ICMPv6

Outline

- **Purpose of ICMPv6 and the structure of all ICMPv6 messages**
- **ICMPv6 error messages**
- **ICMPv6 informational messages used for diagnostics**
- **Common ICMPv4 messages and their ICMPv6 equivalents**
- **IPv6 Path MTU discovery process**

Overview of ICMPv6

- Updated and expanded version of the Internet Control Message Protocol (ICMP) for IPv6
- Reports delivery or forwarding errors and a simple echo service for troubleshooting
- Provides a framework for (later):
  - Multicast Listener Discovery (MLD)
  - Neighbor Discovery (ND) which is ?
  - IPv6 mobility

Types of ICMPv6 Messages

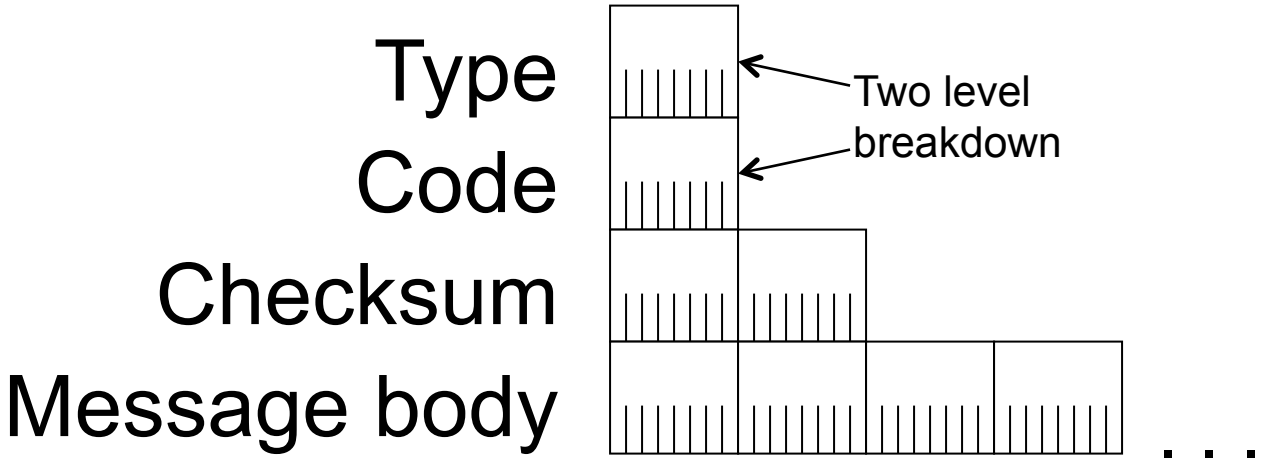
Error messages

- Sent for errors encountered in forwarding or delivery by the destination node or an intermediate router
- The high order bit of the Type field is set to 0
  - Type field is in the range of 0 - 127

Informational messages

- Provide diagnostic functions and additional host functionality
- The high order bit of the Type field is set to 1
  - Type field is in the range of 128 - 255

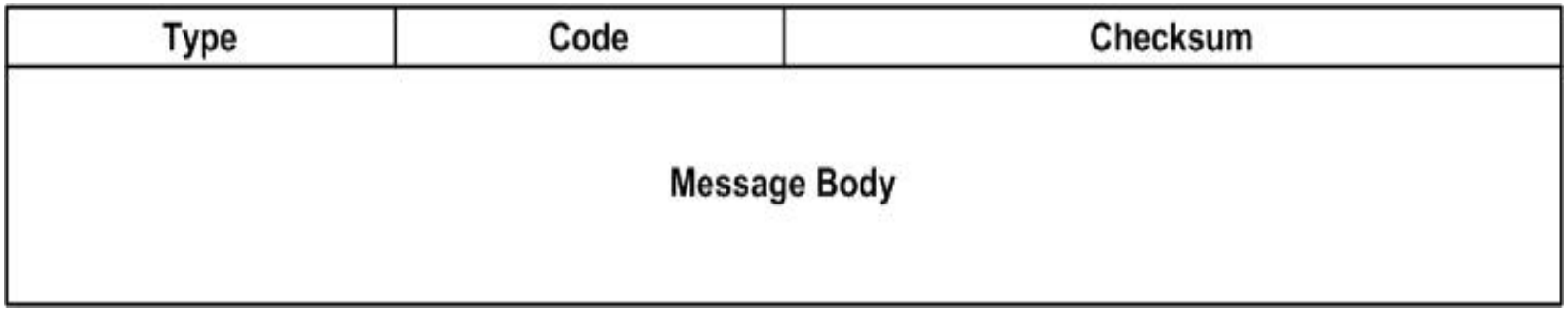
Structure of ICMPv6 Messages



What are each of these?

ICMP

- **Completely Changed – note new header type**
- **Now includes IGMP (Multicast Group Mgmt)**
- **Types organized as follows**
  - **1 – 4 Error messages**
  - **128 – 129 Ping**
  - **130 – 132 Group membership**
  - **133 – 137 Neighbor discovery**
- **General Format**



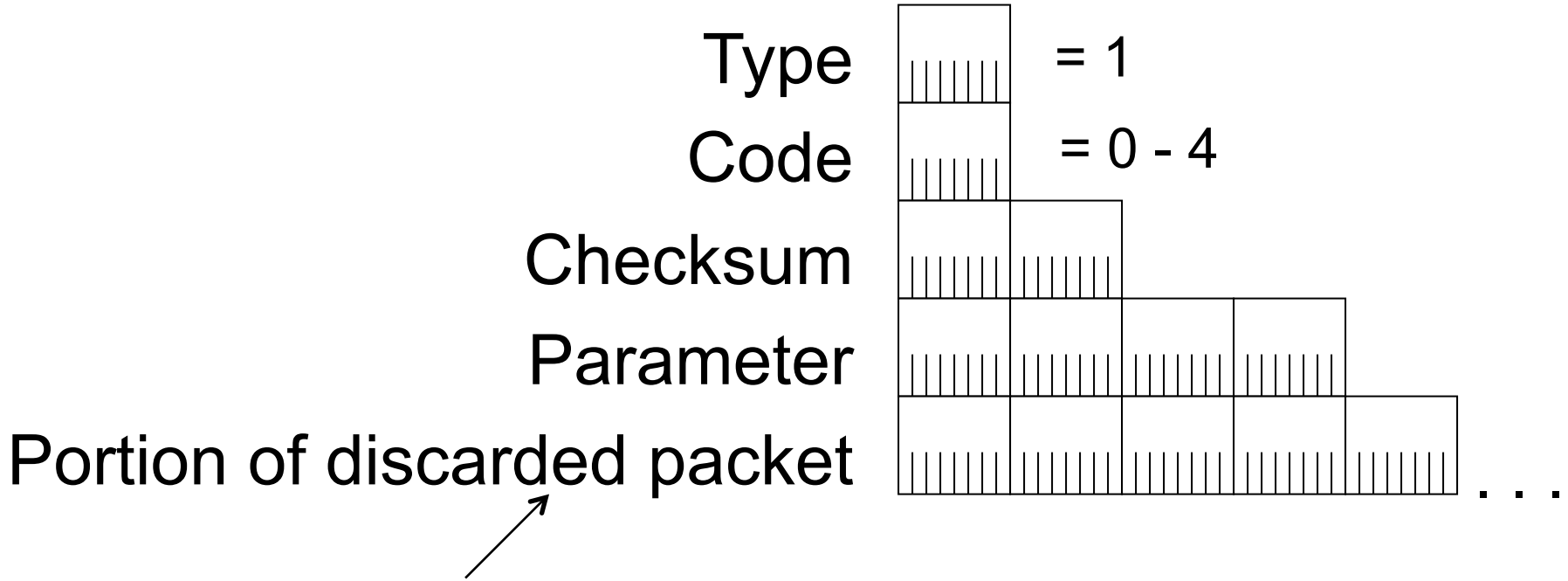
ICMP

Type	Description
1	Destination Unreachable
2	Packet Too Big
3	Time Exceeded
4	Parameter Problem
128	Echo Request
129	Echo Reply
130	Group Membership Query
131	Group Membership Report
132	Group Membership Reduction
133	Router Solicitation
134	Router Advertisement
135	Neighbor Solicitation
136	Neighbor Advertisement
137	Redirect

