The IP datagram built by the program ping.c developed in class includes a header with the minimum possible length (20 characters), i.e., with no optional fields. The IP protocol allows extending the IP header, adding some optional fields that allow requesting or sending additional information to the network nodes through which the packet passes. We now intend to explore this possibility.

Modify it, in such a way that it constructs the IP datagram by adding the optional "Record Route" field to the IP header (described in RFC 791, see below). This field reserves a free area (called route data) inside the extended IP header, intended to contain the list of IP addresses of the nodes crossed by the packet. Each node crossed, in fact, in the presence of the "Record Route" option, should append its IP address in the area route data to the IP addresses list already saved by the previous nodes. The fields length and pointer allow you to manage the memory area during the packet trip, as reported in the text taken from RFC 791:

Record Route

+ -------- + -------- + -------- + --------- // -------- +

| 00000111 | length | pointer | route data |

+ -------- + -------- + -------- + --------- // -------- +

Type = 7

The record route option provides a means to record the route of

an internet datagram.

The option begins with the option type code. The second octet

is the option length which includes the option type code and the

length octet, the pointer octet, and length - 3 octets of route

data. The third octet is the pointer into the route data

indicating the octet which begins the next area to store a route

address. The pointer is relative to this option, and the

smallest legal value for the pointer is 4.

A recorded route is composed of a series of internet addresses.

Each internet address is 32 bits or 4 octets. If the pointer is

greater than the length, the recorded route data area is full.

The originating host must compose this option with a large

enough route data area to hold all the address expected. The

size of the option does not change due to adding addresses. The

title contents of the route data area must be zero.

When an internet module routes a datagram it checks to see if

the record route option is present. If it is, it inserts its

own internet address as known in the environment into which this

datagram is being forwarded into the recorded route begining at

the octet indicated by the pointer, and increments the pointer

by four.

If the route data area is already full (the pointer exceeds the

length) the datagram is forwarded without inserting the address

into the recorded route. If there is some room but not enough

room for a full address to be inserted, the original datagram is

considered to be in error and is discarded. In either case an

ICMP parameter problem message may be sent to the source host.

The candidate will know that he has well formed the extended IP header, if he verifies that the *echo reply* returnfrom the destination will bring the option "Record Route" in the IP header containing in the "route data" field the list of IP addresses of the nodes traversed during the *echo request process*.

For the purpose of carrying out the task, also keep in mind the following:

* Reserve the maximum possible size of bytes in this field, taking into account all the constraints of the IP standard
* Send the packet to node 147.162.2.100
* If the option is not formed correctly, the first intermediate node that recognizes an error sends to our node an ICMP type 12 message (0xC) described by RFC792 (see below)

0 1 2 3

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1

+ - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - +

| Type | Code | Checksum |

+ - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - +

| Pointer | unused |

+ - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - +

| Internet Header + 64 bits of Original Data Datagram |

+ - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - + - +

IP Fields:

Destination Address

The source network and address from the original datagram's data.

ICMP Fields:

Type

12

Code

0 = pointer indicates the error.

Checksum

The checksum is the 16-bit ones's complement of the one's

complement sum of the ICMP message starting with the ICMP Type.

For computing the checksum, the checksum field should be zero.

This checksum may be replaced in the future.

Pointer

If code = 0, identifies the octet where an error was detected.

Internet Header + 64 bits of Data Datagram

The internet header plus the first 64 bits of the original

datagram's data. This data is used by the host to match the

message to the appropriate process. If a higher level protocol

uses port numbers, they are assumed to be in the first 64 data

bits of the original datagram's data.

Description

If the gateway or host processing a datagram finds a problem with

the header parameters such that it cannot complete processing the

datagram it must discard the datagram. One potential source of

such a problem is with incorrect arguments in an option. The

gateway or host may also notify the source host via the parameter

problem message. This message is only sent if the error caused

the datagram to be discarded.

The pointer identifies the octet of the original datagram's header

where the error was detected (it may be in the middle of an

option). For example, 1 indicates something is wrong with the

Type of Service, and (if there are options present) 20 indicates

something is wrong with the type code of the first option.