Topic Review: Multicast Applications

Review: An Alternative Paradigm for Scalable On-Demand Applications: Evaluating and Deploying the Interactive Multimedia Jukebox

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This was published in 1999 in the July/August issue of IEEE Transactions on Knowledge and Data Engineering Special Issue on Web Technologies. It presents a new way to conceptualize multimedia content delivery, as an alternative to existing models such as VoD, pay-per-view, and broadcast TV.

The basic idea of the Jukebox paradigm is that multimedia content would be delivered in a manner similar to an audio Jukebox – users request content from a given catalog to be played. These requests are entered into a queue and scheduled to be fulfilled sometime in the future. In the case of a traditional music jukebox, this scheduling is always FIFO; however, the authors of this paper point out that their jukebox paradigm can utilize several different scheduling policies, depending on the needs of the service provider. When a request is fulfilled and content is played, any number of users can "tune" in and receive the content stream, which is delivered via multicast over the Multicast Backbone (MBone).

The authors begin by describing the features and limitations of existing paradigms. They focus on the following three broad categories: Video on Demand (VoD), pay-per-view (PPV), and broadcast TV. The authors characterize the differences between these paradigms in terms of a trade-off between user control over scheduling and the efficiency of content delivery. From the perspective of service provider resources, pay-per-view and broadcast TV have very efficient content delivery mechanisms because a single stream of content is simultaneously delivered to all interested parties. These schemes, however, are not ideal because users have very limited control over the program schedule. VoD, on the other hand, allows for maximum flexibly for users since they have nearly total control over content scheduling. However, this comes at the cost of delivery efficiency because the resources required to satisfy user demand grows as demand increases. The Jukebox paradigm is presented as an alternative to the above three paradigms, which attempts to bridge the gap between user control and delivery efficiency and achieve a more ideal balance.

The authors present two different types of evaluations to demonstrate the effectiveness of the Jukebox paradigm. The first is an analysis of usage data from a working prototype that implements the paradigm, called the Interactive Multimedia Jukebox (IMJ). The second evaluation is a performance and scalability analysis in simulated environment.

Finally, the paper discusses several "advanced" services provided by the IMJ prototype. These included VCR-like interactivity, distributed program control and content delivery, future reservations, and service pricing.

Analysis

While the Jukebox paradigm presented in this paper is novel and interesting in concept, there are several weaknesses in this paper's presentation of it call its viability into question. The first of these is that the paper never describes a clear advantage of the Jukebox paradigm over the *near* VoD approach. For example, with near VoD, the resources required to satisfy user requests increases with demand. If available resources are exhausted, then users will need to wait before the content they are requesting can be delivered. The paper describes a major disadvantage of near VoD; however, the exact same problem exists with the Jukebox paradigm – if all allocated channels are currently servicing requests, users making new requests will have to wait for the channels to finish servicing existing requests before their desired content can be played. The paper mentions that with the Jukebox scheme, at least users will be able to watch *something* while their waiting, however this could also be achieved with a slight modification to near VoD to allow users to see pending batches along with their wait times and provide the ability for them to join pending batches with low wait times.

A second weakness of the paper is in its evaluations. Starting with the first evaluation regarding the usage of the IMJ prototype application, the paper claims that usage data is critical to finding and correcting problems and learning about the system behavior; yet, the paper offers very little analysis of the data it presents. For example, it states that the length of the Turner cartoon content (30min on average) is the ideal length for the jukebox. However, nowhere is the data that was collected correlated to this assertion. It also begs the question of how longer or shorter content affects the system – i.e. does the system become unusable if the average content length is 1 hour? This section could also have benefitted from some evaluation of user experience, rather than just usage data. For example, what were user wait times like, and what was the rate of reneging? A qualitative evaluation such as a user survey would also have been useful in determining what aspects of the system users found to be beneficial and what could be improved.

The performance evaluation against a simulated large-scale Jukebox system provides more a detailed analysis than the previous section regarding prototype usage data. It also has a more clearly focused goal, which is to demonstrate the scalability of the system and to compare the performance of different scheduling policies. While this evaluation is useful in determining the optimal configuration of a jukebox system, it lacks any significant comparison to other paradigms – in particular near VoD. This is a noticeable oversight, since superior scalability of the Jukebox system was cited as one of its significant advantages over near VoD. The paper is also inconsistent, or at least confusing, in its presentation of the wait time data. For example, at the beginning of this evaluation section, figure 7 clearly shows the average wait time is 11.7 minutes and the maximum wait time experienced is 34.25 minutes for a nominal jukebox system using 100 channels and receives 150 requests per hour. However, these numbers are later contradicted in figure 10 comparing vote-based scheduling policies. It shows an average wait time of 88 minutes with a nominal vote threshold of 1 – which appears to be an equivalent configuration to the system that produced an average wait time of 11.7 minutes. However, even assuming that figure 7 is correct and the average wait time for the nominal system is 11.7 minutes, this is another instance where the lack of comparison with outside systems significantly weakens the paper.

In prior work investigating resource allocation schemes for video on demand systems[1], one of the authors of this paper describes near VoD allocation schemes that can achieve maximum wait times under 5 minutes utilizing less than 100 channels. Of course there could be other factors to consider that make these two studies incomparable; however, without any comparative analysis, the data as it stands indicates the Jukebox paradigm is much less scalable than near VoD.

In the end, the basic contribution of the paper is the conceptualization of video content delivery as analogous to a jukebox. As figure 2 indicates, the jukebox paradigm is flexible enough to encompass the full spectrum of existing approaches, from VoD to broadcast TV. The jukebox metaphor, therefore, provides a unified way for thinking about these types of systems, which might allow more generalized implementations that could adapt their delivery strategy to different uses or conditions.

[1] K. Almeroth, A. Dan, D. Sitaram and W. Tetzlaff, "Long Term Resource Allocation in Video Delivery Systems", IEEE Infocom , Kobe, JAPAN, April 1997