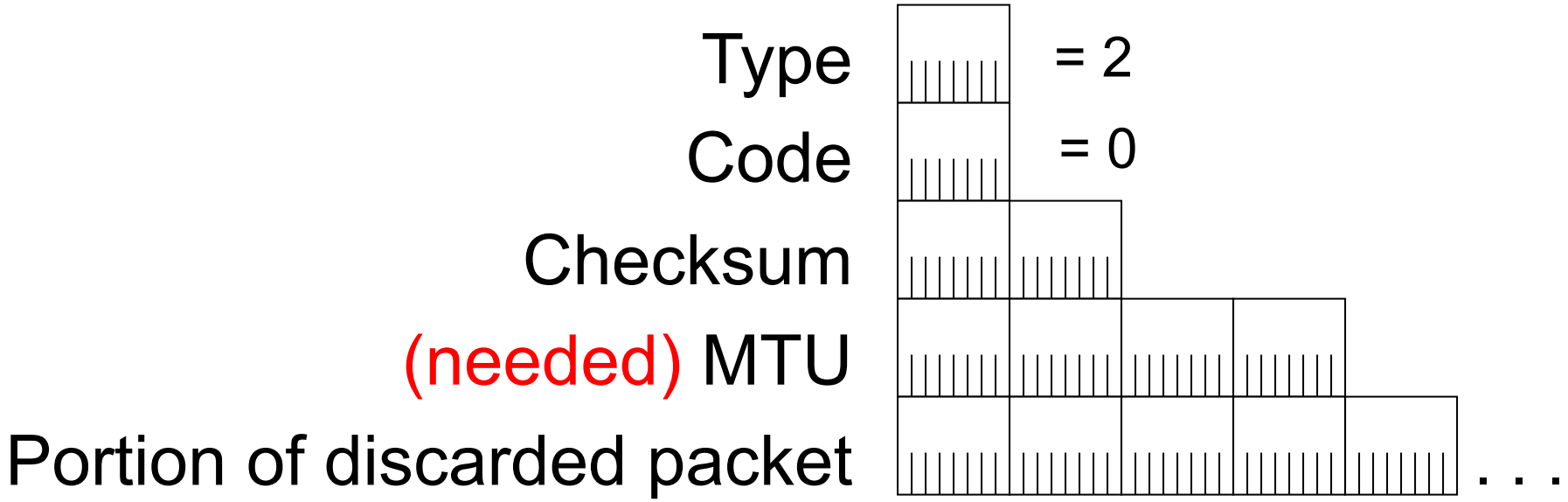
ICMPv6 Error Messages

- Destination Unreachable (Code expands error)
  - Code 0 - No route to destination
  - Code 1 - Can't get to destination for admin reasons
  - Code 2 - Not assigned
  - Code 3 - Address unreachable
  - Code 4 - Port Unreachable
- Packet Too Big
  - Code 0 - Parameter is set to MTU of next hop, I.e., can determine MTU
- Time Exceeded
- Parameter Problem
- ICMPv6 Error messages are rate limited
  - By timer
  - By percentage of bandwidth

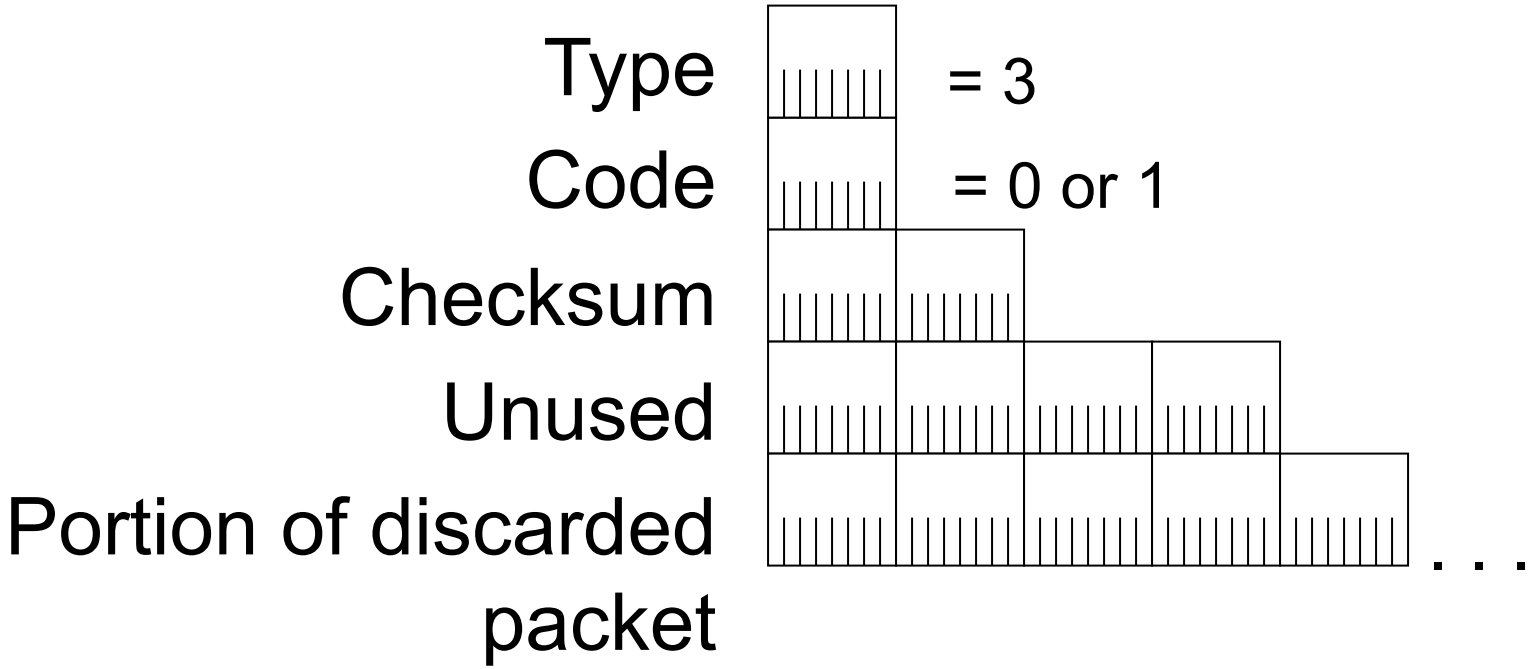
Error: Structure of the Destination Unreachable Message



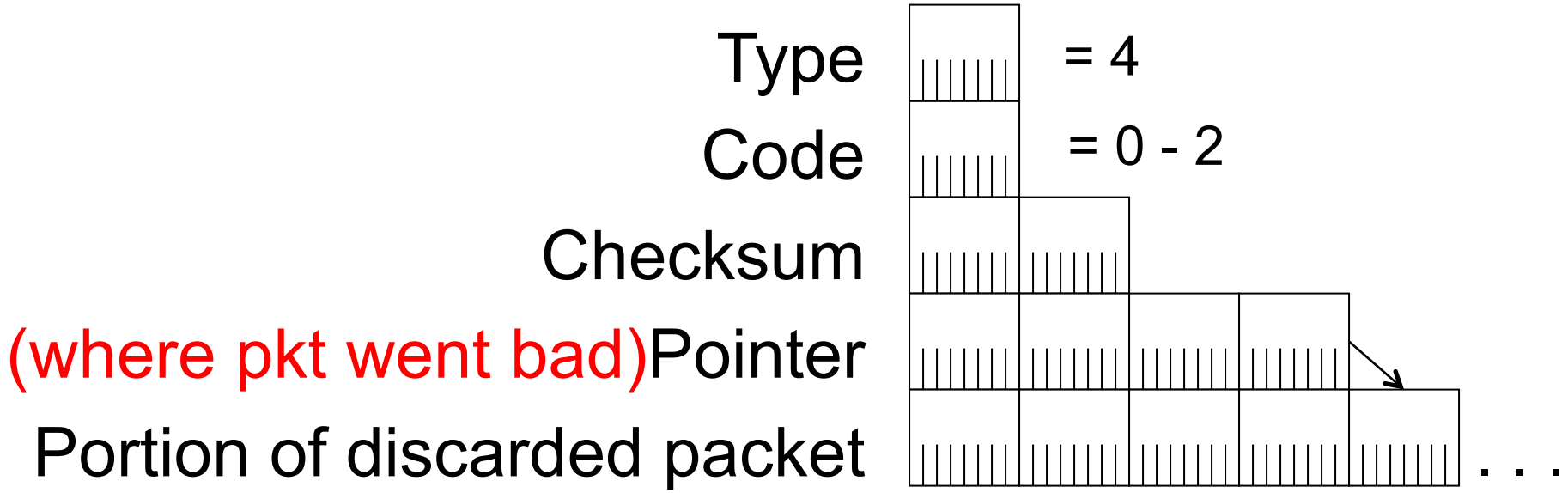
Error: Structure of the Packet Too Big Message



