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Content Storage and Arrangement in Wireless Networks with Object and Substance Communications

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Abstract

Residential broadband consumption is growing rapidly, increasing the gap between ISP costs and revenues. Meanwhile, proliferation of Internet-enabled devices is congesting access networks, frustrating end-users and content providers. We consider the optimal dynamic multicast scheduling to jointly minimize the average delay, power and fetching costs for cache-enabled content-centric wireless networks. We formulate this stochastic optimization problem as an infinite horizon average cost Markov decision process (MDP). It is well known to be a difficult problem and there generally only exist numerical solutions. The improvement offered by coding is quantified for two more specific classes of performance measures. Our proposed algorithm is designed in such a way that it stabilizes the queues and gradually reduces the deficit. Caches are of finite size which can be refreshed periodically from a media vault. We design provably optimal policies that stabilize the request queues and reduce average deficit to zero, the quality-of-service (QoS) target. The user who receives the file will become the base station for that file. To reduce memory consumption, when another user requests the same file the base station sends that file and then deletes it.

1. INTRODUCTION:

In the recent times, there has been a considerable rise of smart portable wireless devices as a means of content expenditure.[1] It is likely to benefit from inherent broadcast nature of wireless medium to convince numerous users at the same time but it has caching as well as content scheduling problems. In our work we are involved in solving joint content placement as well as scheduling problem for elastic and inelastic traffic within wireless networks. The value of predicting demand for several types of content is determined and the impact it has got on designing of caching algorithms. [2][3] Here we build up algorithms in support of content distribution by means of elastic and inelastic requests. We make use of a request queue to completely determine recognition of elastic content. Deficit queue finds out the required service for inelastic requests. Content providers (CPs), who monetize their video offerings via ad-based or subscription-based models, are seeing a direct impact on their revenue from reduced user QoS. Though they use sophisticated techniques such as playback buffering, content caching, adaptive coding, and TCP instrumentation to improve video quality, these approaches are inherently limited and often involve trade-offs (e.g. increasing playback buffers can reduce rebuff ring but increase startup delay). The frustrations associated with providing good QoS to users over a third-party access network may explain why some CPs [4][5] are building their own fiber hoods, while some other CPs are merging with access network operators (e.g. NBC and Comcast). However, we believe that these proprietary solutions cannot be replicated world-wide (for cost and regulatory reasons), and open solutions are needed that allow any CP

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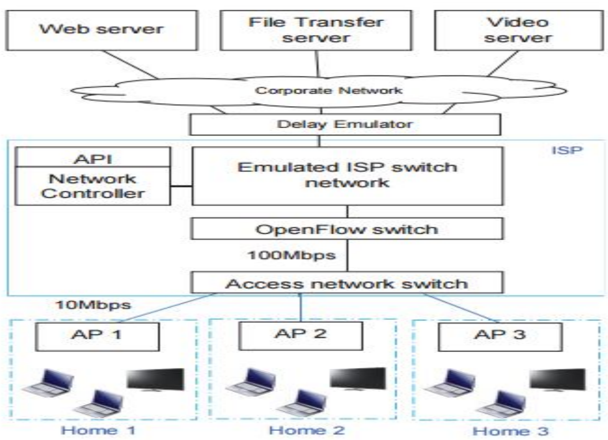
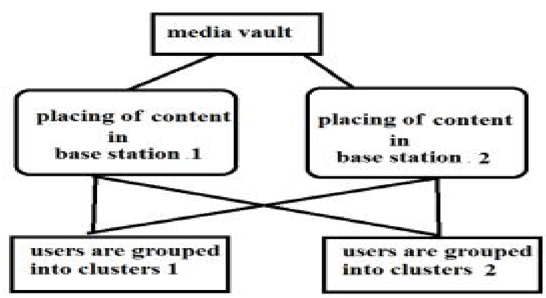
to improve the delivery of their services over any ISP access network. We consider the uniform and non uniform channel cases. By using relative value iteration algorithm (RVIA) [6] and the special structures of the request queue dynamics, as well as the power and fetching costs, we analyze the properties of the value function and the state-action cost function of the MDP for both the uniform and non uniform cases. Based on these properties, for the uniform case [7] the optimal policy schedules a content for multicasting when the request queue state falls in the region corresponding to the content. Further the switch curve is monotonically non-decreasing. Next, for the non uniform case, we show that the optimal policy has a partial switch structure, which is similar to the switch structure in the uniform case [8].



