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OSCAR: An incentive-based collaborative bandwidth aggregation system

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The explosive demand for mobile data, predicted to reach a 25 to 50 times increase by 2015, along with expensive data roaming charges, and user expectation to remain continuously connected, are all creating novel challenges for service providers and researchers. A potential approach for solving these problems, is exploiting all communication interfaces available on modern mobile devices in both solitary and collaborative forms. In the solitary form, the goal is to exploit any direct Internet connectivity on any of the available interfaces by distributing application data across them in order to achieve higher throughput, minimize energy consumption, and/or minimize cost. In the collaborative form, the goal is to enable and incentivize mobile devices to utilize their neighbors' under-utilized bandwidth in addition to their own direct Internet connections. Despite today's mobile devices being equipped with multiple interfaces, there has been a high deployment barrier for adopting collaborative multi-interface solutions. In addition, these solutions focus on bandwidth maximization without paying sufficient attention to energy efficiency and effective incentive systems. We present OSCAR, a multi-objective, incentive-based, collaborative, and deployable bandwidth aggregation system that fulfills the following requirements: (1) It is easily deployable by not requiring changes to legacy servers, applications, or network infrastructure (i.e. adding new hardware like proxies and routers). (2) It seamlessly exploits available network interfaces in solitary and collaborative forms. (3) It adapts to real-time Internet characteristics and varying system parameters to achieve efficient utilization of these interfaces. (4) It is equipped with an incentive system that encourages users to share their bandwidth with others. (5) It adopts an optimal multi-objective and multi-modal scheduler that maximizes the overall system throughput, while minimizing cost and energy consumption based on user requirements and system status. (6) It leverages incremental system adoption and deployment to further enhance performance gains. A typical scenario for OSCAR is shown in Figure 1. Our contributions are summarized as follows: (1) Designing the OSCAR system architecture that fulfills the requirements above. (2) Formulating OSCAR's data scheduler as an optimal multi-objective, multi-modal scheduler that takes user requirements, device context information, and application requirements into consideration, while distributing application data across multiple local and neighboring devices interfaces. (3) Developing the OSCAR communication protocol that implements our proposed credit-based incentive system, and enables secure communication between the collaborating nodes and the OSCAR enabled servers. We evaluate OSCAR via implementation on Linux, as well as via simulation, and compare the results to the optimal achievable throughput, cost, and energy consumption rates. The OSCAR system, including its communication protocol, is implemented over the Click Modular Router framework in order to demonstrate its ease of deployment. Our results, which are verified via NS2 simulations, show that with no changes to current Internet architectures, OSCAR reaches the throughput upper-bound. It also provides up to 150% enhancement in throughput compared to current Operating Systems without changes to legacy servers. Our results also demonstrate OSCAR's ability to maintain cost and the energy consumption levels in the user-defined acceptable ranges.