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Full Duplex 10 Gb/s symmetrical data rates over traditional cable access networks

With the need for high-speed upload services growing due to demand for High Definition video uploads, real-time gaming, live streaming video and virtual or augmented reality, Nokia Bell Labs started to explore the feasibility of delivering symmetrical service over Hybrid Fiber-Coaxial (HFC) cable plants in 2014. Using innovative echo cancelation and interference management technologies, full duplex operation was recently demonstrated over cable, where the network simultaneously supports 10 Gb/s data rates for both uploading and downloading content [1].

The XG-CABLE test used two different cable scenarios. In a first, a point-to-point 100 m coaxial drop cable, XG-CABLE was able to deliver 10 Gb/s symmetric data rates with 1.2 GHz of spectrum. In a second, using HFC network topologies that utilize a Fiber-to-the-Last-Amplifier (point-to-multipoint coax drop) approach, XG-CABLE was able to deliver 7.5 Gb/s of symmetrical data speeds.

The technological assets created for the XG-CABLE proof-of-concept are valuable to meet the ambitious goals set for CableLabs new Full Duplex DOSCIS® 3.1, which is focused on providing cable operators with technology innovations that can transform the industry [2]. By leveraging the technology, operators can effectively use existing HFC cables from the last amplifier location to provide upstream speeds never before achievable due to the limited spectrum available. This will enable operators to more effectively bring ultra-broadband services to consumer locations that were not physically or economically viable unless fiber was brought all the way to the residence.

[1] Nokia Bell Labs, 'XG-CABLE for HFC networks', Technology White Paper, 2016. Available online.

[2] B. Hamzeh, 'Full Duplex DOCSIS® 3.1 Technology: Raising the Ante with Symmetric Gigabit Service', 2016. Available online.

Online ski rental for scheduling self-powered, energy harvesting small base stations

The viral and dense deployment of small cell base stations (SBSs) will lie at the heart of 5G cellular networks. However, such dense networks can consume a significant amount of energy. In order to reduce the network's reliance on unsustainable energy sources, one can deploy self-powered SBSs that rely solely on energy harvesting. Due to the uncertainty of energy arrival and the finite capacity of energy storage systems, self-powered SBSs must smartly schedule their ON and OFF operation. In the recently published paper [1], the problem of ON/OFF scheduling of self-powered SBSs is studied in the presence of energy harvesting uncertainty with the goal of minimizing the tradeoff between power consumption and flow-level delay. To solve this problem, a novel approach based on the ski rental

framework, a powerful online optimization tool, is proposed. To find the desired solution of the ski rental problem, a randomized online algorithm is developed to enable each SBS to autonomously decide on its ON/OFF schedule, without knowing any prior information on future energy arrivals. Simulation results show that the proposed algorithm can reduce power consumption and delay over a given time period compared to a baseline that turns SBSs ON by using an energy threshold. The results show that this performance gain can reach up to 12.7% reduction of the total cost; and that the proposed algorithm can eliminate up to 72.5% of the ON/OFF switching overhead compared to the baseline approach.

[1] G. Lee, W. Saad, M. Bennis, A. Mehbodniva, and F. Adachi 'Online ski rental for scheduling self-powered, energy harvesting small base stations', proceedings of IEEE International Conference on Communications (ICC), May 2016. The article received the ICC'16 TAOS best paper award.

Exploiting Smart Grids to Enhance Energy Efficiency of Communication Systems

Telecommunications are responsible for about 2-4% of the carbon footprint generated by human activity. With the fast widespread of communication devices and services, and the emergence of the Internet of Things (IoT), the situation is expected to worsen. Classical energy efficiency optimization techniques are not any more sufficient. On the other hand, the evolutions in development of environmentally friendly batteries and renewable power sources, and the exploitation of smart grids represent promising alternatives to tackle the challenge of energy usage. These sources, however, suffer from limited and random availability. Thus, classical management techniques, where the focus is on the amount of consumed power, are not any more suitable. Instead, resource allocation schemes should be designed such that they account for the generation source of each acquired amount of power. For instance, data traffic can be efficiently routed to minimize the economic and environmental effects of the consumed power by optimizing a utility function that expresses these effects as a function of the allocated power for data transmission depending on time and location. Real time energy pricing information available through the smart grid is exploited to compute these utilities. Users and bandwidth can also be dynamically allocated such that they account for the power source. Furthermore, the cooperation between base stations can be further exploited not only through dynamic allocation of the resources but also using the exchange of power between them when needed.

[1] M. Ben Ghorbel, M. Guizani, A. Mohamed, and B. Hamdaoui, `'Optimal Energy Exchange Scheme for Energy Efficient Hybrid-Powered Communication Systems', proceedings of IEEE Global Communications Conference (Globecom), Dec. 2016.

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