Error: Structure of the Time Exceeded Message



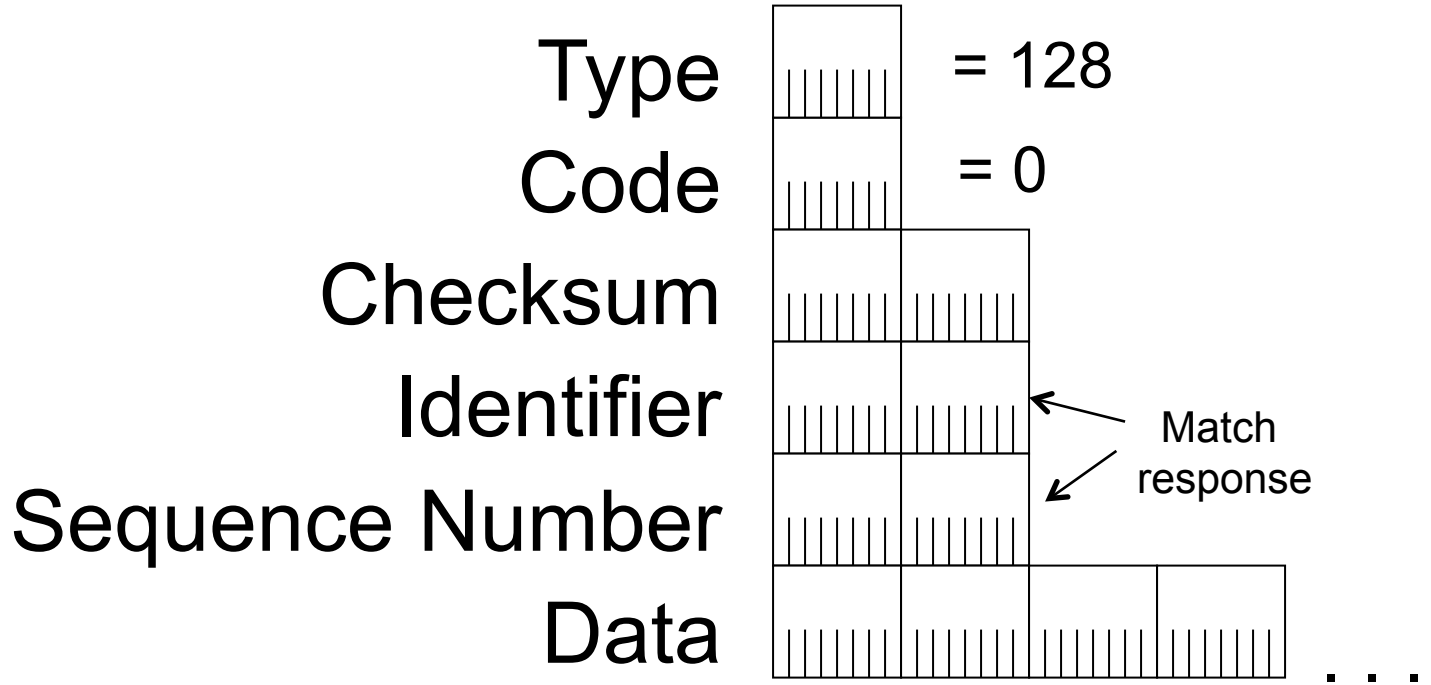
Error: Structure of the Parameter Problem Message – Error in Packet Structure



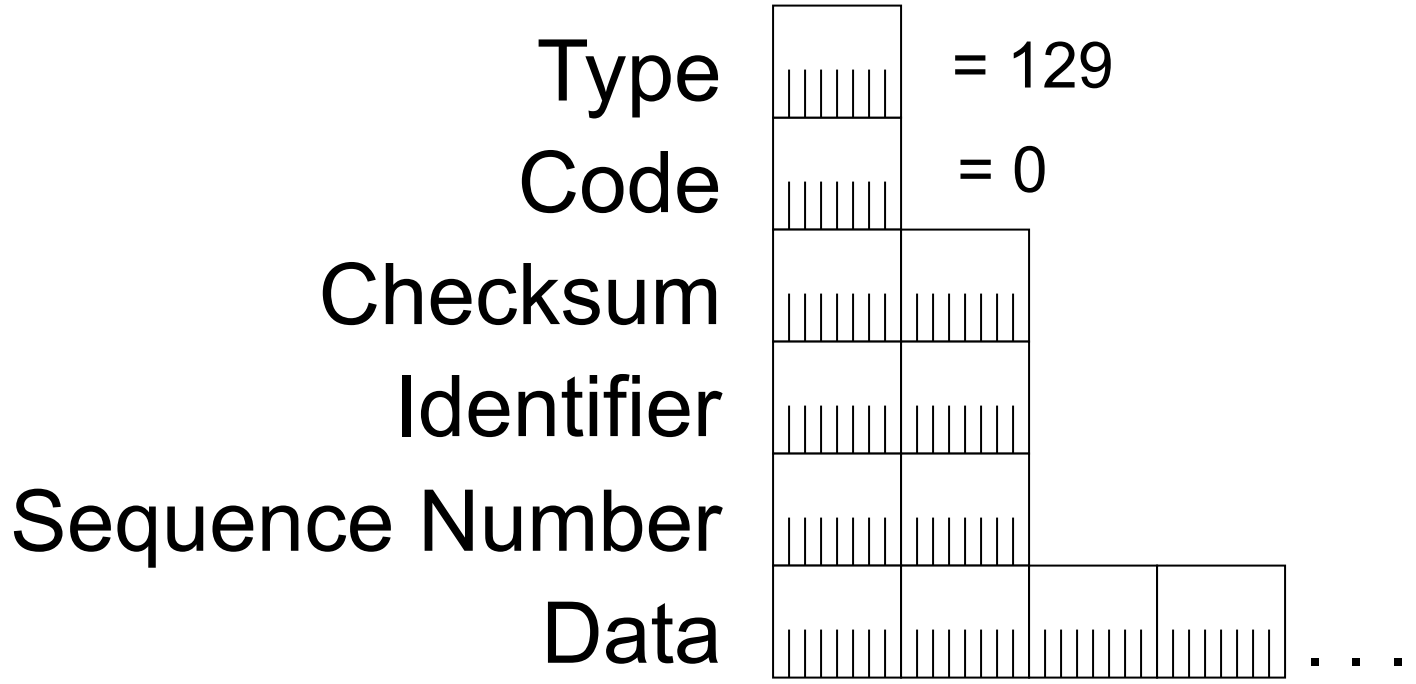
ICMPv6 Informational Messages

- **Echo Request**
- **Echo Reply**
- **Additional informational messages for**
  - **ND (Neighbor Discovery),**
  - **MLD (Multicast Listener Discovery), and**
  - **IPv6 mobility**

