A Novel Approach for Resources Self-Detection and Recovering from Failures in Video-on-Demand Systems

نظام مبتكر للاكتشاف الذاتى للموارد و إعادة التشغيل عند الأعطال فى نظم الفيديو عند الطلب

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Abstract: Proper resource management is an important aspect to efficient and effective use of VoD Systems. In general, resource management involves allocating resources (e.g., streams) in response to requests as well as de-allocating resources at appropriate times, for example, when the requesters no longer require the resources, or the requesters are no longer available, the system will de-allocate the resources (stop streaming). This paper demonstrate a strategy to detect and recover from failures and to prevent the waste of server resources by using the "Leasing" mechanism to grant the allocation of server resources for a certain period of time. In a test scenario, 40% from the bandwidth utilized by the VoD-System was saved by applying the leasing mechanism.

Keywords: Leasing, VoD-Systems, Failure Recovery, Resource Management, Bandwidth Optimization

الإدارة الجيدة للموارد فى غاية الأهمية للاستخدام الأمثل لأنظمة الفيديو عند الطلب. بصفة عامة إدارة الموارد يشمل تخصيصها مثل القنوات للمستخدمين عند الطلب فى التوقيت المناسب. و عند عدم تجديد الطلب يقوم النظام بإغلاق القناة. وسوف نوضح استراتيجية لاكتشاف و استدراك الأخطاء و منع إهدار استخدام موارد الخادم باستخدام آلية LEASING لإعادة استخدام موارد الخادم و بهذا يمكن توفير مايزيد على ٤٠% من المدى المستخدم للشبكة لنظام الفيديو عند الطلب بتطبيق هذه الآلية.

1. Introduction

Distributed systems differ fundamentally from non-distributed systems in that there are situations where different parts of a cooperating group are unable to communicate, either because one of the members of the group has crashed or because the connection between the members in the group has failed. This partial failure can happen at any time, and can be intermittent or long-lasting.

The possibility of partial failure greatly complicates the construction of distributed systems in which components of the system that are not co-located provide resources or other services to each other. The programming model used most often in non-distributed computing, in which resources and services are granted until explicitly freed or given up, is open to failures caused by the inability to successfully make the explicit calls that cancel the use of the resource or system. Failure of this sort of system can result in resources never being freed, in services being delivered long after the recipient of the service has forgotten that the service was requested, and resource consumption that can grow without bounds.

In distributed applications, there may be partial failures of the network or of components on the network [1]. Distributed systems require strategies to detect and recover from failures. Leasing is a way for components to register that they are alive, but to ensure that they are "timed out" if they fail or are unreachable. Leasing is the mechanism used between applications to give access to resources over a period of time in an agreed-upon manner.

The paper is organized as follows; firstly we describe the related work. Next we discuss the leasing conceptual approach followed by a discussion of the leasing approach in the proposed VoD System. Next the relation between leasing and time is described. Finally the results and contribution are presented.

2. Related Work

The fundamental problem in large-scale networks is to satisfy QoS to the end user and achieve economic viability. The problem of resource allocation is discussed in [2] by partitioning the requests based on divide and conquer scheme and precomputation techniques. Divide and conquer scheme reduces the computational complexity independent of the network size. The overall network performance is maximized by adapting to a suitable

