A Real-time scheduling algorithm for on-demand wireless XML data broadcasting

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ABSTRACT

Extensive Markup Language (XML) has been widely used to exchange and storage mass data in mobile computing environment. The existing research focuses on preprocessing XML document and index building, but there are little research relating to how to arrange the scheduling contents and the broadcasting sequence. This paper puts forward a real-time scheduling algorithm for on-demand wireless XML data broadcasting – XML-RxW/L to reduce the request drop ratio, average accessing time and average tuning time. Our work can be divided into the three parts: (1) XML-RxW/L is proposed to reduce the request drop ratio and average accessing time. (2) An index strategy is proposed to reduce the average tuning time by forecasting data item queue. A dynamic adjusting method on the index cycle length of XML wireless data broadcasting (X_DAIL) is proposed to determine the proper index cycle dynamically. (3) A pruning algorithm (X_Prune) of XML document is proposed to remove redundant information of XML documents. An index-building algorithm (X_Index) is proposed based on DataGuide index structure to upgrade the response speed and the accuracy rate of query request. Extensive experimental results show that the XML-RxW/L algorithm has better performance than other state-of-the-art scheduling algorithms on a real data set and a synthetic data set. A real case study by R3 system shows that the proposed algorithm presents an improvement at almost 10% than other comparable algorithms in request drop ratio (RDR), smaller at almost 6–10 s in average accessing time (AAT); and smaller at almost 12 s in average tuning time (ATT).

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1. Introduction

Recent years have witnessed the quick development and population of mobile network technology, the service and application of mobile network has been involved into nearly every aspect of social life, such as communication, social contact, web commerce, cloud service, resource sharing and service, and so on. Aiming at the characteristics of mobile computing, the data broadcasting technology is conducted, and many research results are obtained. The main research topics are how to selects broadcasting data and how to broadcast the data. The applications of data broadcasting have the constraints of time limitation, which require the data broadcasting should be handled within a certain time; at the same time, the broadcasting data has a certain valid time, so that the data must broadcast at this valid time, otherwise, it would be lost. In other words, the broadcasting data selecting strategy and scheduling algorithm should not only response to more user requests, but also satisfy the time constraint requirement of mobile units. The key

technologies are how to reduce the waiting time of users and how to reduce the request drop ratio, which attracts many researchers to study and discuss (Acharya et al., 1995; Xu et al., 2006; Chen et al., 2007; Ng et al., 2008; Liu and Lee, 2010; Lv et al., 2012; Hu et al., 2014; Hu et al., 2014; Kim and Kang, 2010; Guo et al., 2001).

Data broadcasting helps extensive users to access hot data by bandwidth reusing, which supports the mobile computing characteristics of mobile clients. The data broadcasting is divided into three modes: push-based broadcasting (Acharya et al., 1995), on-demand broadcasting (Xu et al., 2006; Chen et al., 2007; Ng et al., 2008; Liu and Lee, 2010; Lv et al., 2012; Hu et al., 2014; Hu et al., 2014), and mixed broadcasting (Kim and Kang, 2010; Guo et al., 2001). The traditional data broadcasting research all make a hypothesis that the broadcasting data item is atomic, which is assumes that the broadcasting data item can not further be divided. But this assumption is invalid in practical application. Especially with the development of 4G technologies, there is no difference between mobile data broadcasting and wired network data transmission. The data type of mobile data broadcasting becomes more and more diversified with the increment of users' requirements, so it is urgent to propose a technology to flexibly reveal the data items characteristics of data broadcasting. Extensive Markup

Language (XML) is an open type data standard. Because of its simple data structure-describing mode, well self-described and expandability, and high-efficiency operability, XML has been widely used to exchange and storage mass data in mobile computing environment. XML is widely supported by mobile network applications as data and information exchange structure, and nowadays it becomes mainstream data expressing and transmission mode in mobile network. So data broadcasting based on XML becomes a research hotspot (Lv et al., 2004; Kong et al., 2005; Wan et al., 2005). The data item of traditional data broadcasting scheduling is atomic flat data item mode (key assignments pair mode), while XML data with structured and semi-structured information makes data item description at will, which makes the data broadcasting scheduling technology based on XML more complicated and dynamic, and puts forward more new and high technology requirements for data broadcasting scheduling application.

Nowadays, most related researches focus on preprocessing XML document (including pruning, merging, and decomposing) and building of air index of XML wireless data broadcasting scheduling (Park et al., 2013; Sun et al., 2014; Park et al., 2006; Fathi et al., 2013; Chung and Lee, 2007; Wu et al., 2011). The above technologies are concerned with how to handle XML documents, and remove redundancy information of XML documents (garbage of users' downloading and duplicate message among broadcasting data items). However, there are no technologies related to how to arrange scheduling contents and how to schedule the broadcasting sequence, sometimes they even adopt traditional data broadcasting algorithm to schedule the XML document, which obviously cannot upgrade the broadcasting performance.

