K.Ravindranath, Gangamalla Divya, Kandimalla Aishwarya,Y Vijaya Durga, Sk. Wasim / International Journal of Engineering Research and Applications (IJERA)
ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 2,Mar-Apr 2012, pp.1606-1613

Optimal State Allocation for Multicast Communications with Explicit Multicast Forwarding

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ABSTRACT

This paper proposes the scalable and adaptive multicast forwarding mechanism based on Explicit Multicast (Xcast). This mechanism optimizes the allocation of forwarding states in routers and can be used to improve the scalability of traditional IP multicast and Source-Specific Multicast. We propose a new multicast forwarding mechanism based on Explicit Multicast (Xcast) forwarding for SSM and IP multicast.Our mechanism needs fewer routers in a multicast tree to store forwarding states and therefore leads to a more balanced distribution of forwarding states among routers

keywords-
Balancestate,IPmulticast,Minimumstate,Protocol independent multicast,Xcastmulticast

I. INTRODUCTION

Multicast is an efficient way of realizing one-to-many and many-to-many communications[1]. Traditional IP multicast is provided with the host group[2] and multicast routing protocols[3-6]. Each multicast group is associated with a class-D IP address, which serves as the destination addresses of data packets. Multicast addresses are assigned in a way that guarantees the Unlike IP multicasting, Source-Specific Multicast (SSM)[8] treats each one-to- many connections as one multicast channel. Each multicast channel is associated with a channel identifier composed of the sender's address and a class-D address[7]. The class-D address is assigned by the sender and is not required to be globally unique. Both SSM and IP multicast adopt the shortest path tree to deliver multicast data. The routing of a shortest path tree is the union of the shortest paths from all receivers in the group to the tree root. For SSM, the root is the sender, and the tree is a source-based tree. For IP multicast, the root is a router called the core in CBT or RP in PIM-SM, and the tree is a shared tree. Each sender first sends data to the root via unicast, from where the data is relayed to all the receivers. Each router in SSM or IP multicast needs to store a forwarding state for each multicast group. Both the traditional multicast scheme and source-specific multicast use a shortest path tree to carry multicast data. For point-to-multipoint communication, the root is the sender, and the tree is called a source-based tree. Multipoint-to-multipoint communication, the root is a router which is called the core in CBT[5] and the tree is called a shared tree. Both the traditional multicast scheme and source-specific multicast use a shortest path tree to carry multicast data. For traditional multicast schemes or source-specific multicast, each router in a shortest path tree has to maintain a forwarding state for the group or channel. The state specifies the adjacent routers which are in the multicast tree, and the ID of the forwarding state is a group address or a channel identifier.

Multiple forwarding states[9] can be aggregated into one state if their IDs are contiguous and their next-hop routers are the same. The ID of the aggregating state is the common prefix of the IDs of the aggregated forwarding states.

Compared with unicast forwarding states, it is more difficult to aggregate multicast forwarding states. Receivers with the same prefix tend to reside in the same geographical area.

For a router outside the area, the forwarding state corresponding to these addresses can be aggregated since the next-hop router in the forwarding states tends to be the same. However, for multicast forwarding states, the class-D addresses are allocated dynamically or by the sender.

II.RESEARCH METHODOLOGY

2.1.DEFINITIONS

2.1.1 MULTICAST

Multicast is the delivery of a message or information to a group of destination computers simultaneously in a single transmission from the source creating copies automatically in other network elements, such as routers, only when the topology of the network requires it.

2.1.2 Source Specific Multicast(SSM)

Source-specific multicast (SSM) is a method of delivering multicast packets in which the only packets that are delivered to a receiver are those originating from a specific source address requested by the receiver. By so limiting the source, SSM reduces demands on the network and improves security.

SSM requires that the receiver specify the source address and explicitly excludes the use of the (*,G) join for all multicast groups in RFC 3376, which is possible only in IPv4's IGMPv3 and IPv6's MLDv2.

.2.1.3 IP MULTICAST

IP multicast is a technique for one-to-many and many-to-many real-time communication over an IP infrastructure in a network. It scales to a larger receiver population by not requiring prior knowledge of who or how many receivers there are. Multicast uses network infrastructure efficiently by requiring the source to send a packet only once, even if it needs to be delivered to a large number of receivers. The nodes in the network (typically network switches and routers) take care of replicating the packet to reach multiple receivers such that messages are sent over each link of the network only once.

