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Leasing Processing Power from Mid network using Wireless Communication

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Abstract: Many mobile applications retrieve content from remote servers via user generated queries. Processing these queries is often needed before the desired content can be identified. Processing the request on the mobile devices can quickly sap the limited battery resources. Conversely, processing user-queries at remote servers can have slow response times due communication latency incurred during transmission of the potentially large query. We evaluate a network-assisted mobile computing scenario where midnetwork nodes with "leasing" capabilities are deployed by a service provider. Leasing computation power can reduce battery usage on the mobile devices and improve response times. However, borrowing processing power from mid-network nodes comes at a leasing cost which must be accounted for when making the decision of where processing should occur. We study the tradeoff between battery usage, processing and transmission latency, and mid-network leasing. We use the dynamic programming framework to solve for the optimal processing policies that suggest the amount of processing to be done at each mid-network node in order to minimize the processing and communication latency and processing costs. Through numerical studies, we examine the properties of the optimal processing policy and the core tradeoffs in such systems.

Keywords: Network-Assisted Mobile Computing, Network Optimization, Leasing capability Data traffic, Minimizing Costs.

I. INTRODUCTION

The processing and storage capabilities of mobile consumer devices are becoming increasingly powerful. A gamut of new mobile applications has thus emerged for providing a better quality of experience for the end users. A class of such applications commonly referred to as mobile augmented reality includes ones that enable delivery of content in response to the user-generated queries for enhancing user's experience of the environment. Text to speech conversion and optical character recognition (OCR) based applications for mobile devices follow a similar paradigm. Several interesting usage scenarios thus arise. A user clicks a picture or shoots a video of a desired object–a building, painting in a museum, a CD cover, or a movie poster–through a camera phone. The video or image is then processed and sent over the network to an application server hosting a database of images. The extracted query image is then matched with a suitable entry and the resulting content–object information, location, title song from a CD, or movie trailer–is then streamed back to the user. A number of existing commercial products provide this type of service. The processing of query image or video on the phone often involves computationally demanding processes like pattern recognition, background extraction, feature extraction, and feature matching ,which when done often can diminish the battery lifetime of the mobile device. Alternatively, the raw data could be transmitted to the application server where the processing could be done. However this would increase the bandwidth demand over the network with several users using such an application and competing for spectrum along with voice and data traffic generated by users of the wireless network. The first-hop wireless link between the mobile device and base station is often bandwidth constrained and backhaul connections in mobile networks have high capital and operation expenditures per bit. Several wireless carriers have also reported a staggering increase in data traffic over mobile networks because of unprecedented use of mobile data applications. Backhaul links that carry the traffic from edges to the core using copper, fiber or wireless links are associated with significant cost for the carriers. Moreover, the transmission latency on the uplink will be higher as larger query data is transmitted through the network. Thus there is an inherent tradeoff between battery usage and latency. As mobile devices become more sophisticated with higher resolution image and video capabilities, the query data will continue to grow resulting in more demand for intelligent navigation of this tradeoff. A user request originates at the Mobile Station (MS). In order to be completed, the request must be transmitted upstream to a remote Application Server (AS) via a Base Station (BS) and a series of relay nodes. We refer to the node at the first hop as the base station, but emphasize that the links between the BS, relay nodes, and AS may be wired or wireless. If the request processing is entirely done at the MS, the limited battery power can be drained. On the other hand, if the processing is done at the AS, communication latency can be high due to limited bandwidth of the wireless access link and large query size. In Fig1, there are a number of systems which enable distributed processing across multiple nodes. We consider systems with leasing servers which are deployed at mid-network nodes to offer processing capability for the user queries before they reach the AS. Deployment of servers by

