

## MADCAP Multicast Scope Nesting State Option

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### Abstract

This document defines a new option to the Multicast Address Dynamic Client Allocation Protocol (MADCAP) to support nested scoping. The new option's purpose is to allow clients to learn which scopes nest inside each other, and hence it may be used for expanding scope searches or hierarchical multicast transport.

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## 1. Introduction

The Multicast Address Dynamic Client Allocation Protocol (MADCAP) [RFC2730] affords client applications the ability to request multicast address allocation services from multicast address allocation servers. As part of the Multicast Address Allocation Architecture [RFC2908], MADCAP gives clients the ability to reserve, request, and extend leases on multicast addresses.

A new MADCAP option, the "Multicast Scope Nesting State" option is proposed to allow clients to learn not only which scopes exist via the existing "Multicast Scope List" option, but how these scopes nest inside each other. This new option will also afford clients the ability to make better scope selections for a given session and also to construct hierarchies of administratively scoped zones. These hierarchies may then be used to perform expanding scope searches instead of the expanding ring or increasing-TTL searches. Expanding scope searches do not suffer from the Split-Horizon Effect present in expanding ring searches, and therefore both simplify protocol design and provide better localization.

### 1.1 Time-To-Live (TTL) Scoping Split Horizon Effect

Multicast searching and localized recovery transport techniques that rely on TTL scoping are known to suffer when deployed in a wide scale manner. The failing lies in the split horizon effect shown below in Figure 1. Here a requestor and responder must each use a TTL that is sufficiently large that they will reach the other. When they are separated by many hops the TTL becomes large and the number of receivers within the multicast tree that only receive either the request or the response can become very large.

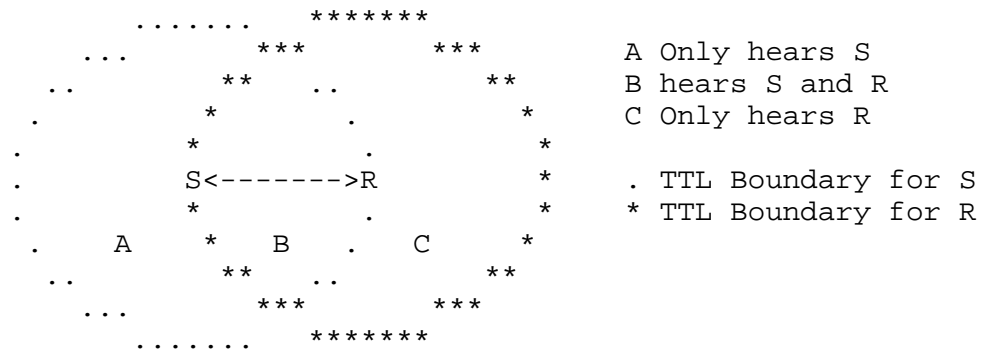


Figure 1 : Split Horizon Problem from TTL scoping

## 1.2 Eliminating the Split Horizon Effect with Administrative Scoping

Ideally, a mechanism that either eliminates or minimizes the size of the A and C regions in Figure 1. as shown in Figure 2. is needed to solve this problem. One mechanism that affords this ability is administrative scoping [RFC2365], in which routers prevent the passing of packets within a certain range of multicast addresses. Routers that have this feature can be configured to provide a perimeter around a region of the network. This perimeter is said to encompass an administratively scoped zone inside of which traffic sent to that particular range of multicast addresses can neither leave nor enter. Routers can construct and manage administratively scoped zones using the MZAP [RFC2776] protocol.

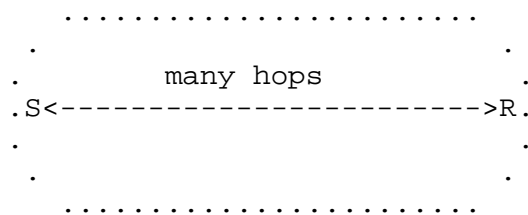


Figure 2 : Eliminating the Split Horizon Effect

MZAP also includes the ability to determine whether or not administratively scoped regions nest inside one another. This allows hierarchies such as that shown in Figure 1. to be constructed.

