a simple downlink beamforming strategy for wireless mobile communication systems including global positioning system (GPS)-enabled mobiles. In the proposed scheme, a base station groups GPS-enabled mobiles into a low speed group and a high speed group, and then re-groups mobiles in the low speed group into low speed sub-groups such that they include mobiles positioned in a similar direction from the base station. For the downlink beamforming, the base station constructs narrow beams for each low speed sub-group, and constructs one omni-directional beam for remaining mobiles.

Keywords— ***Mobile Communications, GPS-enabled Mobiles , Downlink Beamforming, Mobile Grouping***

I. INTRODUCTION

The use of beamforming has been considered as one promising technique to reduce the effects of interference and improve the quality of service (QoS) of wireless mobile communication systems [1],[2]. In addition, GPS-enabled mobiles have been popular and GPS signals have been used in many application [3]-[5]. Similarly, if mobiles periodically report their velocity and location estimated by using GPS signals, base stations could use this information to do a downlink beamforming.

Motivated by this, in this paper, we propose a simple downlink beamforming strategy based on velocity and location information from GPS-enabled mobiles: 1) using velocity information of mobiles, the base station groups mobiles into a low speed group and a high speed group; 2) the base station re-groups mobiles of the low speed group into several sub-groups based on locations of the mobiles (that is, each sub-group includes mobiles positioned in a similar direction from the base station); 3) the base station constructs narrow beams for each low speed sub-group, and constructs one omni-directional beam for remaining mobiles.

II. PROPOSED DOWNLINK BEAMFORMING SCHEME

We propose a simple downlink beamforming strategy for wireless mobile communication systems including GPS-enabled mobiles. Assume that GPS-enabled mobiles periodically report their velocity and location estimated by using GPS signals to a base station.

First, the base station groups GPS-enabled mobiles into a low speed group and a high speed group, and considers only mobiles in the low speed group for a downlink beamforming. Due to frequent handover and signaling overhead, it is not easy and effective to do beamforming for mobiles with a relatively high speed. Note that a threshold value for determining whether a mobile is slow or not should be pre-determined. Then, the base station re-groups mobiles in the low speed group into low speed sub-groups such that they include mobiles positioned in a similar direction from the base station. In order to construct a narrow beam for obtaining a spatial interference suppression gain, mobiles should be located in a similar direction from the base station−the base station constructs narrow beams for each low speed sub-group.

Now we describe a simple sub-grouping algorithm for mobiles in the low speed group. Define S as the number of sub-groups in the low speed group ($S \geq 1$), and N_i as the number of mobiles in the *i*-th sub-group ($i = 1, \cdots, S$). Then, consider line segments connecting each mobile to the base station, and define θ_i as the maximum value of interior angles between any of the two line segments associated with the mobiles in the *i*-th sub-group. At the given value of S, we want to maximize the total number of mobiles covered by narrow directional beams. Thus, a possible criterion for sub-grouping is as following:

do sub-grouping
maximizing $\sum_{i=1}^{S} N_i$
under the constraint of $\theta_i \leq \theta_o$, for $i = 1, \cdots, S$.

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Note that S and θ_o are design parameters determining the number of narrow directional beams and their beam width, respectively, and both of them should be pre-determined.

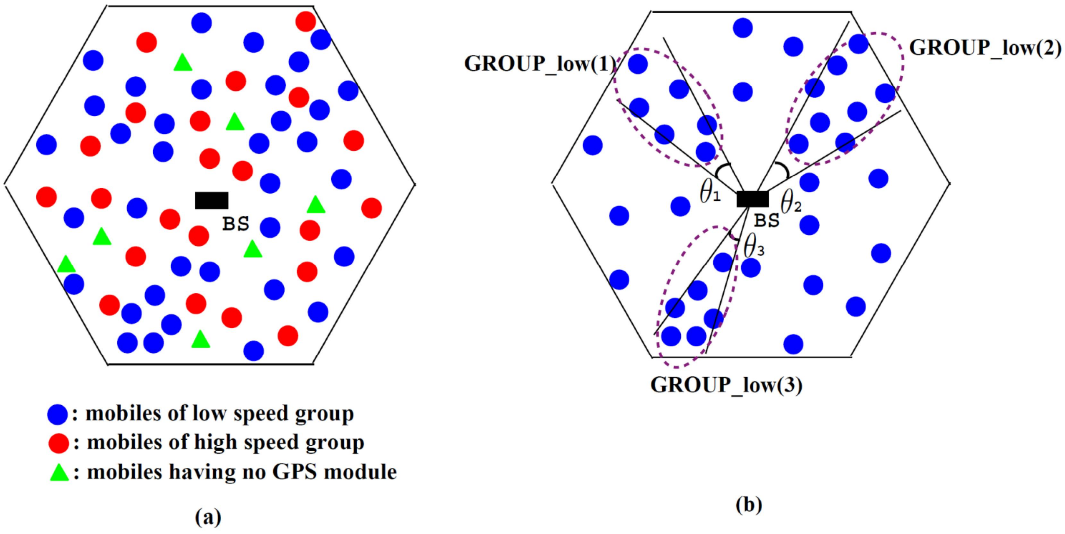

Fig. 1 Mobile grouping example for the proposed downlink beamforming scheme: (a) a given mobiles distribution (b) sub-grouping of the low speed group (here, $S=3$ and $\theta_o=30^o$ were assumed).

Shown in Fig. 1 is a mobile grouping example for the proposed downlink beamforming scheme. For a convenience of the description, a cell with no sectorization was considered. Fig. 1 (a) shows a given mobiles distribution, where low speed mobiles, high speed mobiles, and mobiles having no GPS module were included. Fig. 1 (b) shows the results of sub-grouping in case of $S=3$ and $\theta_o=30^o$ −GROUP_low(1), GROUP_low(2) and GROUP_low(3) are three sub-groups of low speed mobiles which were chosen satisfying $\theta_i \le \theta_o\left(=30^o\right)$, for $i=1,\cdots,S$.

After the sub-grouping, the base station constructs narrow directional beams for each low speed sub-group, and constructs one omni-directional beam for remaining mobiles which includes mobiles having no GPS module, non-subgrouped mobiles in the low speed group, and mobiles in the high speed group. After a pre-determined time interval during which beam patterns are kept to be fixed, mobile grouping is re-executed.

III. Conclusion

We proposed a simple downlink beamforming strategy for wireless mobile communication systems including GPS-enabled mobiles. Using velocity and location information reported by GPS-enabled mobiles, the base station groups low speed mobiles into several sub-groups in which mobiles are positioned in a similar direction from the base station; and then narrow directional beams are constructed for only each low speed sub-group. In addition, we described a sub-grouping algorithm maximizing the total number of mobiles covered by narrow directional beams

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