2. RELATED WORK

We take the Broadcast Incremental Power Algorithm, and adapt it to multicast operation. This algorithm exploits the broadcast nature of the wireless communication environment, and addresses the need for energy efficient operation. We have identified some of the fundamental issues associated with energy-efficient broadcasting and multicasting in infrastructure less wireless networks, and we have presented preliminary algorithms for the solution of this problem.[9] Our studies show that improved performance can be obtained when exploiting the properties of the wireless medium. Users can make two kinds of requests, namely: 1) elastic requests that have no delay constraints, and 2) inelastic requests that have a hard delay constraint. Elastic requests are stored in a request queue at each front end, with each type of request occupying a particular queue. Here, the objective is to stabilize the queue, so as to have finite delays. For inelastic requests, each time an inelastic request is dropped, a deficit queue is updated by an amount proportional to the delivery ratio. I would like the average value of the deficit to be zero. The core of the Internet is well provisioned, but network capacity constraints for content delivery are at the media vault.[10] and at the wireless access links at end-users. A mature location to place caches for a content distribution network (CDN) would be at the wireless gateway, which could be a cellular base station through which users obtain network access. Furthermore, it is natural to try to take advantage of the inherent broadcast nature of the wireless medium to satisfy multiple users simultaneously. We divide users into different clusters, with the idea that all users in each cluster are geographically close such that they have statistically similar channel conditions and are able to access the same base stations. Note that multiple clusters could be present in the same cell based on the dissimilarity of their channel conditions to different base stations[11].



3. EXISTING SYSTEM

The problem of caching, and content scheduling has earlier been studied for online Web caching and distributed storage systems. A commonly used metric is a competitive ratio of misses,

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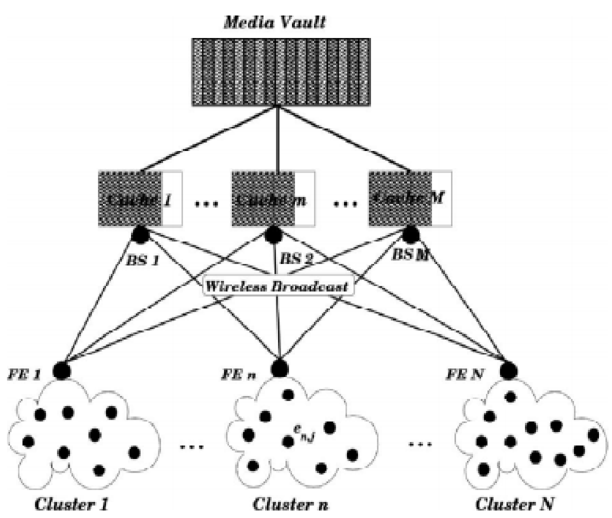
assuming an adversarial model. Load balancing and placement with linear communication costs is examined. Here, the objective is to use distributed and centralized integer programming approaches to minimize the costs. [12] This work does not take into account the network capacity constraints, delay-sensitive traffic, or wireless aspects. The techniques that we will make use of are on the basis of scheduling schemes but these do not suppose content distribution by its attendant question of content placement. In our work we are involved in solving joint content placement as well as scheduling problem for elastic and inelastic traffic within wireless networks. Moreover the value of predicting demand for several types of content is determined and the impact it has got on designing of caching algorithms [2][3]. Here we build up algorithms in support of content distribution by means of elastic and inelastic requests. We make use of a request queue to completely determine recognition of elastic content. Deficit queue finds out the required service for inelastic requests[13].



A. Space Scheduling

Pooling of residential WiFi resources has been shown to be feasible from a research [10] and commercial [14] standpoint. Our intention is to show that the ISP can leverage such mechanisms to improve call admission success (and consequent revenue), without needing to reveal such innovations to CPs. We propose a solution in which the ISP centrally manages the APs and user clients are unmodified. The residential APs are configured as transparent layer-2 devices with no routing or address translation. IP address allocation to each user device is done centrally by the ISP, as is the security authentication, akin to enterprise networks [15].

B. DISTRIBUTION OF CONTENT IN WIRELESS SYSTEMS:

While there has been important work on algorithms of content caching, there is much less on interaction of caching as well as networks. Users can build two kinds of requests, that is: elastic requests that contain no delay constraints, and inelastic requests that contain an inflexible delay constraint.[16] In a request queue, elastic queries are stored at each front end, by a request engaging a particular queue and its objective is to balance the queue, in an attempt to enclose finite delays. Intended for inelastic requests, we adopt a model in which users request content chunks that include a strict deadline, and request is dropped if deadline cannot be met. The proposal here is to fulfill a convinced target delivery ratio.