From the above reviews, it is inferred that the overall consideration of preprocessing XML document, priority scheduling of data items, termination-judging criteria of broadcasting queue and building of broadcasting queue index should be taken into consideration. This paper puts forward a real-time scheduling algorithm for on-demand wireless XML data broadcasting – XML-RxW/L to reduce the request drop ratio, average accessing time and average tuning time (saving energy consumption of mobile units). In our preliminary work (Hu et al., 2014; Hu et al., 2014), we proposed an effective scheduling algorithm LxRxW and a dynamic adjusting method on the index cycle length (DAIL) on overall consideration of the number of lost requests during next item broadcasting time, the number of requests and the waiting time. Besides, on consideration the attribute of data item size, we introduced the split strategies and backpacks theories into on-demand data broadcasting scheduling to deal with inconsistencies of data items size, and proposed two scheduling algorithm: ES-LxRxW (equal split scheduling model based on LxRxW) and US-LxRxW (unequal split scheduling model based on LxRxW). This paper expands the above preliminary work, and the main contributions are as follows:

(1) Aiming at the characteristics of XML wireless data broadcasting, XML-RxW/L is proposed to reduce the request drop ratio and average accessing time of XML document request on overall consideration of the number of lost request during the next data item broadcasting time, the number of requests, and the waiting time.

(2) An index strategy is proposed to reduce the average tuning time (named energy consumption of mobile units) by forecasting data item queue, which slightly increases the request drop ratio and average accessing time, but can markedly reduce average tuning time. A dynamic adjusting method on the index cycle length of XML wireless data broadcasting (X_DAIL) is proposed to determine the proper index cycle dynamically, which can reach optimal integrated performance of the request drop ratio, the average accessing time, and the average tuning time.

(3) Aiming at the preprocessing of XML document, a pruning algorithm (X_Prune) of XML document is proposed to remove redundant information of XML documents. An index-building algorithm (X_Index) is proposed based on DataGuide index structure to upgrade the response speed and accuracy rate of query request.

2. Related work

In addition, the difference is that the data items of the traditional data broadcasting scheduling are simple and atomic; the data items of the XML wireless data broadcasting are XML document fragment. The information format of data items becomes more complicated, and the data item size must be taken into account in the data broadcasting, which makes the scheduling algorithm more and more complicated. At present, the bottlenecks of XML wireless data broadcasting scheduling research are focused on two sides. One is how to preprocess XML document and how reduce redundant information of mobile unit downloads and reduce broadcasting duplicate message. The other is what broadcasting index and weights are used to reasonably arrange broadcasting data items, and what scheduling algorithm is proposed to build data broadcasting queue to reduce the request drop ratio, the average accessing time, and the average tuning time.

Some scholars obtained the positive results on XML document preprocessing, and the index strategy, document pruning strategy, segmentation strategy, and merging strategy are proposed to handle redundant or duplicate information. The representative research results are as follows. Park (Park et al., 2013) established a G-node structure considering the characteristics of XML document, which could extremely take into account the attributes of XML document and context on overall consideration of structural index and relevance of XML document. The experiment showed that the proposed G-node structure could upgrade the broadcasting performance. Aimed at mass XML documents and data broadcasting scheduling problem of extensive users request, Sun (Sun et al., 2014) proposed a two-layer index method to reduce index size and distribution, and also put forward two index distribution strategies to upgrade use ratio of wireless channel. Park and Choi (Park et al., 2006) proposed a Path Summary method based on XML tree and XPath query to reduce redundant information of XML document by broadcasting channel. Fathi (Fathi et al., 2013) proposed an index building method on overall consideration the energy consumption of mobile user units and the security of XML document broadcasting. Chung and Lee (Chung and Lee, 2007) established two-layer structure (XML data tree and XML index tree), which respectively expressed XML data information and index information. They also put forward three kinds of index copy strategies to reduce energy consumption. Wu (Wu et al., 2011) proposed a sub tree-broadcasting mode between document level and node level, which took sub tree of XML document as minimum broadcasting unit, and adopted aided information to build incidence relation of XML document segments. He also put forward a XML document merging technology to reduce redundant information among XML documents, and upgrade the use ration of broadcasting channels. The above research results all focuses on the preprocessing of XML document, and reduce average tuning time by building different index strategies. But they did not consider the scheduling algorithm for XML wireless data broadcasting based on their XML documents preprocessing and index building, and also did not comprehensively consider other attributes of XML document, such as data item size, weights, document request number, request drop ratio, the average accessing time, and the average tuning time. So the research results are not all-around for XML wireless data broadcasting.