The most common low-level protocol to use multicast addressing is User Datagram Protocol (UDP). By its nature, UDP is not reliable—messages may be lost or delivered out of order. Reliable multicast protocols such as Pragmatic General Multicast (PGM) have been developed to add loss detection and retransmission on top of IP multicast.

2.1.4 Unicast

The most common concept of an IP address is in unicast addressing, available in both ipv4 and IPv6. It normally refers to a single sender or a single receiver, and can be used for both sending and receiving. Usually, a unicast address is associated with a single device or host, but it is not a one-to-one correspondence. Some individual PCs have several distinct unicast addresses, each for its own distinct purpose. Sending the same data to multiple unicast addresses requires the sender to send all the data many times over, once for each recipient.

2.1.5 XCAST MULTICAST

The explicit multi-unicast (Xcast) is a variation of multicast that supports a great number of little multicast sessions. It is done by adding all the IP addresses in the destination field of the IP header, instead of using a multicast address. The multicast schemes can be used to minimize the bandwidth consumption. Xcast can be used to minimize the bandwidth consumption for little groups, but the great advantage is that it eliminates the signalization and the state information for every session of a traditional multicast scheme. Thanks to this it is capable to support a great number of little sessions.

ADVANTAGES

(1)The routers do not need to keep information for every session or channel. This makes Xcast very scalable about the number of sessions it can support.

(2)They don't need protocols for multicast routing. They are routed correctly thanks to the common unicast protocols.

(3)There is no critic node. Xcast minimizes the network latencies and maximizes efficiency.

(4)With traditional IP multicast routing protocols it is necessary to establish a communication between unicast and multicast routing protocols. That means a slow error recovery. Xcast reacts immediately to unicast routing changes.

(5)With Xcast all sources know the channel members and all routers are able to know the number of times each packet has been duplicated in its domain.

(7)The receptors can be heterogeneous since Xcast allows that every receptor is able to have its own requirements of service in a single multicast channel.

(8)Flexibility: unicast, multicast and Xcast represent costs of bandwidth, signalization and processing respectively. Easy transition between different mechanisms.

DISADVANTAGES

(1)They have got big headers. Each packet contains all the remaining destinations.

(2)It requires a more complex header processing. Every direction needs a look up to the routing table, so it is needed the same number of consults as it was unicast, furthermore, a new header must be generated after every jump.

(3)Limits the session to just a few users.

APPLICATIONS

Xcast is an important compliment to the existing multicast schemes since it supports a great number of little sessions. Allows efficient applications such as VoIP, videoconferencing, collaborative meetings... Maybe these applications could be done using just unicast, but in some cases, where the bandwidth is limited it becomes really useful. In general it supposes more efficiency.

2.2 EXISTING SYSTEM

Each state, identified by a channel ID or a group address, specifies the adjacent routers in the tree. Multiple forwarding states cannot be aggregated into one state, because their IDs may not be contiguous, and their next-hop routers may be different. SSM uses an individual tree for each sender in a group, but IP multicast can use a single shared tree to deliver the data from all senders in the group.

2.2.1 LIMITATIONS

Router may not have enough memory space to store all the multicast groups.

A router may take long time to look up the forwarding state for each packet.

For traditional multicast schemes or source-specific multicast, each router in a shortest path tree has to maintain a forwarding state for the group or channel . Compared with unicast forwarding states, it is more difficult to aggregate multicast forwarding states . The reason is that the ID of a unicast forwarding state is the destination IP address of data packets, and the destination IP address is allocated according to its geographical location. However, for multicast forwarding states, the class-D addresses are allocated dynamically or by the sender. Besides, the parent router and the child routers of the groups with contiguous IDs may be totally different. Therefore, it is more difficult to aggregate multicast forwarding states.