4. PROPOSED WORK

In this research work, we develop algorithms for content distribution with elastic and inelastic requests. Use a request queue to implicitly determine the popularity of elastic content, the deficit queue determines the necessary service for inelastic requests. Content may be refreshed periodically at caches[9]. The first is the case of file distribution along with streaming of stored content. The second is the case of streaming of content that is generated in real-time the content expires after a certain time. We propose an algorithm for optimally allocating network resources, leveraging bulk transfer time elasticity and access path space diversity. Simulations using real traces show that

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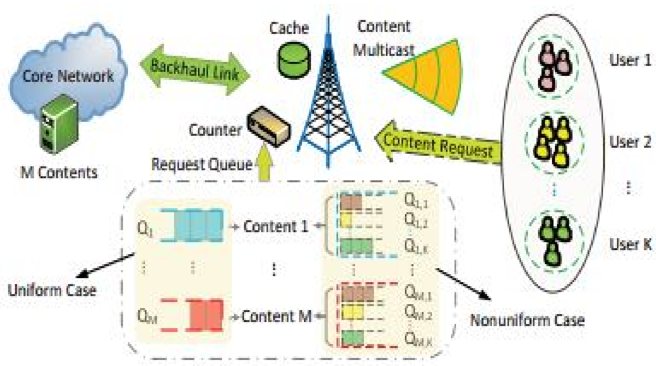
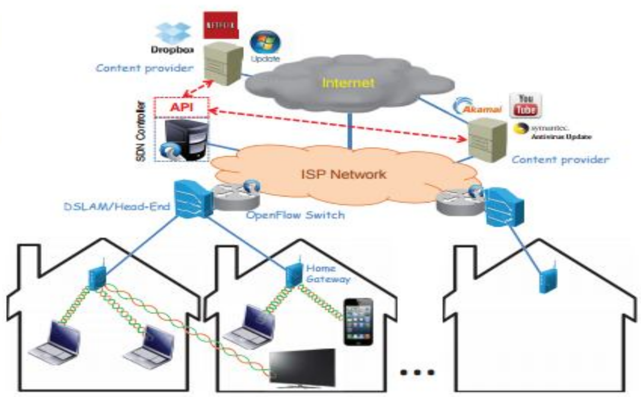
virtualization can reduce video degradation by over 50%, for little extra bulk transfer delay. We prototype our system and validate it in a test-bed with real video streaming and file transfers.[11]



Queue Size	Policy in Definition 1	Policy with Monotonically Non-decreasing Switch Curves
(N_1, N_2)	$2^{(N_1+1)(N_2+1)}$	$\binom{N_1+N_2+2}{N_1+1}$
$(4, 4)$	3.36×10^7	252
$(8, 8)$	2.42×10^{24}	48620

TABLE I: Policy space size in the uniform case at $M = 2$



5. Proposed Methods

1. The Virtualization Mechanism

The mechanism we develop for the ISP to execute the above APIs leverages the time dimension and space dimension and schedules resources for traffic flows as per our algorithm [17]

2. Time Scheduling

The term "elasticity" of bulk transfers, inferred from the deadline parameter in the API call, is used to dynamically adjust the bandwidth made available to such flows. Upon API invocation, the ISP creates a new flow-table entry and dedicated queue for this flow in the switches along the path[18].

3. Space Scheduling

Pooling of residential WiFi resources has been shown to be feasible from a research and commercial standpoint. Our intention is to show that the ISP can leverage such mechanisms to improve call admission success. [19]

4. Virtualization Algorithm

Our algorithm takes as **inputs:** The bandwidth requirement for each flow – for streaming video flows, these are supplied with the API call, while for bulk transfers these are computed periodically as described. For our test-bed, we write a C program on our APs that opens a monitor port and scans for all client transmissions, records their signal strengths, and reports these back to our controller.[5] **The output** of the algorithm is an assignment of clients to APs. The objective function is to balance the load, or equivalently minimize the maximum (peak) load, across the access links, so that the minimum residual bandwidth at any access link is maximized to accept future traffic flows [20].

