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Grouped Vectoring for Digital Subscriber Line (DSL) Systems

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Workload: LITERATURE:30%, IMPLEMENTATION:40%, VALIDATION:30%

DESCRIPTION

Digital subscriber line (DSL) access networks have a very specific topology. A cable binder containing a large number of twisted pairs is connected to the access point in the street and branches out to the different customers. This topology exhibits a major drawback. In the binder, the twisted pairs are electromagnetically coupled, which results in crosstalk. Every twisted pair in the binder thus disturbs the communication process of its neighbors. This crosstalk is the main limiting factor for the performance of twisted pair access networks. For downstream transmission, i.e. transmission from the access point in the street to the customer premises, crosstalk can be canceled by coordinating signals by means of so-called vectoring and precoding based transmission schemes.

Vectoring is ideally applied across all users in the DSL network. All crosstalk in the network can then be canceled, and users can communicate free of interference. An important requirement for being able to apply vectoring across all users, is that their twisted pair cables are connected to the same DSL access multiplexer (DSLAM, pronounced 'dee-slam'). In some cases however, different users are connected to different DSLAMs. This can occur when the number of users in the network is larger than the number of ports on one DSLAM, when multiple Internet service providers (ISPs) are active on the same DSL network, or when the copper cable of some users is partly replaced by optical fiber. In these cases, full vectoring is not available and one should resort to *grouped vectoring* (GV). In grouped vectoring scenarios, two or more vectoring groups exist. Vectoring is then possible among users that are in the same group, but not among users that are in a different group.

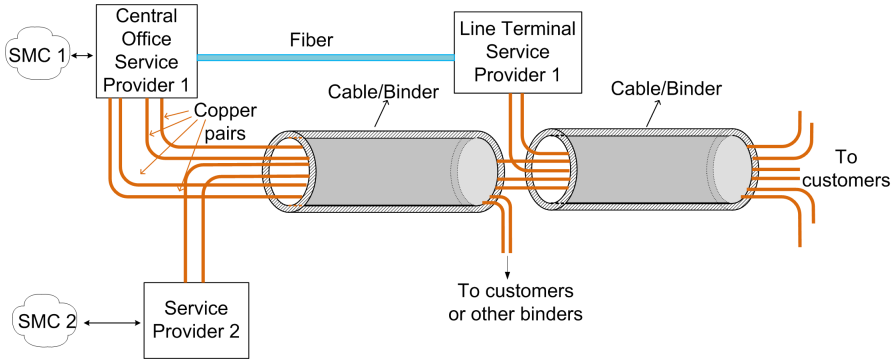

Figure 1: Example of a DSL network. Two Internet service providers are active on the same cable binder. Moreover, Internet service provider 1 has partly replaced the copper cable of some users by a fiber cable. In this example, there are 3 vectoring groups: one for each central office, and one for the line terminal of Internet service provider 1. Image source: Scholarpedia.

When defining the vectoring operation in a GV scenario, i.e. defining suitable vectoring matrices, two main approaches can be distinguished. One approach consists of finding the best possible vectoring matrices, taking into account the full complexity of the DSL network. Algorithms that find such vectoring matrices however have such high complexity, that they are impossible to implement in practice. An alternative approach consists of choosing the vectoring matrices of each group as if there were no other groups in the network. This approach is simple enough for practical implementations, but does not achieve the same performance as the optimal algorithms of the first approach.

The goal of this project is to develop an algorithm that combines the best of both worlds: it should have low complexity such that it can be implemented in practice, and it should be able to achieve close to optimal performance. In the first stage of the project, your task will be to study and implement the existing approaches towards grouped vectoring, and evaluate their performance making use of a DSL simulation environment. In the second stage you will develop a new algorithm, and compare both its complexity and its performance to the state of the art.