2.3 PROPOSED SYSTEM

We propose a new multicast forwarding mechanism based on Explicit Multicast (Xcast) forwarding for SSM and IP multicast. Each IP packet in Xcast can include multiple receiver addresses in the header. Upon receiving an Xcast packet, the router encapsulates multiple receiver addresses in a packet and uses an existing unicast routing protocol to find the neighboring routers to which the packet must be delivered. We focus on two problems and formulate each of them as an optimization problem. The first problem, referred to as MINSTATE, minimizes the total number of routers that store forwarding states in a multicast tree. The second problem, referred to as BALANCESTATE, minimizes the maximum number of forwarding states stored in a router for all multicast groups

1.3.1 CAPABILITIES OF PROPOSED SYSTEM

(1)Reduce the number of forwarding states stored in a router and balance the distribution of forwarding states among routers

(2)It allows only a portion of branching routers to store forwarding states and also allows non branching routers to store states

Increase the scalability of both SSM and IP multicast with respect to the number of members in a multicast group and the number of multicast groups in a network.

In this paper, we propose a new multicast forwarding mechanism with resource optimization using Xcast. When a group has only a few receivers, no router in the tree maintains the forwarding state. As the number of receiver grows, some routers are chosen dynamically to store the forwarding states. As the number of receiver decreases, some of these routers abandon the forwarding states.

2.4 MINIMIZING THE NUMBER OF STATE NODES IN EACH MULTICAST TREE

We propose two algorithms which can find the optimal solution, i.e., the minimum number of state nodes in a multicast tree. The first one is a dynamic programming algorithm. It first finds the minimum number of state nodes in a multicast tree from the leaves to the root and then assigns the state nodes from the root to the leaves. The second one is a distributed greedy algorithm. Each state node independently determines if it can remove its forwarding state or move the forwarding state to its parent node. The advantage of the first algorithm is that it can find the optimal assignment rapidly. The advantage of the second algorithm is that it can beimplemented as a distributed asynchronous protocol.

2.4.1DYNAMICPROGRAMMING ALGORITHM

In the dynamic programming algorithm, it first calculates j from the corresponding values of its child nodes . Variable is chosen in the way such that the number of state nodes in the sub-tree rooted at m is minimized. j represents the case that m is a state node. For other scenarios, ( ) tm τ j represent the case the m is a stateless node. The root is not considered since we assume it must be a state node. After the minimum number of state nodes in the multicast tree is obtained, the algorithm then assigns the state nodes of the multicast tree. mj is the number of destinations of tm p from the downstream interface to m in the assignment obtained from our algorithm. . The resultant assignment of state nodes is the same as Fig. 1.

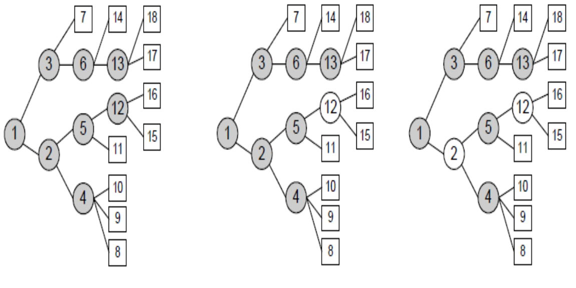
2.4.2 DISTRIBUTED GREEDY ALGORITHM

Although the above dynamic programming algorithm can find the optimal assignment rapidly, it is not suitable to be implemented as a protocol since it induces large overhead when a receiver joins or leaves a multicast tree. Each node on the path from the root to the receiver has to update ( ) tm □ □j , and some stateless nodes have to cache the information. we propose a distributed greedy algorithm, which is denoted P1_greedy. The algorithm is more suitable to beimplemented as a protocol. At any instant, each state node independently checks if it can remove the forwarding state or move the state to its parent node. The algorithm is a greedy algorithm because the former operation reduces the number ofstate nodes, and the latter operation makes the allocation of state nodes more compact such that more state nodes can become stateless later. The algorithm stops when all state nodes can no longer perform the above two operations. In thisalgorithm, each node does not need to know the topology of the whole multicast tree. It has to know only the identities of its upstream state node, parent node, child nodes, and destinations from all downstream interfaces. The operations of differentstate nodes are asynchronous. We assume that at most one state node removes or moves its forwarding state at any instant.

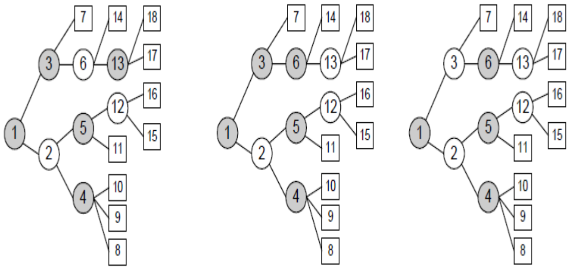
The algorithm is based on the following observations.

