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SON-POWERED DYNAMIC OPTIMIZATION OF RELAY LAYER TO ENHANCE COVERAGE AND CAPACITY OF A CELLULAR NETWORK COMBINED WITH CENTRALIZED SON ON MACRO LAYER

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ABSTRACT

The usage patterns of cellular networks can change dramatically over short periods of time, such as when a large number of people crowd a very small space within a cell's coverage area for only a short period of time. In order to save on costly and inefficient current solutions, the techniques presented herein suggest a Self-Organizing Network (SON)-optimized system of relays as a layer on top of an existing system. Such relays can be deployed ad hoc, such as in the cars of people arriving at a troubled location, to alleviate temporary coverage and load issues. SON will control the activation and deactivation of these ad hoc relays and the joint optimization of both the macro and relay layers.

DETAILED DESCRIPTION

The usage patterns of cellular networks can change dramatically over short periods of time. For example, tens of thousands of people may crowd a very small space within a cell's coverage area for a sporting event, rock concert, *etc*., and then disperse 2-3 hours later. Such gatherings may also occur unexpectedly in low coverage areas.

In conventional arrangements, such events often require costly and inefficient hardware deployments. For example, one current industry solution is to deploy additional small cells, which require asset/site acquisitions, small cells and spectrum, which is not cost effective. Another solution is to temporarily deploy mobile hardware, such as "cell-on-wheels" base stations, which is also inefficient due to the logistics and cost of deployment and removal against the short time of operation.

The techniques presented herein address these situations by dynamically controlling and optimizing a layer of relays that are designed and operated to increase coverage of their macro layer cell (i.e., a cell of the parent cellular network) or alleviate its

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traffic load. Such relays can be deployed ad hoc, do not require additional spectrum, cost less than conventional mobile hardware, and can be installed on portable/mobile elements (e.g., cars, buses, *etc*.), which also resolves the cost of asset/site acquisitions

The relays can:

- Employ different types of technology for communication with different pieces of user equipment (UE), including the same as the cellular cell donor, a different cellular technology, an unlicensed spectrum technology such as a IEEE 802.11x, *etc*.;
- Be mounted on different platforms, such as constant deployment with remote electrical tilt (RET) and/or variable azimuth, carried on platforms such as drones, deployed on vehicles of users, *etc*., thus dynamically increasing the number of relays at the locations of users; and
- Be activated and deactivated per need by a Self-Optimizing-Network (SON) management system, which also optimizes their configurations.

The relays, which are controlled and orchestrated by SON, will appear to the macro layer as a piece/device of user equipment (UE) (i.e., on the macro side they will work in the cellular technology of the macro system). On the individual UE side, under their own coverage area, different relay behaviors and protocols will be supported by SON. The relays will have the option of communicating with individual UEs using the same technology as that of the macro layer (i.e.., transparently aggregate data from individual UEs to the macro layer and route data from the macro layer to the individual UEs without translation); using another cellular technology; or using IEEE 802.11x or another form of unlicensed spectrum technology. SON will support and optimize all these options.

SON will periodically discover the locations and distribution of relays using, for example, the Global Positioning System (GPS) or other location methods and maintain a database of relay locations, operation technology, properties, parameter settings, and availability. In addition, the SON will, using data it reads from the macro layer, locate areas with coverage, service quality, and/or capacity issues.

The SON will also dynamically activate and deactivate relays on a need basis, to alleviate problems found in the macro layer. SON will also dynamically optimize the parameters of the relays (depending on their technology of operation) in order to harmonize their activity with each other, particularly in areas where relays are concentrated in a small area with high capacity (e.g. relays on cars of spectators in a sporting event). Moreover, SON will take the relay layer into consideration when optimizing the macro layer, to create a heterogeneous landscape of radio coverage.

SON's handling of the relay layer (activation/deactivation, parameter optimization *etc*.) and its heterogeneous combined control of the relay and macro layers will be done in a closed loop manner, the same way SON does today on the macro layer (e.g., a snapshot phase, an action phase, and a feedback phase that will check KPIs on both layers and either revert the action or commit it and move on to the next cycle). SON's closed-loop optimization of both the macro and relay layers is an addition to current SON implementations.

In a possible expansion of the techniques presented herein, multi-relaying or relay cascading will also be supported. That is, it could be possible for a relay to communicate with the macro layer through another relay and so on, under the orchestration of SON.

In FIG. 1, below, three car-borne relays are parked within the coverage area of a macro layer cell. Several UEs in that area suffer from coverage and/or capacity issues. In this example, SON optimizes the cluster and decides to switch two relays on while keeping another one off and communicating directly with the UE in its vicinity.

