“Spatial Data Focusing”

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Associating wireless information to certain physical locations is an interesting feature that many applications can benefit from. This capability is known as geocasting. Just like pictures are tagged with the location where they have been clicked, geocasting enables to tag a real physical location by wirelessly transmitting data that are only decodable within desired delimited areas. Thus, users can receive information related to the place where they are. This is what is achieved to some extent by applications like Google map where metadata related to user’s location are sent. To do so, GPS coordinates of users are required. These systems are limited in terms of spatial resolution, especially in indoor environments, and necessitate some time to calculate user’s locations, thereby introducing a delay, which can be a real limitation. Furthermore, as a general matter, all systems that are based upon user’s locations lead to privacy issues. The geocasting scheme to be investigated in this internship is fundamentally different. The idea is to transmit data related to locations whether a user is present or not. So instead of considering a user who locates himself with respect to a global reference system and then correlate his position to some databases to discover surrounding locations of interest, the user is able to read the data only when he is located at the right spot. In that case, it is really the location that is tagged, and not the person. This approach therefore respects users’ privacy and does not introduce any delay as the data is always sent to the desired location (it is up to the user to decide whether or not he wants to listen). Furthermore, since this approach does not require positioning capability, all the classical positioning system infrastructure (e.g. satellites, multiple base stations…) is not required anymore. The only added infrastructure is the capability for base stations to focus data to specific spots. For this scheme to be attractive enough, this feature has to be performed with minimum complexity, low cost, and compact size. To date, no existing techniques are capable of realizing the geocasting scheme without hardware that is too complex, too expensive, too bulky, and too demanding in terms of energy.

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Consequently, the goal of this PhD is to **investigate physical solutions that enable the broadcasting of information to specific spatial locations, using limited infrastructures**. From a scientific point of view, the problem is to find a way for a base station to **wirelessly transmit data that are decodable only within desired areas**. To do so, an approach combining **signal processing** and **Multiple-Input Multiple-Output (MIMO) systems** will be undertaken in order to overcome the limitations of classical beamforming techniques. The idea is for an **antenna array** to exhibit **hyper resolution spatial data focusing**.

This PhD involves multidisciplinary aspects including electromagnetic wave propagation and digital communications. It also deals with MIMO systems and antenna arrays.

The plan for the PhD is the following:

1. Development of the appropriate signal processing to perform spatial data focusing
2. Test the spatial data focusing performance in controlled environment (i.e., in anechoic chamber)
3. Investigate the influence of the channel on the robustness of the proposed techniques using:
    a. Simplified channel models (theoretical study)
    b. Statistical-based directional channel models
    c. Real MIMO channels, measured during the PhD
4. Test the spatial data focusing performance in real environments for selected test cases. These measurements will be conducted using USRPs from NI

The candidate will benefit from a favorable environment as this work is part of the GEOHYPE project, funded by the French ministry of research (ANR), started in November 2016. The funding of this project includes the PhD grant as well as traveling expenses for conferences, equipment, etc. The project will take place at the Laboratory of Electronics and Electromagnetism (L2E) in collaboration with the ULB university in Brussels, Belgium (Prof. François Horlin and Prof. Philippe De Doncker), where regular meetings will be organized.

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