The number of state nodes in a multicast tree must be reduced in order to minimize the number of forwarding states maintained in a node.

- In order to balance the distribution of forwarding states, a state node should move its forwarding state to the node with the least number of forwarding states.



(a) Initial assignment. (b) Node 12 removes its forwarding state. (c) Node 2 removes its forwarding state.



(d) Node 6 removes its forwarding state. (e) Node 13 moves its forwarding state to node 6. (f) Node 3 removes its forwarding state.

we propose two algorithms which can find the optimal solution, i.e., the minimum number of state nodes in a multicast tree . The advantage of the first algorithm is that it can find the optimal assignment rapidly. The advantage of the second algorithm is that it can be implemented as a distributed asynchronous protocol.

2.5MINIMIZING THE MAXIMUM NUMBER OF FORWARDING STATES IN A ROUTER

2.5.1 INTRODUCTION

In this section, we consider the problem of optimizing the assignment of state nodes among multiple multicast groups. Although the algorithms proposed in last section can minimize the total number of forwarding states maintained in all routers, the distribution of forwarding states among routers is not balanced. Since it is more difficult to aggregate multicast forwarding states, some routers may not have enough memory to store all forwarding states, but others are under-utilized and capable of storing more forwarding states. In this section, therefore, we regard minimizing the maximum number of forwarding states in a router as the objective of theoptimization problem. With the objective, a router with too many states will move some states to other routers in order to reduce the objective value. Therefore, the distribution of forwarding states among routers can be more balanced. Note that we can also use minimizing the maximum memory usage of a router as the objective function, where the memory usage of a router is the number of forwarding states stored in the router over the maximum number of forwarding states that the router can have. We model the optimization problem as an Integer Linear Programming (ILP) problem. We design two algorithms to solve this problem. The first one is based on Lagrangean relaxation on the proposed ILP formulation. It decomposes the problem into multiple sub-problems. Each sub-problem is toassign the state nodes in a single multicast tree, similar to P1. The second algorithm is based on the distributed greedy algorithm described in last section.

2.5.2 LAGRANGEAN RELAXATION

Although standard algorithms for ILP, such as branch-andbound and cutting-plane algorithms, can find the optimal solution, the computational time grows exponentially for large problems. Therefore, we design an algorithm using Lagrangean relaxation on the ILP formulation. Although the algorithm cannot obtain the optimal solution, it can find a good solution in reasonable time. The algorithm first finds a feasible solution, and then improves the solution iteratively. It decomposes the original problem into multiple sub-problems. In each sub-problem, each node is associated with a cost, i.e., the Lagrange multiplier. Each sub-problem is to assign the state nodes of a single multicast tree such that the total cost of all state nodes in the tree is minimized.

III RESEARCH CONTENT AND PRESENTATION

DIFFERENT APPROACHES

Several approaches have been proposed to reduce the number of multicast forwarding states stored in a router.

(1)The first approach[9-12] uses a single multicast tree to deliver data of multiple multicast groups with similar receivers. A receiver may receive undesired data from a multicast group in which it does not join. Hence, the multicast tree has to be chosen carefully in order to reduce the amount of undesired data.

(2)In the second approach , only the branching routers of a multicast tree maintain the forwarding states. A branching router of a multicast tree maintain the forwarding states. A branching router is a router which connects to at least three adjacent routers in the multicast tree. A multicast packet is not duplicated on the path from a branching router to its nearest downstream branching router.

3.1 PROBLEM DEFINITION

We propose a scalable and adaptive multicast forwarding mechanism based on Explicit Multicast (Xcast). This mechanism optimizes the allocation of forwarding states in routers and can be used to improve the scalability of traditional IP multicast and Source-Specific Multicast. Our mechanism needs fewer routers in a multicast tree to store forwarding states and therefore leads to a more balanced distribution of forwarding states among routers. (1) The first problem, referred to as MINSTATE, minimizes the total number of Routers that store forwarding states in a multicast tree.(2) The second problem, referred to as BALANCESTATE, minimizes the maximum number of forwarding states stored in a router for all multicast groups, which is proved to be an NP-hard problem. We design a distributed algorithm that obtains the optimal solution to the first problem and propose an approximation algorithm for the second problem.