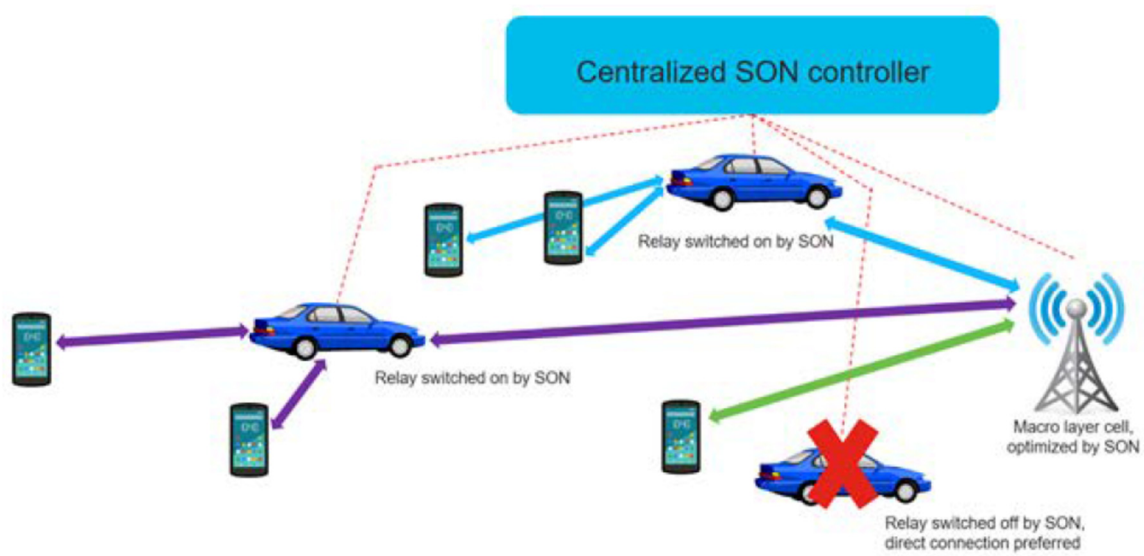

FIG. 1: A cluster with three relays, where SON switches two on and keeps one off, optimizing the cluster as a whole

In FIG. 2, below, one car bearing a relay has been driven away. The remote UEs previously served through it remain in a coverage hole. As such, SON dynamically decides to switch the remaining relay on, to alleviate the coverage issue.

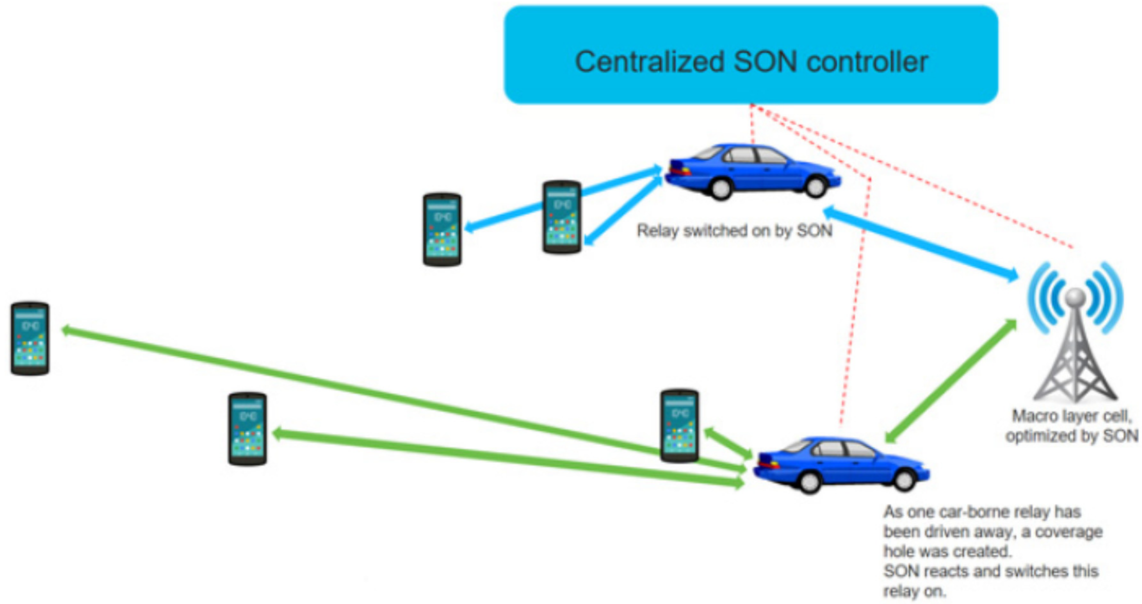

FIG. 2: A relay that had previously been kept off is now switched on by SON to alleviate a newly-created coverage hole.

The techniques presented herein may utilize existing deployed relays, with SON controlling relays which were already deployed. The relays could be located at fixed locations or integrated as part of vehicles and can be used during their parking period. The techniques presented herein may also provide real-time response to network conditions with no need to wait for the cell/drone to arrive at the location of the event, as the vehicles are already there , having been brought there by their drivers/owners - the same crowd that is causing the load. The moment load/coverage/accessibility/any degradation is detected, SON immediately activates relays to resolve the issue. The techniques presented herein would not suffer from low battery issues because the moment low battery issue is detected the SON will turn on an adjacent relay (e.g., the relay of the adjacent vehicle) and will turn off the relay with the low battery status. The techniques presented herein may also provide "Any event, Any service" where SON continually re-configures the network, selecting the optimum relays out of the dozens that are already deployed over the entire network, not just in case of massive events or IoT service. This could be at any location for any service, for example, it could be web browsing issues at the road caused due to a car accident event, which SON will resolve by turning on relays on vehicles at the accident area, which will enable any service that was consumed to become available. The techniques presented herein may be used at "Any location," such as to resolve underground parking lots coverage issue, by turning relays on vehicles parked at better-covered areas of the parking lot. In a further enhancement of the techniques presented herein, relay-to-relay communication is enabled So that relays in poorly covered areas can be connected by turning on another relay, which will be used for aggregation of the UEs of both relays. The techniques presented herein are also transparent to the network.

REFERENCES

3GPP Specification #: 28.627, Telecommunication management; Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP); Requirements.

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