Akamai constitutes an instance of server leasing capabilities in the network, where uplink queries requesting content are processed without these uplink data having to travel all the way to backend servers. Content Centric Networking (CCN) promulgates an architecture that optimizes uplink bandwidth by aggregating data interest queries on the uplink via intermediate CCN-compliant node processing using name-based addressing internet data. An offshoot of the architecture is deployment of intermediate node caches that process queries for data and respond with content if they have it. We consider how to utilize network assisted computing to alleviate the processing burden on the MS thereby reducing its battery consumption and extending its operational lifetime. Leasing processing power from mid-network nodes can help lower communication latency because rather than transmitting the entire, large request message over multiple congested links to the AS, mid-network processing will reduce the message size. Introducing the ability to lease processing power from mid-network nodes brings in the tradeoff of leasing cost. As discussed, battery consumption and latency can be reduced by leasing processing power. However, if leasing is costly because of scarce processing capability available at the midnetwork nodes or if the users are averse to their data being accessed by the leasing servers, then battery usage and latency will increase. Depending on the relative costs between battery usage, latency, and leasing, it may or may not be beneficial to lease. We examine these tradeoffs in this paper. Using the dynamic programming framework, we solve for the optimal processing policies that suggest amount of processing to be done at a node in the network. The optimization objective is to minimize the processing and communication latency and processing costs. We consider cases where the processing times and leasing costs have linear or concave variation with the amount of processing and assess the properties of the optimal processing policy and the core tradeoffs between leasing cost, latency, batter power, and communication over the wireless access link.

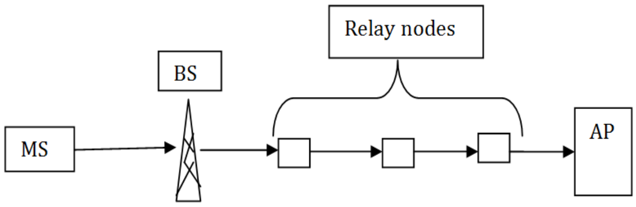

Fig 1 Existing System Architecture

II. RELATED WORKS

The processing of query image or video on the phone often involves computationally demanding processes like pattern recognition, background extraction, feature extraction, and feature matching [2], [5], which when done often can diminish the battery lifetime of the mobile device. Alternatively, the raw data could be transmitted to the application server where the processing could be done. However this would increase the bandwidth demand over the network with several users using such an application and competing for spectrum along with voice and data traffic generated by users of the wireless network. The first-hop wireless link between the mobile device and base station is often bandwidth constrained and backhaul connections in mobile networks have high capital and operation expenditures per bit. Several wireless carriers have also reported a staggering increase in data traffic over mobile networks because of unprecedented use of mobile data applications. Backhaul links that carry the traffic from edges to the core using copper, fibre's or wireless links are associated with significant cost for the carriers. Moreover, the transmission latency on the uplink will be higher as larger query data is transmitted through the network. Thus there is an inherent trade-off between battery usage and latency. As mobile devices become more sophisticated with higher resolution image and video capabilities, the query data will continue to grow resulting in more demand for intelligent navigation of this trade-off. A user request originates at the Mobile Station (MS). In order to be completed, the request must be transmitted upstream to a remote Application Server (AS) via a Base Station (BS) and a series of relay nodes. We refer to the node at the first hop as the base station, but emphasize that the links between the BS, relay nodes, and AS may be wired or wireless. If the request processing is entirely done at the MS, the limited battery power can be drained. On the other hand, if the processing is done at the AS, communication latency can be high due to limited bandwidth of the wireless access link and large query size. There are a number of systems which enable distributed processing across multiple nodes [8], [10]. We consider systems with leasing servers which are deployed at mid-network nodes to offer processing capability for the user queries before they reach the AS. Deployment of servers by Akamai constitutes an instance of server leasing capabilities in the network, where uplink queries requesting content are processed without these uplink data having to travel all the way to backend servers. Content Centric Networking (CCN) promulgates an architecture that optimizes uplink bandwidth by aggregating data interest queries on the uplink via intermediate CCN-compliant node processing using name-based addressing internet data. An offshoot of the architecture is deployment of intermediate node caches that process queries for data and respond with content if they have it. We consider how to utilize network assisted computing to alleviate the processing burden on the MS thereby reducing its battery consumption and extending its operational lifetime. Leasing processing power from mid-network nodes can help lower communication latency because rather than transmitting the entire, large request message over multiple congested links to the AS, mid-network processing will reduce the message size. Introducing the ability to lease processing power from mid-network nodes brings in the trade-off of leasing cost. As discussed, battery consumption and latency can be reduced by leasing processing power. However, if leasing is costly because of scarce processing capability available at the mid network nodes or if the users are averse to their data being accessed by the leasing servers, then battery usage and latency will increase. Depending on the relative costs between battery usage, latency, and leasing, it may or may not be beneficial to lease. We examine these trade-offs in this paper. We consider cases where the processing times and leasing costs have linear or concave variation with the amount of processing and assess the properties of the optimal processing policy and the core trade-offs between leasing cost, latency, batter power, and communication over the wireless access link. A typical application where Network-Assisted Mobile Computing would be useful is in media applications such as Mobile Augmented Reality [4], [9]. Many mobile devices are equipped with a small camera. In Mobile Augmented Reality, a picture captured by a mobile device corresponds to a request, such as streaming a desired video or audio stream to the mobile device. One of the main technical difficulties of MAR is matching the original picture to the desired media content. A series of image processing techniques are used to do this. The final step requires matching the processed image to the requested content in a large database. It is often the case that this database is so large it cannot feasibly be stored on the limited memory of the mobile device. Therefore, a request must be transmitted uplink to the Application Server. Once the request has been fully processed, the desired content can be streamed downlink to the requesting handheld device. There has been an extensive body of work focusing on the problem of downlink streaming of media content. In this paper, we focus on the uplink transmission and processing of a single original request. A request originates at the Mobile Station. In order to locate and stream the desired content, a request message must traverse multiple mid network hops before arriving at the Application Server. Due to the large file sizes (video/audio streams) which the requests correspond to, as well as the vast number of these files, it is infeasible to store them all on a memory limited mobile device. As such, they are stored in a large database at the remote Application Server and the request must be transmitted upstream in order to be satisfied. The request message must be processed (i.e., speech processing or image processing, feature extraction, feature matching [2], [5], etc.) before the media stream can be transmitted downstream. Some tasks are quite simple while others are more complex. There are also a number of scalable media standards which allow simple transcoding by simply discarding bits. In current systems, all of this processing is either done at the MS or the AS. The original request message can be a very large image file and transmitting it over multiple congested links to the AS will result in large delays. If the request were processed prior to transmission, the information needed to be transmitted may be smaller, significantly reducing the communication delay. However, limited computation power and battery resources make it undesirable to process the entire request at the MS.