EXAMPLE OF OUR MECHANISM

Fig. 1 is an example of our mechanism. Node 1 is the root of the multicast tree. Assume nodes 1, 4, 5, and 6 have the forwarding states of this tree. Fig. 1 also lists the downstream routers stored in the forwarding state of each router. Not all branching routers have to store the forwarding states. Our mechanism is orthogonal to the first approach which uses a single multicast tree to carry data of multiple groups and

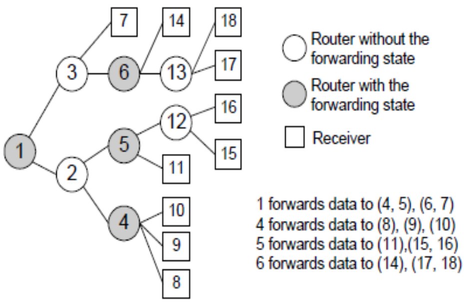


Figure 1. Example of our mechansim. The nodes within a bracket are the destinations of a Xcast datagram.

can be integrated together. Compared with the second approach, our mechanism can assign the forwarding states more flexibly among routers. Since not all branching routers have to store the forwarding states. Moreover, non-branching routers can also maintain the forwarding states. In order to assign the forwarding states efficiently, we formulate two optimization problems. For each multicast tree, the first problem, denoted P1, is to minimize the number of routers storing the forwarding states. The second problem, denoted P2, is to minimize the maximum number of forwarding states stored in a router.

3.2 PROBLEM DESCRIPTION

In this paper, the network is modeled as a connected directed graph G(V, A) where V and A are the set of vertices and arcs. Each vertex is either a host or a multicast router. Each can be represented as multiple arcs. A multicast tree is a forward shortest path tree. Data are delivered unidirectionally from the root of the tree to each receiver. For point-to multipoint communication, the root is the sender. For multipoint-to-multipoint communication, the root is a relay node, like an RP in PIM-SM or a session relaying server in EXPRESS .We assume each receiver of a group is a host connected to a Designated Router (DR). Therefore, each receiver must be a leaf node of the multicast tree, and all leaf nodes of a multicast tree are the receivers. For each multicast tree, a vertex m is upstream to another vertex n if m is on the shortest path from the root to n. In this case, n is also regarded downstream to m. In this paper, vertex and node are used interchangeably.
For each multicast group, a set of multicast routers is selected to maintain the forwarding states of the group. Multicast data are sent between these routers via Xcast. For each group, a multicast router d storing the forwarding state of a group is a state node of the multicast tree. The nearest state node u which is upstream to d is the upstream state node of d.In this case, d is a downstream state node of u. All intermediate nodes on the path from u to d are stateless nodes. Each receiver is a downstream receiver of its upstream state node. A state node may have more than one downstream state node and downstream receiver from each interface. In Fig. 1, for example, nodes 1, 4, 5, and 6 are state nodes of the multicast tree. Nodes 4 and 5 are the downstream state nodes of node 1 from the downstream interface to node 2. Node 15 and 16 are the downstream receivers of node 5 from the interface of to node 12. Node 1 is the upstream state node of node 6.

When the number of downstream state nodes and downstream receivers from an interface increases, the header of each data packet contains more destination addresses. Each stateless node has to look up more addresses in the unicast forwarding table. For each state node, therefore, we regard the maximum number of destinations from each downstream interface as a constraint. A destination is either a downstream state node or a downstream receiver. In other words, from each downstream interface, a state node can have at most destinations, ≥□ 1. The root is a state node. Each leaf node, i.e. receiver, of a multicast tree is not a state node since it does not deliver data to any other node.

3.3 SYSTEM ARCHITECTURE

3.3.1 TOPOLOGY CONSTRUCTION

(1)In this module, we are constructing network topology.

(2)Topology is constructed by getting the names of the nodes, state nodes and the connections among the nodes as input from the user.
(3)While getting each of the nodes, their associated port and ip address also obtained.

(4)For successive nodes, the node to which it should be connected is also accepted from the user.