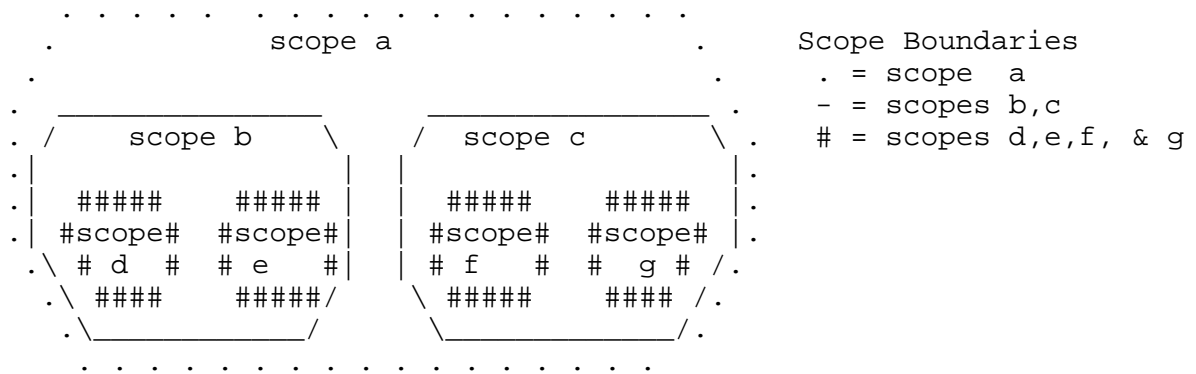


Figure 3 : Admin Scope Zone Nesting Hierarchy example

A generic expanding scope search algorithm [KERM] that exploits the existence of a hierarchy of administratively scoped zones is:

- 1) Starting with the smallest known scope for the session, a requestor in that session issues a request and waits for a reply.
- 2) If a node within that scope hears a request at a certain scope that it can satisfy it sends a response at that same scope, possibly after some random delay to reduce duplicate responses.
- 3) Nodes that receive a response to a particular request while waiting to send a response to that request, suppress their own response.
- 4) If a requestor issues a request to a scope, and does not hear a response after a specified amount of time, it retransmits its request at the same scope a small number of additional times. Should these retries fail to elicit a response, the requestor increases the scope to the next largest scope and tries again.
- 5) Requestors increase the scope of the request according to step 4 until either a response is received, or the largest legal scope for the session is reached. Should attempts to elicit a response at the largest possible scope for the session fail to yield a response, the requestor may conclude that the request cannot be met.

### 1.3. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Throughout the rest of this document, the words "server" or "MADCAP server" refer to a host providing multicast address allocation services via MADCAP. The words "client" or "MADCAP client" refer to a host requesting multicast address allocation services via MADCAP.

## 2. Multicast Nested Scoping State

Two scopes, X and Y, can be related in one of four possible ways.

- 1) X nests inside Y,
- 2) Y nests inside X,
- 3) X and Y do not nest (the overlap case), and
- 4) X and Y nest inside each other.

The fourth case SHOULD be interpreted as meaning that X and Y have exactly the same border. This does not mean that X and Y are the same scope since X and Y may correspond to different ranges of the multicast address space.

This state MUST be stored in the MADCAP servers which MUST allow the state to be updated as network conditions change. Each MADCAP server SHOULD therefore define two pieces of state that describe whether "scope X nests in scope Y" and vice versa. For the remainder of this document the nesting relationship shall be denoted as the "/" where X/Y defines the relation "X nests inside Y". This relation shall be understood to take one of the values "true", or "false". Nesting relationship state that is indeterminate is considered to be "false".

