“Physical layer-based geocasting using multidimensional modulations and antenna arrays”

3-year PhD proposal at Sorbonne University

Keywords: Multidimensional Modulations, Wireless Communications Architectures, Wave Propagation, MIMO systems, Antenna Array, Digital Communications

Context

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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About the PhD

A research group at L2E is currently investigating 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. Solutions combining signal processing and Multiple-Input Multiple-Output (MIMO) systems are currently investigated in order to overcome the limitations of classical beamforming techniques. The idea is for an antenna array to exhibit hyper resolution spatial data focusing. The proposed PhD is part of this research and will investigate the benefits of using multidimensional modulations as additional degrees of freedom to enable efficient data focusing. To that aim, the candidate will investigate both time and frequency resources and dedicated transmitter and receiver architectures that could enhance data focusing capabilities in scenarios where the user is cooperative.

This PhD involves multidisciplinary aspects ranging from digital communication to electromagnetic wave propagation. It also deals with MIMO systems and antenna arrays.

The plan for the PhD is the following:

1. Development of dedicated multidimensional modulations and mapping(s) for geocasting scenarios
2. Development of dedicated solutions to recover the carrier at the receiver and to estimate the channel gain
3. Experimental assessment of the robustness of the developed techniques using USRP
4. Improvement of dedicated receiver architecture to enhance the angular selectivity

Notes

- The PhD candidate will work at the L2E lab (http://www.l2e.upmc.fr/en) of Sorbonne University (www.sorbonne-universite.fr/en), located in Paris, France, with co-supervision from Philippe De Doncker from the Opera lab (http://opera.ulb.ac.be/opera/) of the ULB University (http://www.ulb.ac.be/ulb/presentation/uk.html), located in Brussels, Belgium, where regular stays will be organized.
- The candidate should hold a Master Degree in Electronics, or equivalent. A high degree of self-motivation and excellent communication skills are expected.
- Duration: 3-year program, starting from September 2018 onwards
- Application deadline: **11th May 2018**

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