apportioning scheme, thereby satisfying the end-to-end QoS requirements. In precomputation techniques, certain computations are performed in advance during the period when the resource is not in use. This reduces the time required to handle the request. The precomputation technique is carried out based on estimation which is based on heuristics leading to inconsistency. In [3], admission control and resource reservation schemes are addressed. The admission control scheme divides the problem into smaller sub-problems: division of end-to-end QoS into the local QoS requirement, mapping of the local QoS requirement into the resource requirement, and reclaiming of the resource allocated in excess. The resource allocation problem is addressed by establishing a multicast tree and then reserve the necessary resources reducing the call rejection probability. The algorithm is developed for static groups where all the receivers are known before the session starts. Distributed multimedia applications require dynamic QoS [4] for continuous streaming of multimedia. Load balancing can be achieved by minimizing load on heavily loaded machines i.e., minimizing Bottleneck Resource Utilization (BRU). A client server architecture; Adaptive Distributed Multimedia System (ADMS) along with reduced BRU, is proposed. In ADMS, the user has to state the QoS requirements. The system has the flexibility to accept or reject the request based on the availability of the resources. It presents a unified feasible way to solve admission policy but fairness is not guaranteed. In order to deliver good QoS, the VoD service should be nearly immediate and continuous [5, 6]. A set of work load models are developed to identify the limitations of greedy allocation algorithm: (i) they do not minimize customer's waiting time. (ii) they perform poorly when load conditions vary. To solve these limitations, a set of rate-based policies are proposed, which work by ensuring that the channels are available for allocation on consistent basis. In this method, it is difficult to determine the number of channels needed to provide the desired QoS. In [7, 8, 9, 10, 11], various issues to manage group dynamics, resource reservation, allocation of resources and admission control in multicast applications are examined. Dynamic group management is critical as members can join and leave the group at any instant of time. Resources must be reserved appropriately as excess reservation leads to the wastage of the resources. Poon et al. [12] proposed an algorithm to dynamically find the batching time by newly updated arrival rate so as to minimize the bandwidth which is a complex procedure and time consuming. The Patching scheme proposed in [13, 14, 15] extends the capability of the standard multicast to support true Video-on-Demand. All the above techniques will perform efficiently only if enough resources are available. Ramesh et al. [16] proposed a hybrid strategy which is a combination of two popular approaches: pyramid broadcasting and recursive patching.

Fragmentation of video into segments enables VCR functions like pause and resume, rewind and forward to be handled easily.

3. The Leasing Approach

What is a Lease?

- A grant to use a resource for a certain period of time.

Why Leasing?

- Handles intrinsic unreliability in a distributed computing
  - Partial failure, Slow connection
- Solves problems of traditional distributed systems
  - Resources never freed
  - Services delivered long after the request
  - Unbounded resource consumption
- Provides extra benefits
  - Resource management

The primary idea behind leasing is that it requires a continued proof-of-interest on the part of the lease holder (VoD Client) if it is to continue holding some resources. If the lease holder fails to demonstrate interest, then the lease expires and the resource is released.

The failure of a lease holder (VoD Client) to demonstrate proof-of-interest may be because the holder is honestly no longer interested in the resource, or because he has crashed or became disconnected from the network.

By granting a lease, the system guarantees that failures will be detected, and when will they be detected – if a lease is granted for 10 minutes, then 10 minutes is the longest window during which unnoticed failure may exist.

Leasing provides a way to for distributed systems to automatically clean up after failed components [17]. A component that fails won't have the opportunity to free up its resources.

Leasing guarantees that irrelevant data will simply be forgotten when leases expire. As a result, the system is self-healing in face of failures of resource holders.

Leases Characteristics:

- Leases are specified using desired lease duration, rather than an explicit lease expiration time.
- Relative time – a resource consumer requests a lease for duration (an hour…).
- Lease holder can renew/cancel the lease any time prior to expiration.
- Lease grantor can refuse renewal request.
- Time required for sending the message to renew the lease – leases should be requested large enough that the time required to send a renewal message will be enough. Most leases will be on the order of five to ten minutes.
- Leases are negotiated.
- The grantor (VoD Server) has the final say on the lease that is offered.
- A lease requestor (VoD Client) asks for a lease of a given duration, and the grantor replies with the actual duration, which may be the requested value, zero (denying the lease), or any value in between, ease period granted can't be more than what is requested.
- The grantor (VoD Server) returns the lease; the receiver (VoD Client) effectively holds it.

4. Leasing in the proposed VoD System

Leases are requested for periods of time, and these requests may be granted, modified, or denied. The most common example of a lease is when a VoD Client is registered with a VoD Server. A VoD Server will not want to keep a VoD Client forever, because it may disappear. Keeping information about nonexistent VoD Clients is a waste of resources on the VoD Server. As a result, a VoD Server grants a VoD Client access to a resource for a limited time (the lease period). If the resource is needed beyond the original lease period, then the VoD Client can renew the lease by requesting additional lease periods. Once the resource is no longer needed, the VoD Client may relinquish its lease. If the VoD Client does not renew a lease before expiration of the lease period, the VoD Server assumes VoD Client failure and terminates the lease to prevent resource leaks.