## 3 Multicast Scope Nesting State Option

The "Multicast Scope Nesting State" option is proposed to augment the "Multicast Scope List" option within the MADCAP protocol by providing additional information to applications about how scopes nest. The proposed option is OPTIONAL, that is MADCAP servers MAY implement this new option, however they are not required to.

MADCAP servers shall learn this additional nesting information by means of static configuration or via some other protocol such as MZAP [RFC2776] that manages administrative scopes in a dynamic fashion.

### 3.1 Multicast Scope List Option

To understand the "Multicast Scope Nesting State" option one must first understand the "Multicast Scope List" option.

The Multicast Scope List option in MADCAP is used by MADCAP servers to inform MADCAP clients of which zones are visible. Visible scopes are enumerated inside the option as successive tuples, where each tuple consists of the following information:

- o Scope ID:  
The smallest address for the range of multicast addresses covered by this scope.
- o Last Address:  
The largest address for the range of multicast addresses covered by this scope.
- o TTL:  
The TTL to be used when sending messages to this scope.
- o Name(s):  
One or more language specific names for the scope.

### 3.2 Representing the Multicast Scope Nesting State

Given a Multicast Scope List containing descriptions for  $n$  scopes one can form  $n(n-1)/2$  pairings. As was shown in section 2 each pairing can take on one of four possible states. Thus, for a list of  $n$  scopes there exists 2 pieces of information for each pairing for a total of  $n(n-1)$  pieces of information regarding which scopes do and do not nest inside each other.

There are several ways to represent this state using full matrices, sparse-matrices, and using lists of variable length lists. In the interests of maximal efficiency and flexibility, the Multicast Nesting State Option uses a bit-packed matrix approach. In this approach a matrix is constructed using pieces of X/Y state where X is the row and Y is the column. A "1" in the matrix means that the relationship "row nests inside column" is true, while a "0" means that this relationship is either false or indeterminate. The diagonal of the matrix is removed, since this is the case where X is the same as Y, and each row is then zero-padded to the next byte boundary to give the final representation.

An example of how a matrix would be constructed for the following scope nestings S1/S2, S2/S3, S2/S4, S3/S5, S4/S5, S5/S6, and S6/S7. Note that a number of additional nesting relationships are implied from this set.