III. SYSTEM ANALYSIS

A user request originates at the Mobile Station (MS). In order to be completed, the request must be transmitted upstream to a remote Application Server (AS) via a Base Station (BS) and a series of relay nodes. In Fig 2 We refer to the node at the first hop as the base station, but emphasize that the links between the BS, relay nodes, and AS may be wired or wireless. If the request processing is entirely done at the MS, the limited battery power can be drained. On the other hand, if the processing is done at the AS, communication latency can be high due to limited bandwidth of the wireless access link and large query size. There are a number of systems which enable distributed processing across multiple nodes. We consider systems with leasing servers which are deployed at mid-network nodes to offer processing capability for the user queries before they reach the AS. Deployment of servers by constitutes an instance of server leasing capabilities in the network, where uplink queries requesting content are processed without these uplink data having to travel all the way to backend servers. We consider how to utilize network assisted computing to alleviate the processing burden on the MS thereby reducing its battery consumption and extending its operational lifetime. Leasing processing power from mid-network nodes can help lower communication latency because rather than transmitting the entire, large request message over multiple congested links to the AS, mid-network processing will reduce the message size. Introducing the ability to lease processing power from mid-network nodes brings in the trade off of leasing cost. A battery consumption and latency can be reduced by leasing processing power. However, if leasing is costly because of scarce processing capability available at the mid network nodes or if the users are averse to their data being accessed by the leasing servers, then battery usage and latency will increase. Depending on the relative costs between battery usage, latency, and leasing, it may or may not be beneficial to lease. In the section we identified special properties of the optimal processing policy under various scenarios. We now examine some of these properties through numerical studies with example cost functions and systems. Latency, battery usage, and leasing costs have a tightly woven relationship.A substantial amount of work has examined Network-Assisted Computing. However, the main distinction between the previous works and ours is that we focus on allowing processing power to be leased from mid-network nodes and how to make this decision in an optimal manner. Even without the ability to lease processing power from mid-network nodes, limited battery resources present a substantial challenge. While batteries are becoming more efficient, the growing sophistication and abundance of applications makes power saving necessary. There has been an extensive body of research on reducing power usage via hardware and software design. These designs can significantly reduce the amount of battery resources required to process a request. However, a hardware design optimized for one application may be highly inefficient for another. A single device may have a Mobile Augmented Reality application which requires speech processing, while another application requires video processing. As the number of mobile applications increase, all options to save battery resources will prove to be useful.

