EcoR: An Economic Incentive model for facilitating storage of materialized query results in Mobile-P2P environments

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Abstract

In mobile ad-hoc peer-to-peer (M-P2P) networks, challenges to efficient data management arise from rampant free-riding, resource constraints (e.g., energy, bandwidth, memory space) of mobile devices, and frequent network partitioning. We propose EcoR, an economic incentive model for facilitating storage of materialized query results in M-P2P environments. EcoR combats free-riding, optimizes energy and bandwidth consumption of the mobile peers, thereby facilitating network connectivity.

Introduction

In a Mobile ad-hoc Peer-to-Peer (M-P2P) network, mobile peers (MPs) interact with each other in a peer-to-peer (P2P) fashion. Proliferation of mobile devices (e.g., laptops, PDAs, mobile phones) coupled with the ever-increasing popularity of the P2P paradigm [1,2,3] strongly motivate M-P2P applications. For example, students attending a college festival in a campus may want to share information about the events during the next two hours. Visitors to a museum or historical place may wish to know now about guided tours and historical movie-screening events during the next few hours. Car users may want to know about available parking slots in busy city areas.

Such P2P interactions among mobile users are generally not freely supported by existing mobile infrastructures. Notably, our application scenarios consider tolerance to weaker data consistency.

Challenges to efficient data management in M-P2P networks arise from rampant free-riding, resource constraints (e.g., energy, bandwidth, memory space) of mobile devices, and frequent network partitioning. To address these challenges, we propose EcoR, an economic incentive model for facilitating storage of materialized query results in M-P2P environments. EcoR combats free-riding, optimizes energy and bandwidth consumption of the mobile peers, thereby facilitating network connectivity. Our work differs from existing works since they primarily address M-P2P data dissemination [3] and replica allocation in MANETs [4]. Furthermore, existing works do not address query results materialization to reduce query processing overheads.

The Eco-R model for M-P2P networks

The economic incentive model of EcoR is partially adopted from our previous work in [1] and [2]. In [1] and [2], a data item's relative importance is quantified by its *price* in terms of a virtual currency. The price of a data item depends on its access frequency, the number of users who accessed it, the number of its existing replicas, its consistency and the average response time required for accessing it. A query issuing user needs to pay the *price* of his requested data item to the user serving his request, thereby discouraging free-riding and enticing better user participation.

In EcoR, data-providing MPs periodically broadcast their list of data items to find MPs, which are willing to host their items. Upon receiving replies from other MPs, data-providers select a set of MPs for hosting their items based on remaining energy, bandwidth, current load, service capacity and available memory space of these MPs. We shall refer to this set of MPs as ***cohorts***. This facilitates better quality of service due to multiple copies, which ensure lower querying hop-counts and consequently, lower query response times. The cohorts are willing to host data items because they can earn revenue from queries on the items. EcoR stipulates that cohorts should pay 50% of the revenues from hosting items to the original data-providers. Thus, EcoR provides an incentive for data-providers to make multiple copies of their items at different cohorts since they can earn revenue even without hosting the items.

Interestingly, the same mobile user queries may be issued frequently e.g., several different students may ask about events in the next two hours in a college festival. This strongly motivates storage of materialized query results so that query processing is performed only once during a time period. This saves MP energy and bandwidth and provides better query response times. In EcoR, cohorts store materialized results for queries, whose access frequency exceeds an application-dependent threshold. When a cohort receives a query, it matches the query with its existing queries. If a match is found, the cohort sends query results directly to the user since no query processing is required.

In essence, the data-providers act as the back-end, while the cohorts act as the front-end. In our college festival application scenario, members of the student organization can act as data-providers, while their friends or student volunteers can act as cohorts since they can earn revenue by acting as cohorts. Observe how EcoR inherently supports load-balancing among the MPs by efficiently dividing the work between the data-providers and the set of cohorts.

Incidentally, materialized query results are associated with an expiry time because updates to the underlying data may necessitate updates to the query results. Such expiry times are essentially application-dependent, and the updates to the results should be performed incrementally. Cohorts delete their existing queries, whose access frequency falls below a certain threshold so that they have adequate memory space for storing results of newer frequently issued queries. Interestingly, mobile users generally look for approximate answers to their queries. Hence, EcoR follows a policy of lazy-updates in which data-providers send the updated data to the cohorts only when significant updates have occurred to the data. This optimizes network bandwidth usage, and saves energy of the MPs, thereby facilitating better network connectivity.

Conclusion

We have proposed EcoR, a novel economic incentive model for facilitating storage of materialized query results in M-P2P environments. EcoR combats free-riding, optimizes energy and bandwidth consumption of the mobile peers, thereby facilitating network connectivity. In the near future, we plan to evaluate the performance of EcoR.

References

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