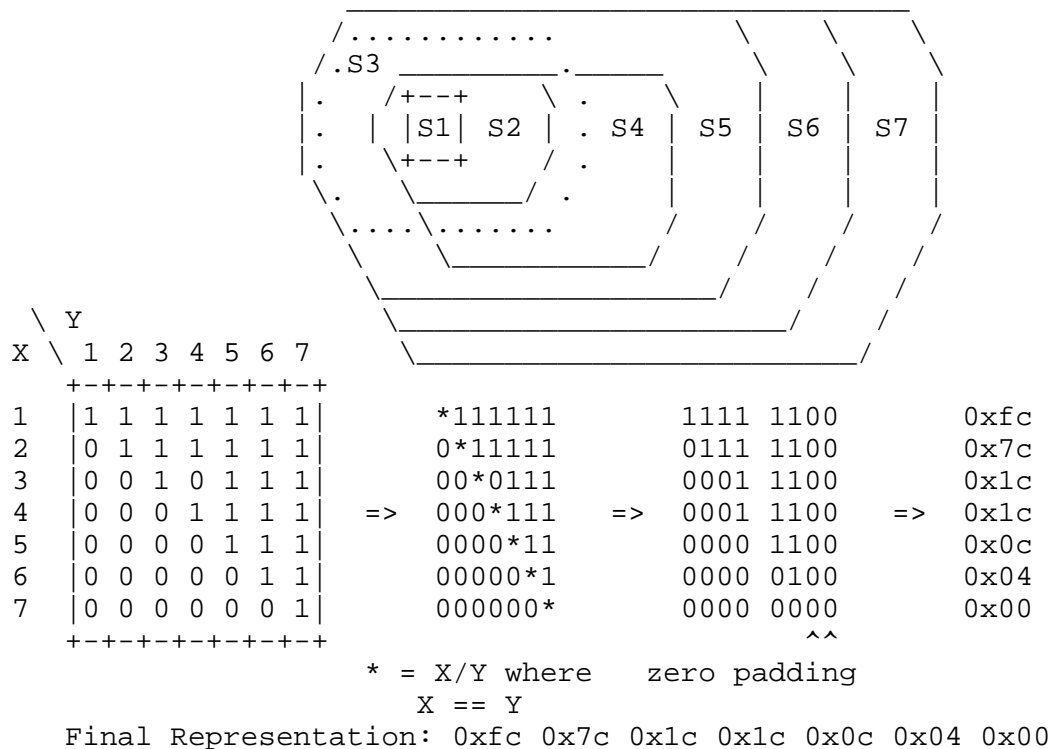


Figure 4. Scope Nesting Example

### 3.3 Multicast Scope Nesting State Option Usage

The "Multicast Scope Nesting State" option is dependent upon the "Multicast Scope List" option. This decision was made according to the following reasoning. The Multicast Nest State Option requires that the scopes be identified along with their nesting properties. Since the information needed to describe a scope is contained in the Multicast Scope List option and this information can change, the MADCAP messages that contain the Multicast Scope Nesting State option must be atomic and therefore must include the "Multicast Scope List Option".

Thus, the "Multicast Scope Nesting State" option MUST only be used in messages that carry the "Multicast Scope List" option, specifically:

ACK (in response to GETINFO)

Since the Multicast Nest State option is dependent upon the Multicast Scope List option, it MUST NOT be included without the Multicast Scope List option.

Clients that need to explicitly learn the nesting relationships between scopes should therefore send a GETINFO message to the server with the "Multicast Scope List" AND "Multicast Scope Nesting State" option codes listed in an Option Request option.

#### 4. Managing Dynamically Nested Scopes

Scopes can either be manually or automatically configured. When scopes are manually configured the relationships between them will also be static, assuming that network does not partition due to router failure. Should the network partition or heal after a partition it is highly likely that the nesting relationships will change. Scope nesting relationships will also change as a network is brought up or when a change is deliberately made to a router either through manual reconfiguration or by some automatic means.

To ensure that nesting relationships are correctly determined when scope boundaries undergo change MADCAP servers MUST include a mechanism that allow for:

- a) whether the nesting decision is still under consideration or can be considered definitive, and therefore be announced to MADCAP clients.
- b) whether one or both scopes for a particular nesting state entry have been destroyed, and hence whether the nesting state should therefore be discarded.
- c) whether the scope boundaries have changed so that whereas scope X did or did not nest inside scope Y, the opposite is now true.

To realize a) and b) MADCAP servers MUST implement the following two timers; NEST\_NO\_DECISION\_TIMER, ZONES\_EXIST\_TIMER.

The first timer, NEST\_NO\_DECISION\_TIMER, is used to mark time between a MADCAP server's first hearing of a scope and making a decision about its relationship to other zones. Up until the time this timer expires MADCAP servers MUST NOT conclude that the scope nests within another.

The NEST\_NO\_DECISION\_TIMER timer will also be used to timeout X/Y = "false" state to allow X/Y to be reset to true in the event that the boundaries for zone X and zone Y change so that zone X now nests inside zone Y.

The second timer ZONES\_EXIST\_TIMER will be used to timeout the internal state between two scopes in the event that one or both scopes are destroyed.

#### 4.1 MADCAP Server processing of MZAP messages

When MZAP is used to discover the nesting relationship between scopes MADCAP servers will eavesdrop into the MZAP messages that are periodically transmitted by the Zone Border Routers (ZBR) during the normal course of administrative scope boundary maintenance. In this way they will be able to learn which scopes exist (via Zone Announcement Messages, ZAMs) and which of these scopes do not nest (via Not Inside Messages, NIMs). This state must be cached within the MADCAP server.