Info: Structure of the Echo Request Msg



Info: Structure of the Echo Reply Message



Just Turn the message around

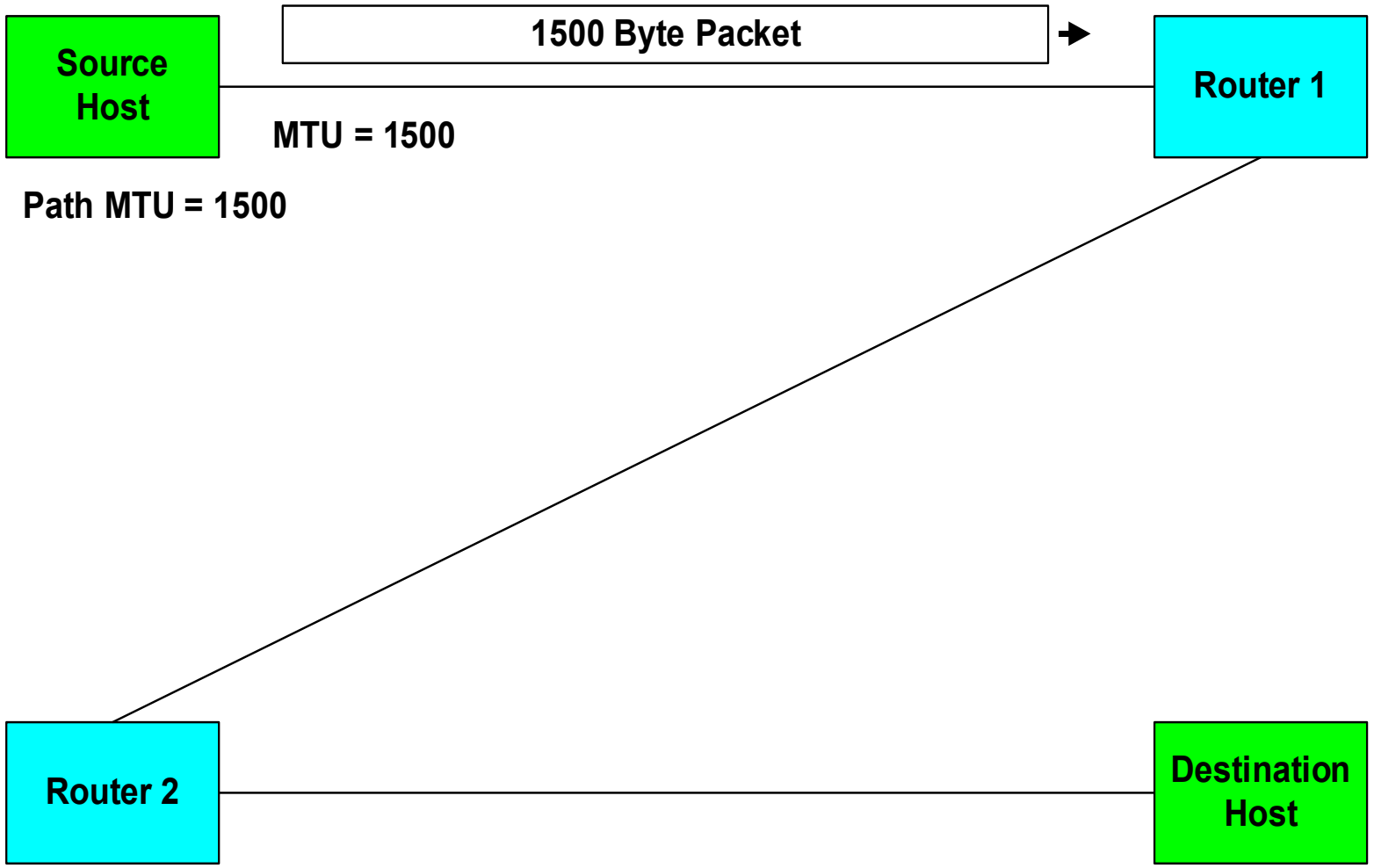
ICMPv4 Messages and their ICMPv6 Equivalents

Common ICMPv4 Message	ICMPv6 Equivalent
Destination Unreachable- Network unreachable (Type 3, Code 0)	Destination Unreachable-No route to destination (Type 1, Code 0)
Destination Unreachable-Protocol unreachable (Type 3, Code 2)	Parameter Problem-Unrecognized Next Header field (Type 4, Code 1)
Destination Unreachable-Port unreachable (Type 3, Code 3)	Destination Unreachable-Port unreachable (Type 1, Code 4)
Destination Unreachable-Fragmentation needed and DF set (Type 3, Code 4)	Packet Too Big (Type 2, Code 0)
Time Exceeded-TTL expired (Type 11, Code 0)	Time Exceeded-Hop Limit exceeded (Type 3, Code 0)
Parameter Problem (Type 12, Code 0)	Parameter Problem (Type 4, Code 0 or 2)
Source Quench (Type 4, Code 0)	This message is not present in IPv6.
Redirect (Type 5, Code 0)	Neighbor Discovery Redirect message (Type 137, Code 0).

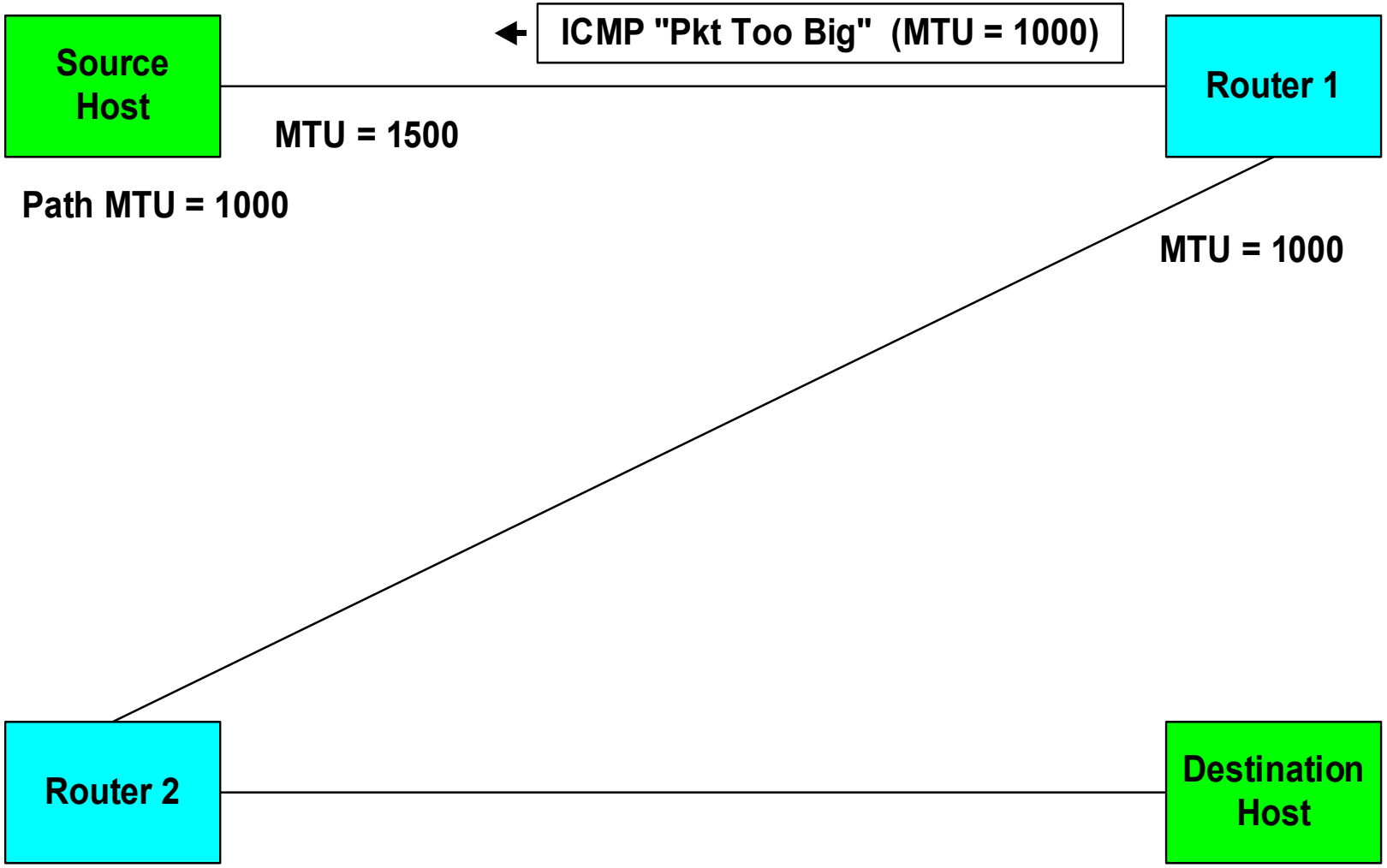
Path MTU Discovery

- For a given flow, the source host assumes that the path MTU is the MTU of the first link
- If a packet reaches a link with a smaller MTU, that router discards it and returns an *ICMP* error message along with that link's MTU
- This continues until the packet reaches the destination
- The source host caches the smallest link MTU as the "Path MTU" for that flow