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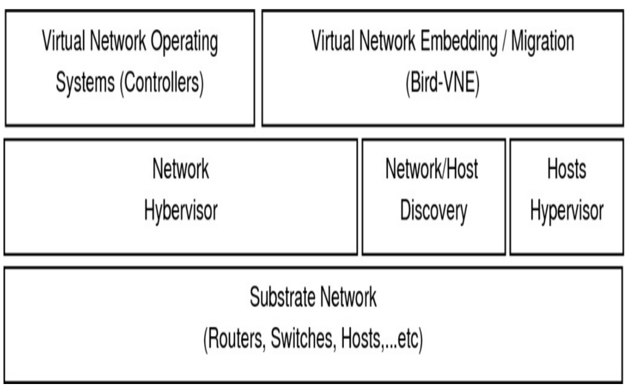
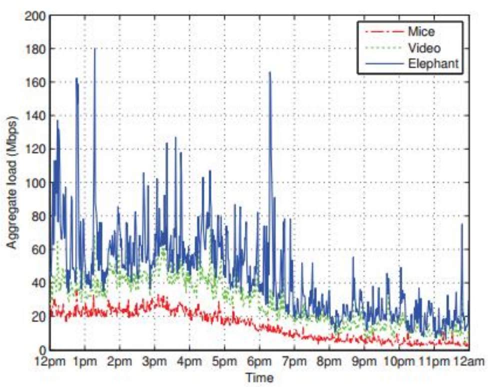
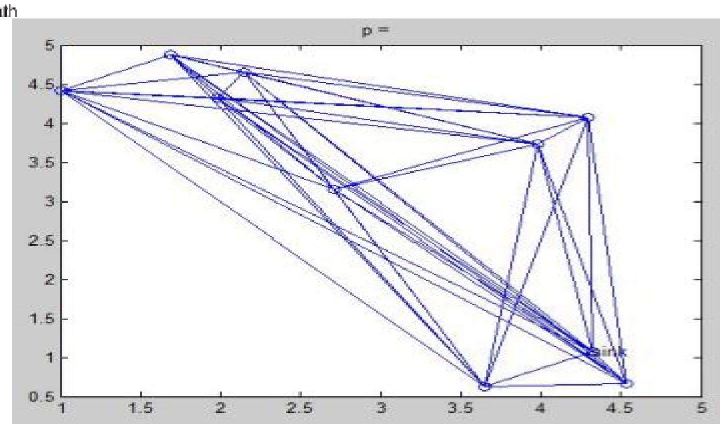
```
...
RESOURCES: {..., 4 ⇒ (LINK0, 150), 5 ⇒ (LINK1, 100)}
procedure UTILFN(BALL, BIN, ALLOC)
    ...
    BW: {0 ⇒ {0, 10, 0, 0};                          ▷ VM0 traffic
         1 ⇒ {20, 0, 0, 0};                          ▷ VM1 traffic
         2 ⇒ {0, 0, 0, 50};                          ▷ VM2 traffic
         3 ⇒ {0, 0, 50, 0}}                          ▷ VM3 traffic
    PATH: {0 ⇒ {1 ⇒ [4, 5]};                         ▷ S0 → S1 path
           1 ⇒ {0 ⇒ [5, 4]}}                         ▷ S1 → S0 path
    for all OBALL in 0...3 except BALL do
        OBIN ← ALLOC[OBALL]
        if OBIN ≠ NULL and OBIN ≠ BIN then
            for all LINK in PATHTOLCA[BIN][OBIN] do
                UTIL[LINK] +← BW[BALL][OBALL] + BW[OBALL][BALL]
        if OBIN == NULL then
            for all LINK in PATHTOROOT[BIN] do
                UTIL[LINK] +← BW[BALL][OBALL] + BW[OBALL][BALL]
        if OBIN ≠ NULL and OBIN == BIN then
            for all LINK in PATHTOROOT[BIN] do
                UTIL[LINK] −← BW[BALL][OBALL] + BW[OBALL][BALL]
    ...
```





6. RESULT

Observe that the random linear coding strategy depends on the client to find a sufficient number of linearly independent combinations in devices that are not too far away. One might argue that for small values of q there exists performance measures for which the partitioning strategy outperforms random linear coding.[21] Our first result demonstrates that this is not true that random linear coding outperforms the partitioning strategy for any value of q and any cost function



7. CONCLUSION

In the content caching and scheduling instead of having multiple base stations for the same content, one base station will have the content. Multiple base stations will be available but duplicated contents will be restricted. Same contents will not be stored in multiple base stations. Memory consumption will be low in the base stations. We showed how an algorithm that jointly performs scheduling and placement in such a way that lyapunov drift is minimized is capable of stabilizing the system. In designing these schemes, we showed that knowledge of the arrival process is of limited value to taking content placement decisions. Further we consider inelastic traffic and suppose that lifetime of an inelastic content is equivalent to length of a frame.

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