When a MADCAP server S receives a NIM from a ZBR containing information that scope X does not nest in scope Y, it MUST update its internal state in the following manner.

- 1) S MUST update its internal X/Y state to "false".
- 2) S MUST restart NEST\_NO\_DECISION\_TIMER for the newly updated X/Y state.

#### 4.2 Updating State for Dynamic Scopes due to timer expiration.

MADCAP servers will update X/Y nesting state upon the expiration of timers in the following manner.

- o If the NEST\_NO\_DECISION\_TIMER expires for a state entry X/Y AND no MADCAP messages have been received that indicate scope X does not nest inside scope Y, a MADCAP Server, S, MUST conclude that scope X nests inside scope Y. As a result S will change X/Y from "false" to "true".

When a state change from "false" to "true" occurs for X/Y, S must also start the ZONES\_EXIST\_TIMER timer for X/Y. The ZONES\_EXIST\_TIMER should only reset when a Zone Announcement Message (ZAM) has been received for both zone X and zone Y since the last time it was restarted. This ensures that both zone X and zone Y are known to still exist.

- o If the ZONES\_EXIST\_TIMER expires for a state entry X/Y, S SHOULD conclude that either zone Y or zone X no longer exists and hence that both X/Y and Y/X state should be destroyed.

## 5. Multicast Scope Nesting State Option Format

Code	Len	Count	Nest	State	Matrix
17	p	m	Nl		Nm

Code: 16 bits

Option identifier 17.

Len: 16 bits

The length of the option in bytes.

Count: 8 bits

The number of zones present in the Nest State Matrix. This value MUST be identical to the Count field in the preceding Multicast State List option. If this is not the case the scope nesting state information MUST BE ignored.

Nest State Matrix:

The compressed bit-packed representation of the matrix, derived in the same manner as shown in Figure 4. Note for N scopes the compressed matrix will be N times  $\text{ceil}((N-1)/8)$  bytes long, where  $\text{ceil}()$  is the function that rounds up to the nearest integer. The scopes corresponding to the rows and columns of this matrix list in the same order as they appear in the Multicast Scope List Option.

## 6. Constants

[NEST\_NO\_DECISION\_TIMER] The time after which a MADCAP server or client can assume that a message announcing that two zones do not nest should not be received. The length of this timer is dependent upon the zone announcement protocol used to inform the MADCAP router of which zones currently exist. When MZAP [RFC2776] is used this value should be greater than the MZAP timeout value NIM-INTERVAL +30%. This corresponds to a timeout value of  $1800 + 30\% = 2340$  seconds (39 minutes).

[ZONES\_EXIST\_TIMER] The time after which a MADCAP server or client should assume that the zone in question does not exist when zones are detected dynamically. The length of this timer is dependent upon the zone announcement protocol used to inform the MADCAP router of which zones currently exist. When MZAP [RFC2776] is used this value should be no less than the MZAP timeout value NIM-HOLDTIME, which has a default of 5460 seconds (91 minutes).

## 7. Security Considerations

Since this document proposes an extension to the MADCAP protocol via the addition of a new option, the same set of security concerns apply.

In addition to these concerns are those that would arise were the information in the Multicast Scope Nesting State option to be falsified. In this case the clients would be misinformed as to which scopes nest inside one another. In this event, the client would then make incorrect decisions regarding the order in which to use the scopes. The effect of this would be to use larger scopes than necessary, which would effectively flatten any scope hierarchy present and nullify the advantage afforded by the hierarchy's presence.

Thus a malformed or tampered Multicast Scope Nesting option may cause protocols that rely upon the existence of a scoping hierarchy to scale less well, but it would not prevent them from working.

## 8. IANA Considerations

The Multicast Nesting State Option has been assigned MADCAP option code 17 by the IANA [RFC2730].

## 9. Acknowledgments

The Author would like to acknowledge Mark Handley and Dave Thaler for the helpful discussions and feedback which helped shape and refine this document.

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## Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.