In most standard Mobile Augmented Reality systems, processing is performed either entirely at the Mobile Station, quickly draining its limited battery resource, or entirely at the Application Server, leading to large communication delays.

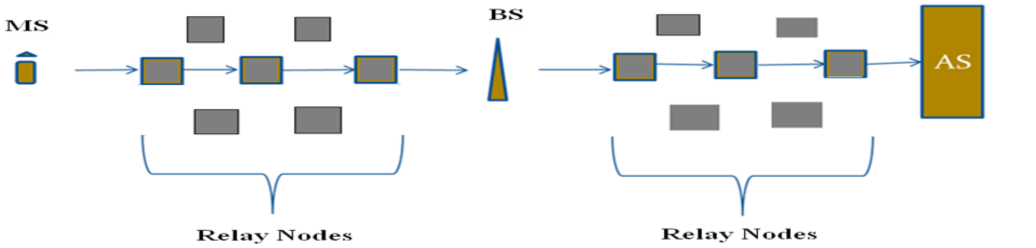

Fig 2 System Architecture

These works examine load splitting where processing is split between Mobile Station and Application Server.

IV.PROBLEM DESCRIPTION

In many media applications, such as the application described in the previous section, a large database of information is required in order to serve a request. It is infeasible to store all of this information on the mobile device. Therefore, a request must be transmitted uplink to the Application Server. Once the request has been fully processed, the desired content can be streamed downlink to the requesting handheld device. There has been an extensive body of work focusing on the problem of downlink streaming of media content. In this paper, we focus on the uplink transmission and processing of the original request. The uplink pathway from Mobile Station (MS) to Application Server (AS) is shown in Fig. 1. A request originates at the Mobile Station. In order to locate and stream the desired content, a request message must traverse multiple mid networks nodes before arriving at the Application Server. Due to the large file sizes (video/audio streams) which the requests correspond to, it is infeasible to store them all on a memory limited mobile device. As such, they are stored in a large database at the remote Application Server and the request must be transmitted upstream in order to be satisfied. The request message must be processed before the media stream can be transmitted downstream. In current systems, all of this processing is either done at the Mobile Station or at the Application Server.

The original request message can be a very large image file and transmitting it over multiple congested links to the Application Server will result in large delays. If the request were processed prior to transmission, the information needed to be transmitted may be smaller, significantly reducing the communication delay. However, limited computation power and battery resources make it undesirable to process the entire request at the Mobile Station. We propose to mitigate the power drain at the Mobile Station and the large communication delays by allowing some processing of the request to be performed at mid-network nodes. This removes some of the processing burden off the Mobile Station while reducing the request message, and in turn, the communication delays. Certainly, "leasing" the processing power at the mid-network nodes does not come for free, and we examine how to balance the battery life, latency, and leasing costs.