3.3.2 MIN STATE

(1)In Order to eliminate the drawback of Time delay the following state is useful.
(2)In MIN state i.e.…Minimizing the number of state nodes in each multicast tree. One Router will lookup and send to the intermediate nodes.
(3)All the messages will send to the Router. The Router will find the destination and it will send the messages to the destination.

3.3.3 BALANCE STATE

(1)In Balance State…If Router has a child nodes means it act as a router else it act as an intermediate nodes.
(2)The SSM will send the message to its Parent and parent will forward the information to correct destination. It has all information about its Network Topology.

IV FIGURES

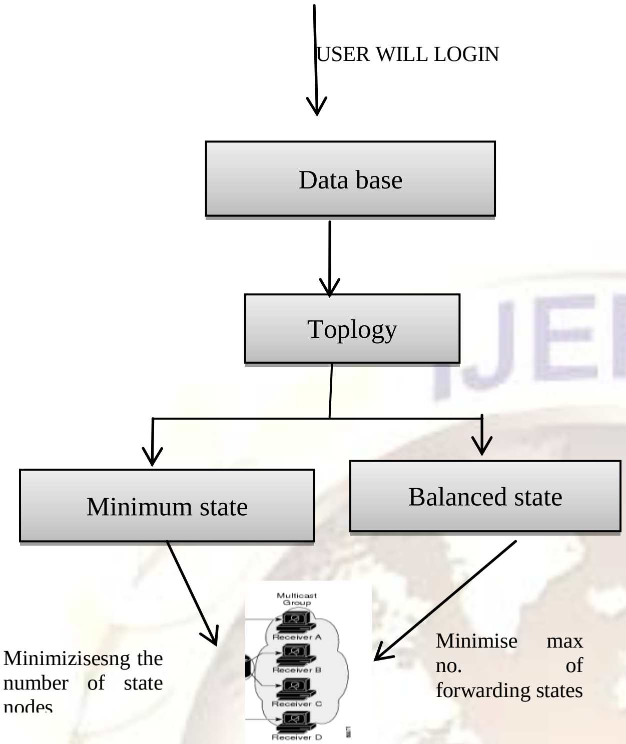


Fig1:System architecture

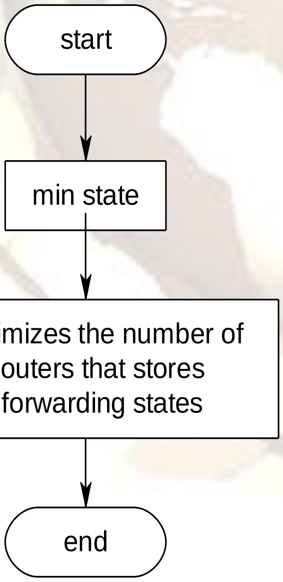


Fig2:Minimum state

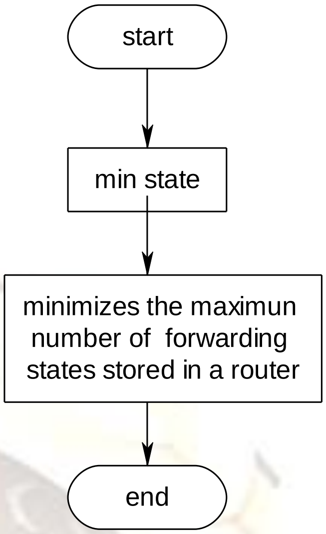


Fig3:Balanced state

V CONCLUSION

In this paper, we propose a new multicast forwarding mechanism with resource optimization based on Xcast. Withour algorithms, a set of routers in each multicast tree isadaptively chosen to maintain forwarding states. Multicast packets are sent between these routers via Xcast. The assignment of the forwarding states at routers in a multicast tree is formulated as two optimization problems. The first one is to minimize the number of routers which maintain the forwarding states in each multicast tree. The second one is to minimize the maximum number of forwarding states stored in a router. Several algorithms for both problems are proposed. We prove that our algorithms can find the optimal solution to the first problem. By simulation, we also show that the solution to the second problem is close to the optimal solution. We prove that the approach which assigns all branching routers as the only routers with forwarding states is a special case in our mechanism. We show that our mechanism uses less forwarding states, and the distribution of forwarding states is more balanced. More flexible and efficient allocation of multicast forwarding states among routers can be achieved by our algorithms compared with traditional IP multicast.

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