Figure 1 illustrates message exchanges for some typical leasing scenarios. A registering component requests registration for duration *LR*, which may be accepted at time *TG* for a granted lease period *LG* < *LR*. *LR* may be *any*, which allows any value for *LG*. To extend registration beyond *LG*, registering components must renew the lease prior to an expiration time *TE* = *TG* + *LG*; otherwise, registration is revoked. This cycle continues until the VoD Client component cancels or fails to renew a lease. The VoD Server assign *LG* within a configured range, *LMIN* < LG < *LMAX*. While a granted lease may not be revoked prior to *TE*, the VoD Server may deny any lease request.

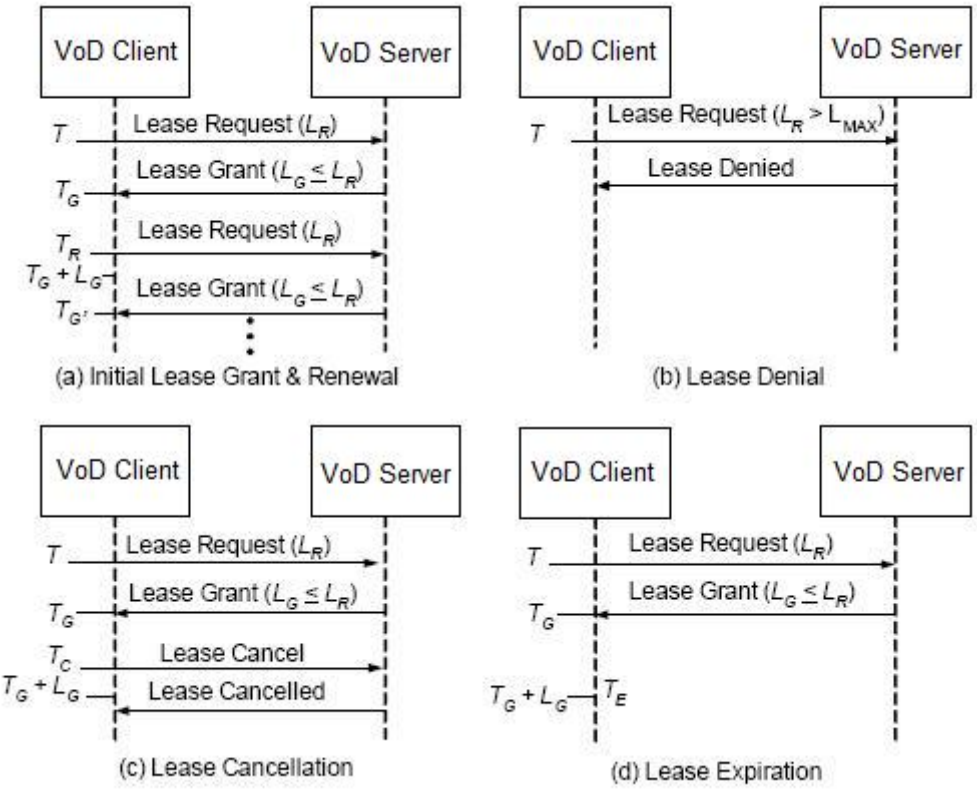

Figure 1: Message exchange for different Leasing scenarios

The LifetimeManager component is responsible about applying the Leasing mechanism.

5. Leasing and Time

The duration of a lease is determined when the lease is granted (or renewed). A lease is granted for a duration, rather than until some particular moment of time, since such a grant does not require that the clocks used by the client and the server be synchronized [18]. The difficulty of synchronizing clocks in a distributed system is well known. The problem is

somewhat more tractable in the case of leases, which are expected to be for periods of minutes to months, as the accuracy of synchronization required is expected to be in terms of minutes rather than nanoseconds. Leasing is expected to be used by clients and servers who are widely distributed. In such a case, clock drift of many minutes is a common occurrence. Because of this, the decision was to use durations rather than absolute time. The reasoning behind such a choice is based on the observation that the accuracy of the clocks used in the machines that make up a distributed system is matched much more closely than the clocks on those systems. While there may be minutes of difference in the notion of the absolute time had by widely separated systems, there is much less likelihood of a significant difference over the rate of change of time in those systems. This decision does mean that holders of leases and grantors of leases need to be aware of some of the consequences of the use of durations. In particular, the amount of time needed to communicate between the lease holder and the lease grantor, which may vary from call to call, needs to be taken into account when renewing a lease. If a lease holder is calculating the absolute time (relative to the lease holder's clock) at which to ask for a renewal, that time should be based on the sum of the duration of the lease and the time at which the lease holder requested the lease, not on the duration and the time that the lease holder received the lease.