V.PROPOSED METHOD

To overcome the above problem our idea is to refine this existing approach by implementing the request must be transmitted upstream to a remote Application Server (AS) via a Base Station (BS) and a series of relay nodes. We refer to the node at the first hop as the base station, but emphasize that the links between the BS, relay nodes, and AS may be wired or wireless. If the request processing is entirely done at the MS, the limited battery power can be drained. On the other hand, if the processing is done at the AS, communication latency can be high due to limited bandwidth of the wireless access link and large query size. We consider how to utilize network assisted computing to alleviate the processing burden on the MS thereby reducing its battery consumption and extending its operational lifetime. Leasing processing power from mid-network nodes can help lower communication latency because rather than transmitting the entire, large request message over multiple congested links to the AS, mid-network processing will reduce the message size. Introducing the ability to lease processing power from mid-network nodes brings in the trade off of leasing cost. A battery consumption and latency can be reduced by leasing processing power. However, if leasing is costly because of scarce processing capability available at the mid network nodes or if the users are averse to their data being accessed by the leasing servers, then battery usage and latency will increase. Depending on the relative costs between battery usage, latency, and leasing, it may or may not be beneficial to lease. A substantial amount of work has examined Network-Assisted Computing. However, the main distinction between the previous works and ours is that we focus on allowing processing power to be leased from mid-network nodes and how to make this decision in an optimal manner. Even without the ability to lease processing power from mid-network nodes, limited battery resources present a substantial challenge. While batteries are becoming more efficient, the growing sophistication and abundance of applications makes power saving necessary.

A. Leasing Model

Utilizing the processing power of intermediary nodes is the main idea behind Network-Assisted Mobile Computing. In the figure 4.1, leasing processing power from mid-network nodes can be extremely beneficial to reduce latency and to extend the battery life of a mobile device. However, it comes with a cost. These costs can capture the fee required to lease CPU power from the mid-network nodes. Additionally, these costs may capture potential security risks by giving access of client data to these nodes.

While batteries are becoming more efficient, the growing sophistication and abundance of applications makes power saving necessary. There has been an extensive body of research on reducing power usage via hardware and software design. Even without the ability to lease processing power from mid-network nodes, limited battery resources present a substantial challenge. In Fig 3, some operations, such as transcoding, can be done on Encrypted data, while other would require decrypting the data. The mobile station send one sentence for ex: (how are you), in the application server receive the sentence into audio.

Fig.3 Leasing Model

B. Amplify-and-Forward

In amplify-and-forward, the relay nodes simply boost the energy of the signal received from the sender and retransmit it to the receiver in shown Fig 4. We focus on the uplink scheduling of how much processing to perform at each node in order to minimize latency, battery usage and leasing costs .Normal signal of input is given and output we obtain is more it will improve the power and maximum utilization of bandwidth frequency improved. When the efficiency of the signal is improve without loss of data.

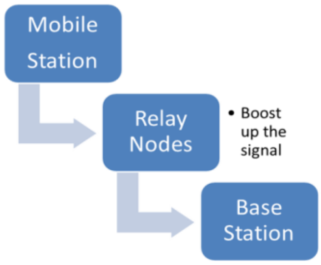

Fig 4 Amplitude and forwarding

C. Decode-and-Forward

In decode-and-forward, the relay nodes will perform physical-layer decoding and then forward the decoding result to the destinations. If multiple nodes are available for cooperation, their antennas can employ a space-time code in transmitting the relay signals. It is shown in Fig 5; cooperation at the physical layer can achieve full levels of diversity similar to a system, and hence can reduce the interference and increase the connectivity of wireless networks.

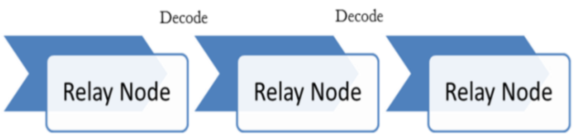

Fig 5 Decode-and-forward

D. Multi-Hop Transmission

Multi-hop transmission can be illustrated using two-hop transmission. When two-hop transmission is used, two time slots are consumed. In Fig 6 the first slot, messages are transmitted from the mobile station to the relay, and the messages will be forwarded to the Application Server in the second slot. The outage capacity of this two-hop transmission can be derived considering the outage of each hop transmission.