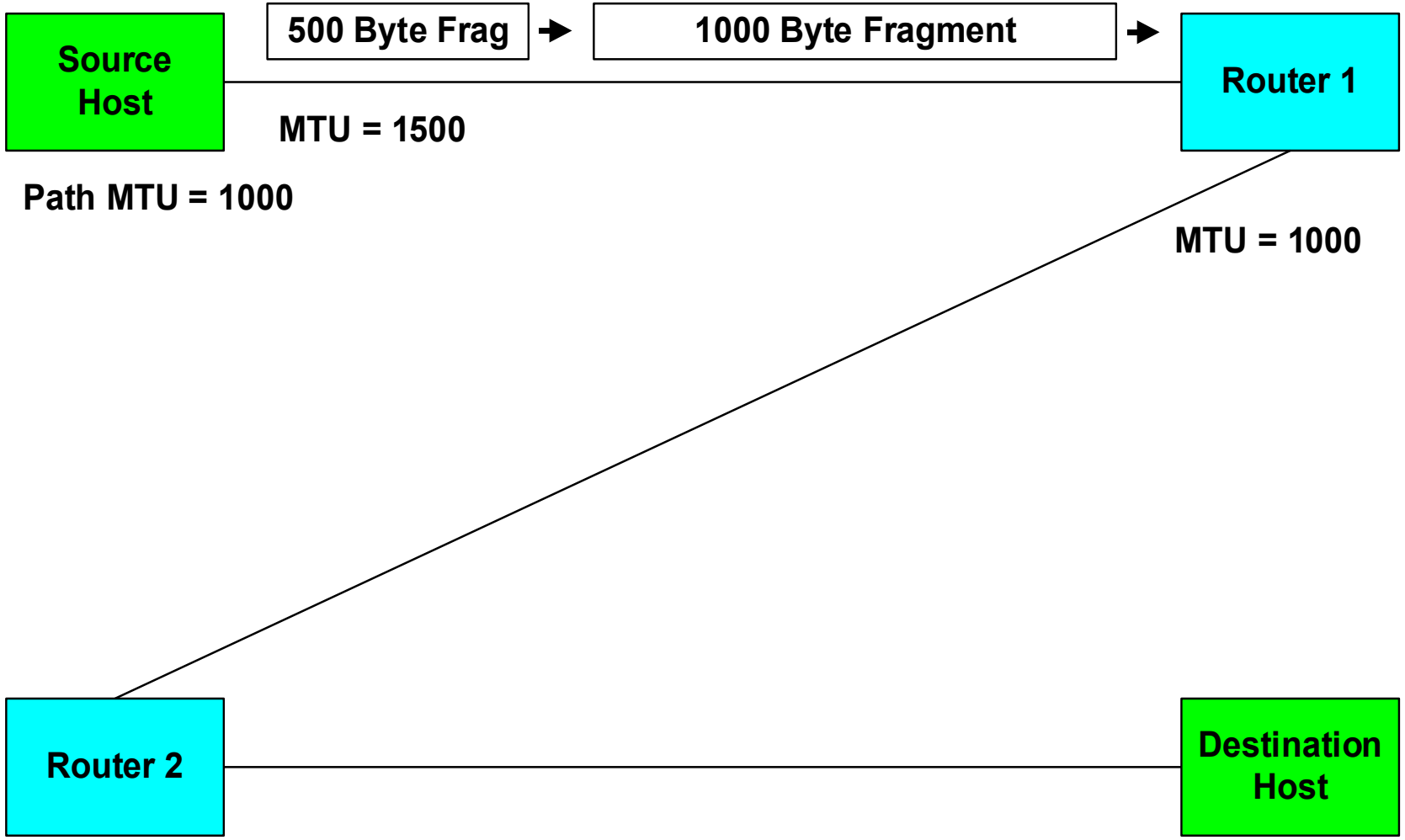
Path MTU Discovery



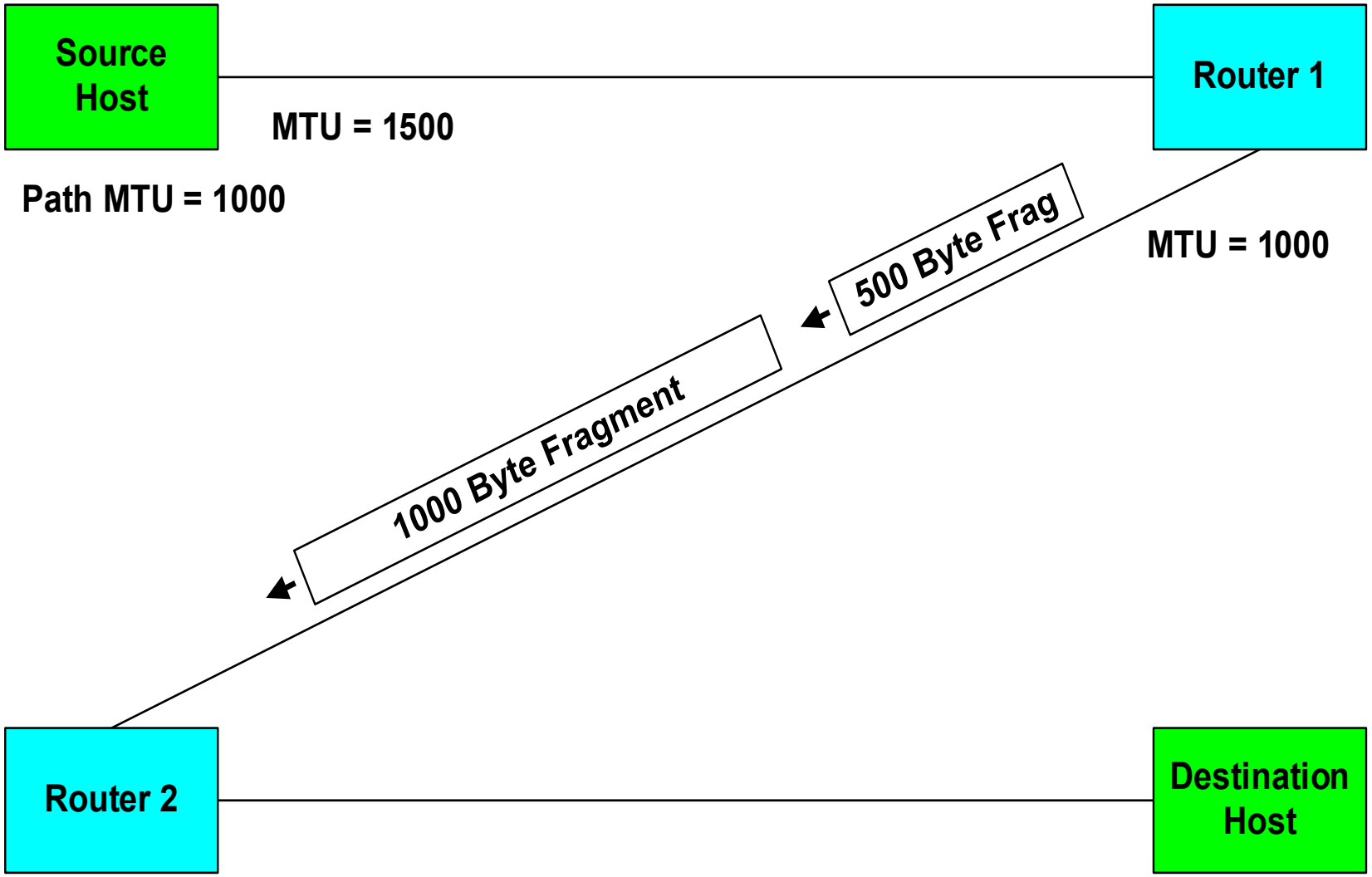
Path MTU Discovery



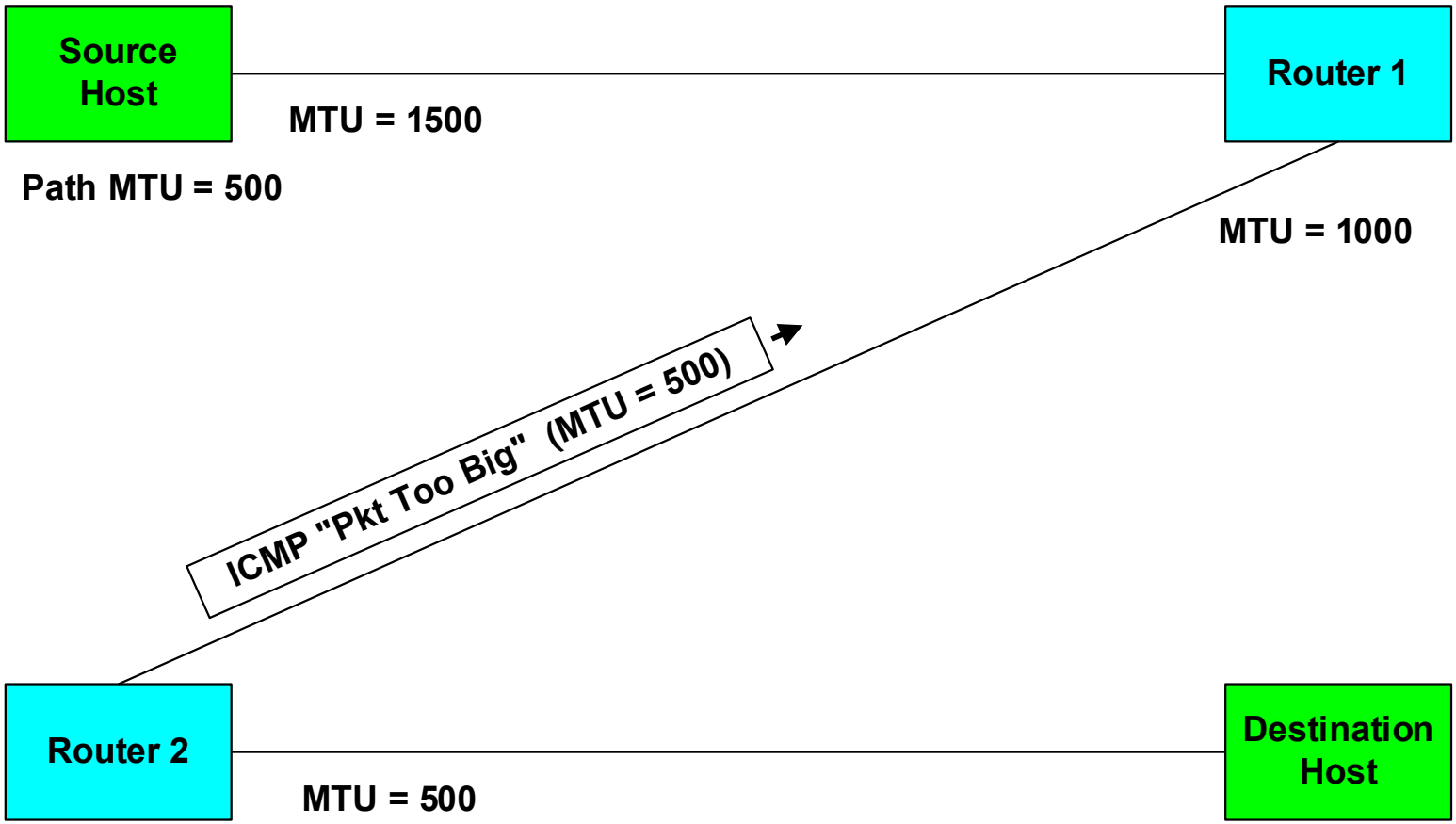