6. Results

The network load from our VoD system [19, 20] was measured with and without using the leasing approach. A single VoD server and 5 VoD clients were used, in both cases the network load for 15 minutes was measured, one minute after starting the monitoring tools the VoD server was started, one minute later 5 VoD clients simultaneously were started, eight minutes later 2 VoD clients were killed, the system was monitored for another five minutes. The results shows that the network utilization while running the system with the leasing mechanism was enhanced since the VoD server was able to detect the absence of the 2 VoD clients and closed the corresponding streams. Figure 2 shows that, in our test scenario, 40% from the bandwidth utilized by the VoD System (5 Streams x 1482 kbps = 7410 kbps) was saved by applying the leasing mechanism. Since 2 of the started clients were not able to renew their granted leases and the allocated streams were released from the VoD Server. The leasing interval could be controlled dynamically based on the server load, in situation where the server load reaches critical limits; the leasing interval could be reduced to a minimum to detect no longer active clients as soon as possible.

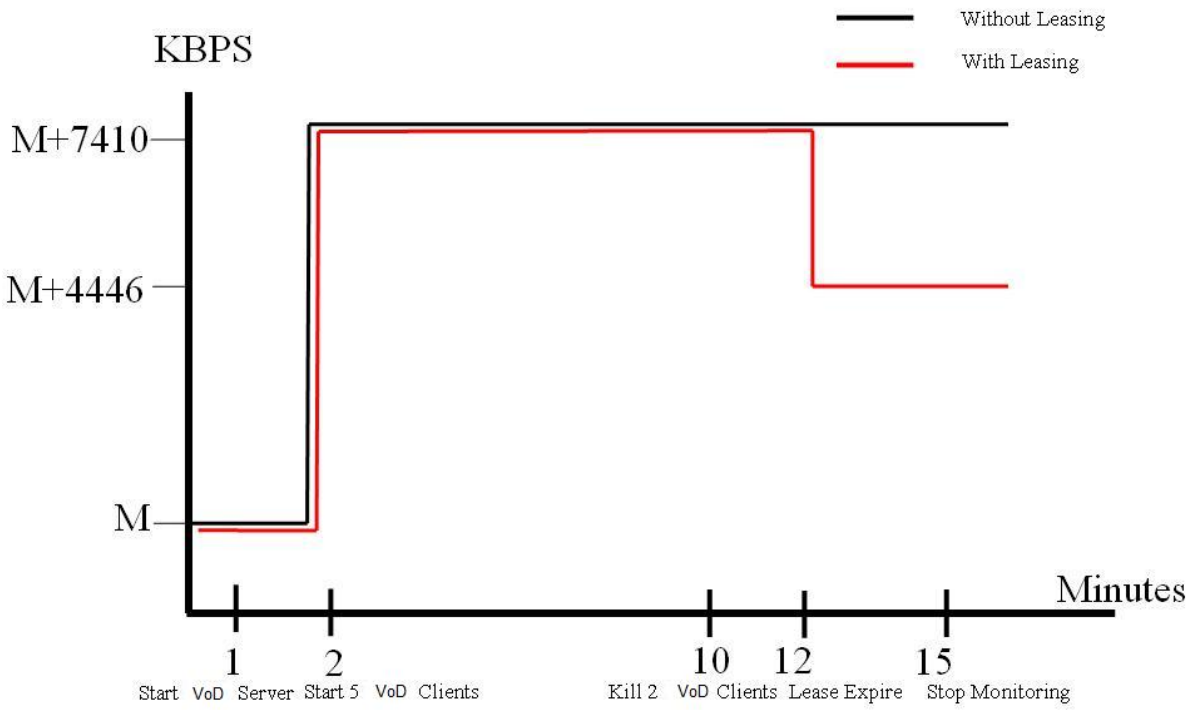

Figure 2: The network load from the proposed VoD System with and without using the leasing approach

7. Contribution and Future work

The paper presented a new approach to optimize resources utilization for VoD Systems by applying the Leasing mechanism where access to resources is leased to consumers, rather than granted to them perpetuity – as a way to acknowledge that systems fail.

In future work, situations where VoD Systems are deployed with a load-balancing mechanism, a mechanism is needed to synchronize leases from a group of streaming servers.

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