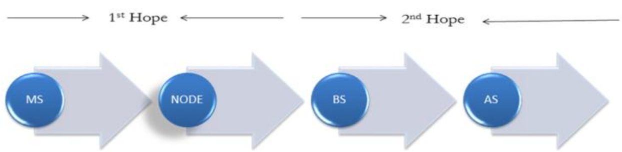

Fig 6 Multi hop transmission

VI. EXPERIMENTAL RESULTS

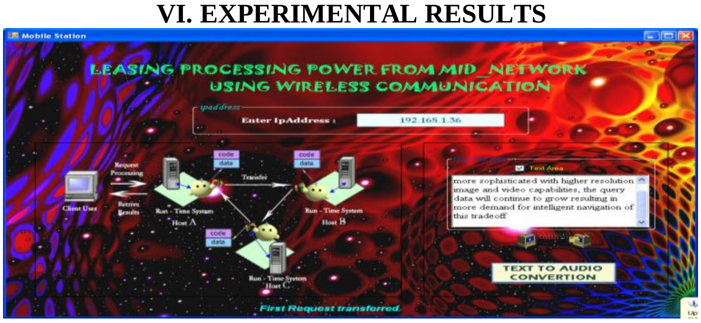

Fig 7 Entering IP Address and Text to convert

Fig 8 Identifying Relay Node

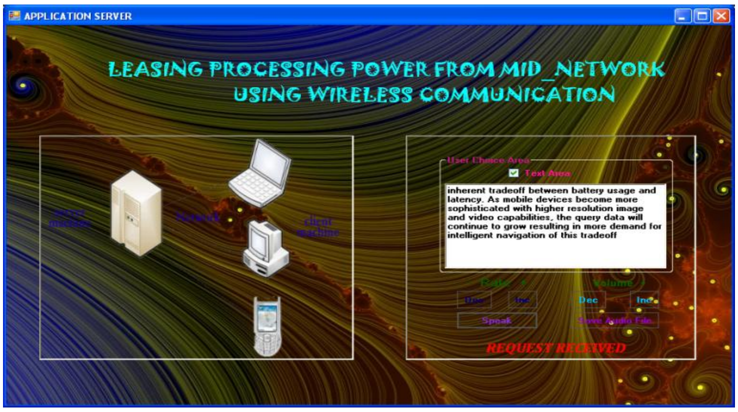

Fig 9 Request received

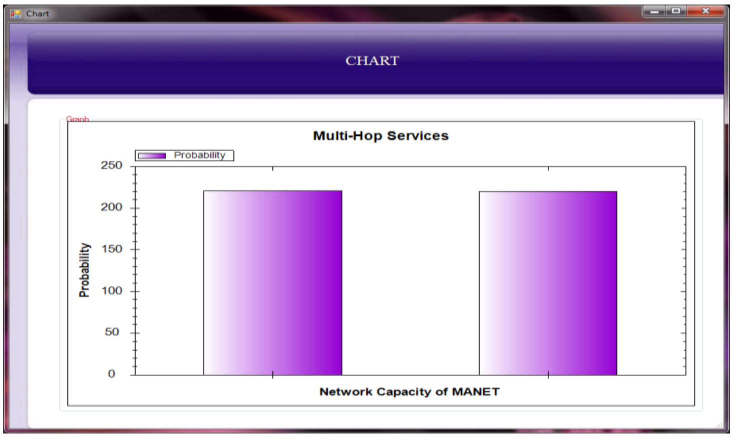

Fig 10 Graphical representation of multi hop services

VII. Conclusion

Many of these applications require significant computation power, especially in the case of multimedia applications. As the demand, as well as the sophistication and required computation power, for these types of applications increases, battery and communication bandwidth limitations may prevent the use of many of these applications. By "leasing" processing power from mid-network nodes, the battery drain and communication latency may be diminished. Network-Assisted Mobile Computing can help alleviate the processing burden off the Mobile Station without increasing the service latency. Using Dynamic Programming, we identified the optimal processing policy. We identified some important properties of the optimal policy which can be used to guide future system design. A number of factors must be considered for deployment of such a network-assisted mobile computing system. While there exist technology for collaborative networks [6], one must consider the amount of processing and data that will be permitted to be shared at mid-network nodes. If high security is required, there may be additional costs required to handle mid-network processing. The design challenges will be application and system dependent. For instance, if the processing only requires transcoding, this can be done on fully encrypted data by simply dropping packets, making mid-network processing simple and secure. However, it is certainly the case that query partitioning will be limited if the data must remain encrypted during the whole query processing. Much as transcoding encrypted media has been an interesting area of research, one may want to consider developing processes which allow for other query processing on encrypted data.The future enhancementis to convert any multimedia application such as image, video with secure manner.

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