Path MTU Discovery



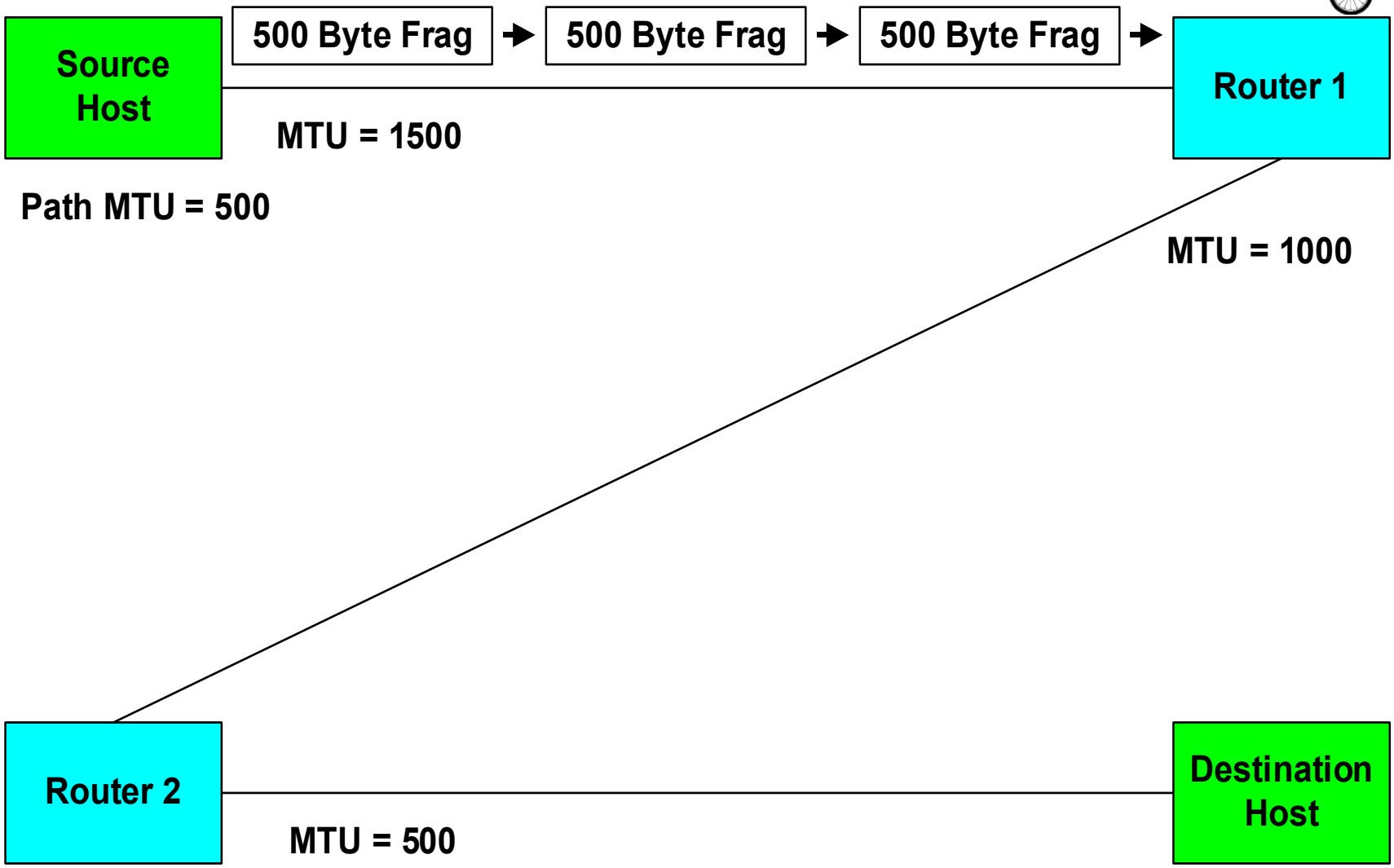
Path MTU Discovery



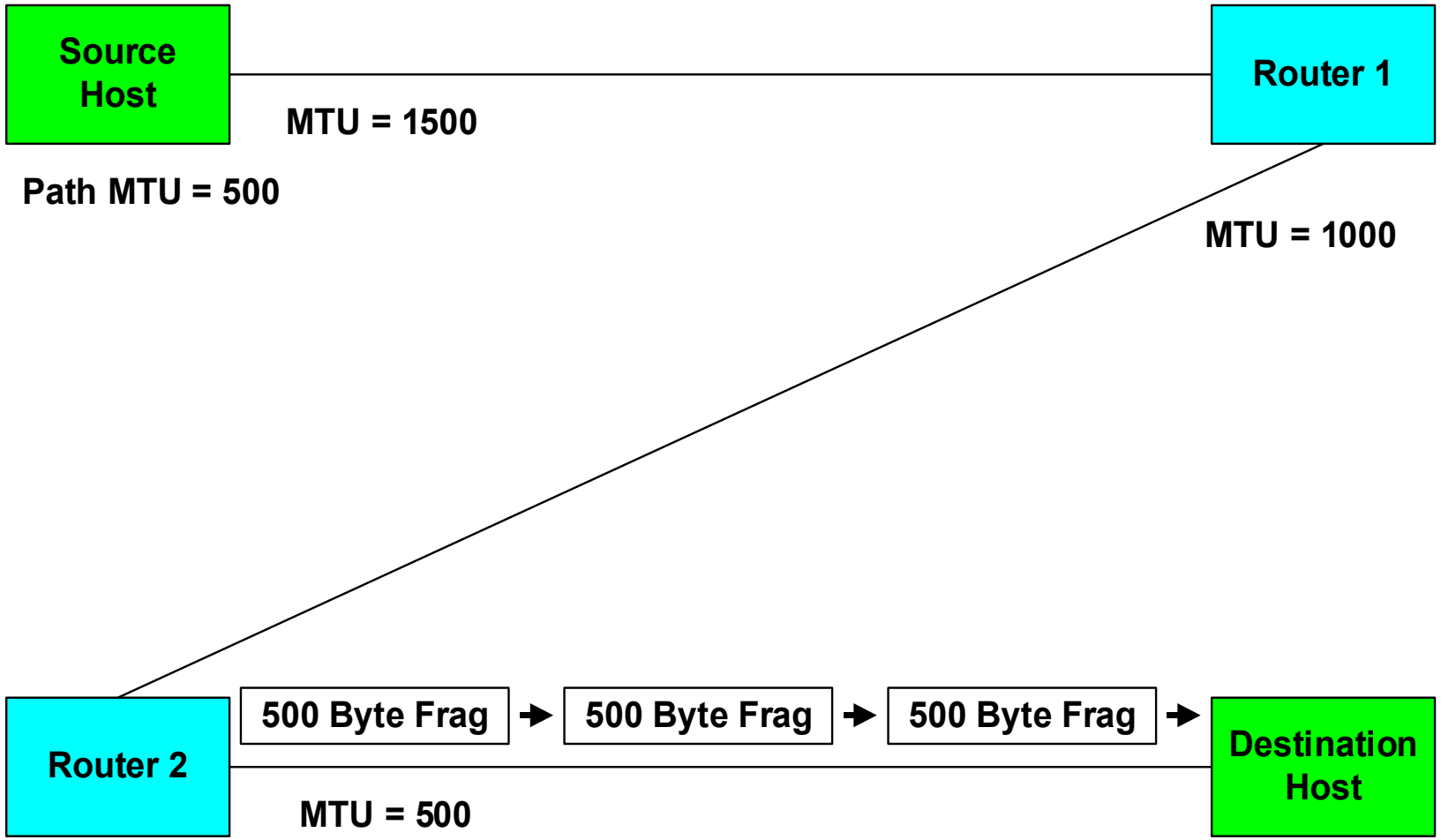
Path MTU Discovery



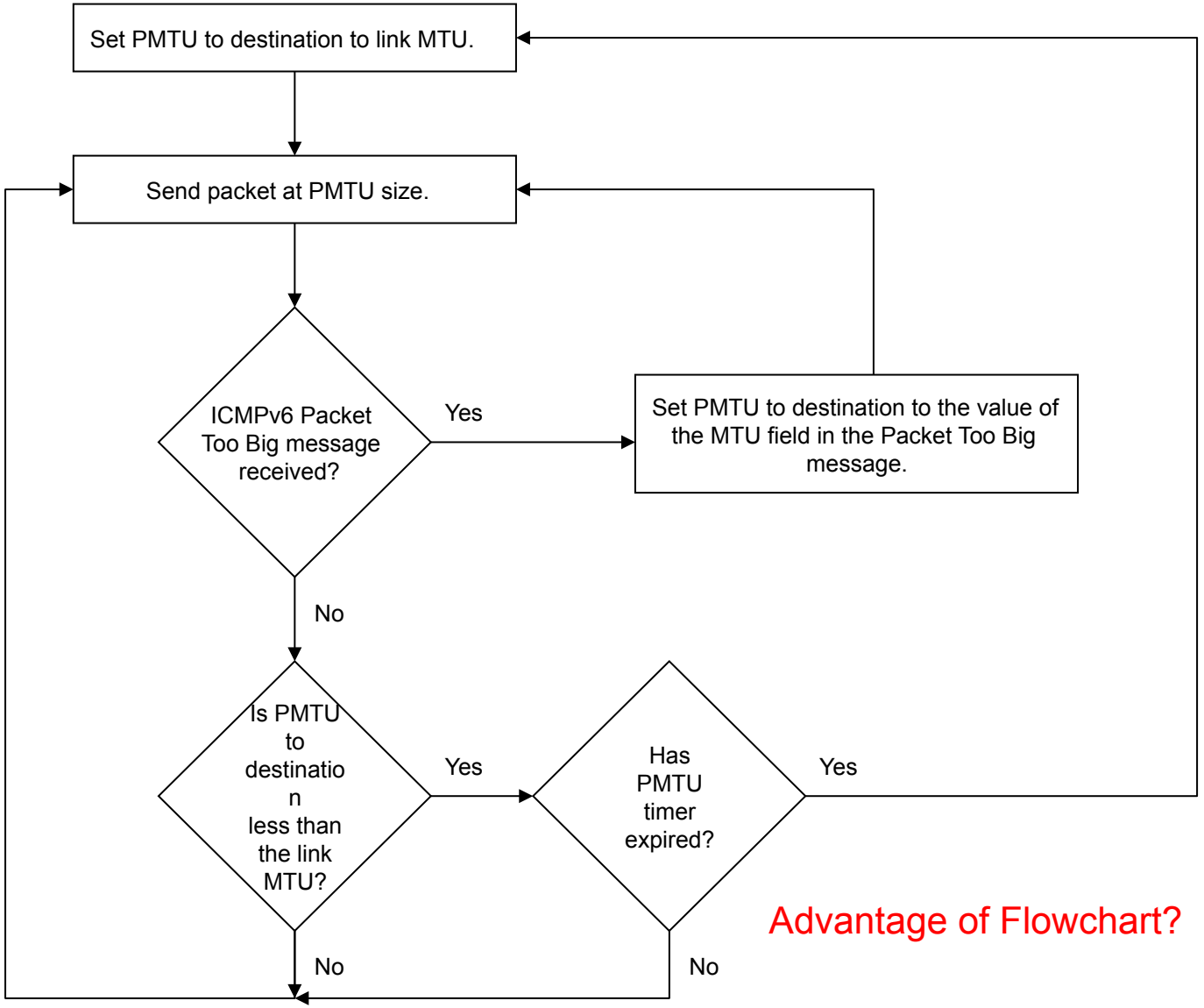
Path MTU Discovery



Path MTU Discovery



Changes in PMTU – Path MTU

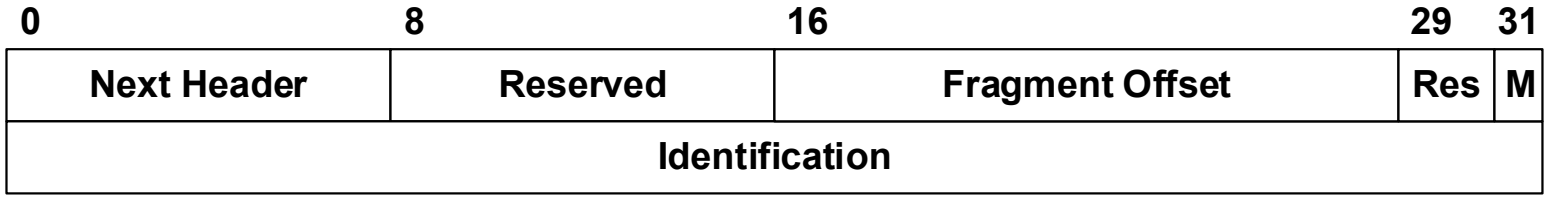


Advantage of Flowchart?

Consequences of New Fragmentation Method

- Improved router performance (since routers don't fragment), but must handle ICMP error packet
- No more "fragments of fragments"
- Hosts that do not support Path MTU discovery must limit packet size to 576 bytes
- All links must support a MTU of at least 576 bytes or do "local" fragmentation (a la ATM AAL5)
- This makes dynamic route changes problematic, since the new path may include a smaller MTU
  - QoS promises associated with flows cause the same problem
  - Result: no dynamic path changes in IPv6, which means no longer best effort on a random path of routers

IPv6 Fragment Extension Header

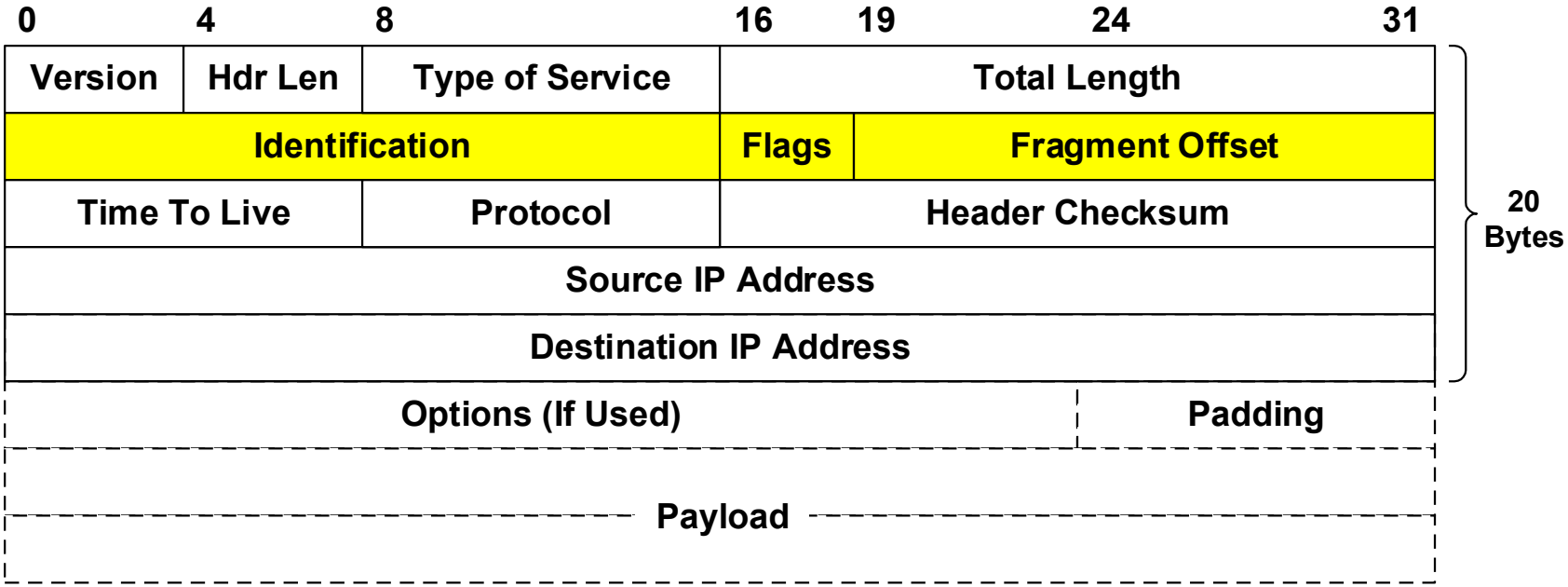


Fragment Offset - offset of data in this packet, from the start of the original packet (counted in 8-byte units)

M Flag - Set to 1 if more fragments coming, set to 0 if this is the last fragment

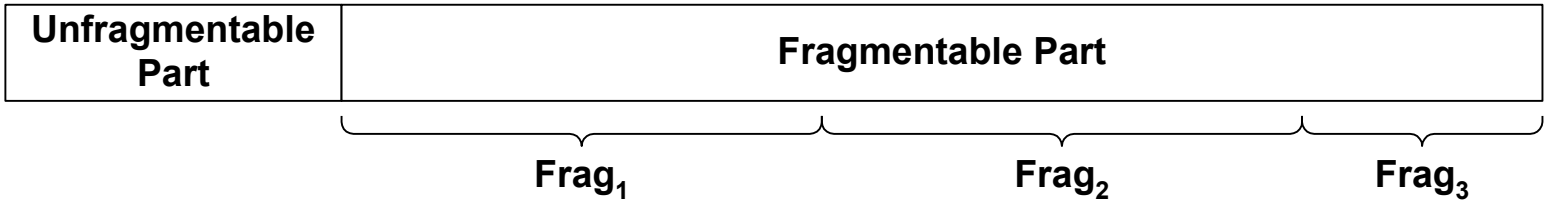
Identification - a value unique to the original packet and common to all fragments

IPv4 Fragmentation-Related Fields

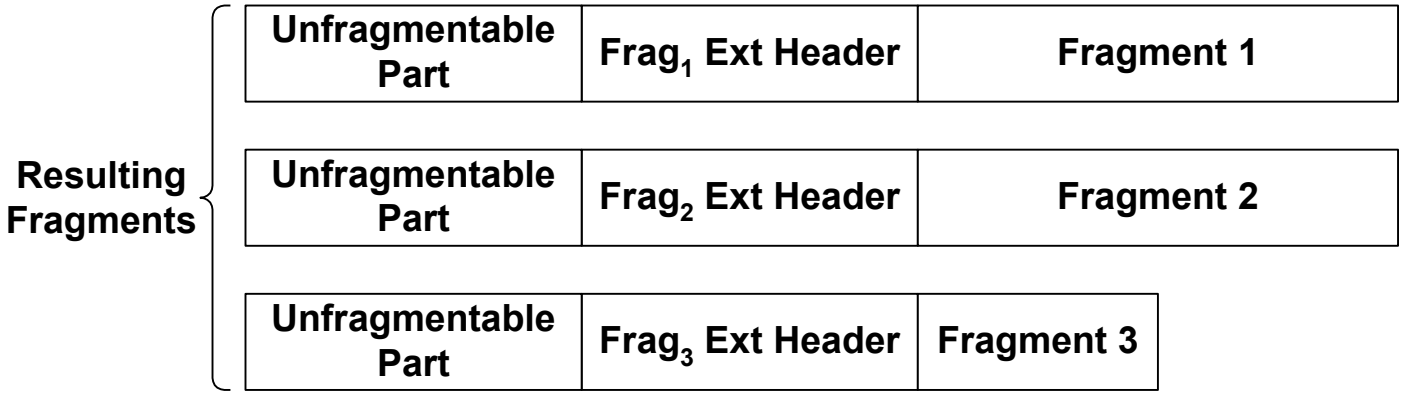


IPv6 Fragmentation Example

Original IPv6 Packet



The Unfragmentable Part contains the IPv6 base header plus any extension headers that must be processed en route to the destination. The remainder of the original packet is the Fragmentable Part (which may include additional extension headers, along with the payload).



Summary

- **Structure of all ICMPv6 messages**
- **ICMPv6 error messages**
- **ICMPv6 informational messages used for diagnostics**
- **Common ICMPv4 messages and their ICMPv6 equivalents**
- **IPv6 Path MTU discovery process**