Case Study of Voice Disconnection During Calls on the Hikari Denwa IP Telephone Service due to DHCP Conflicts

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Abstract

This article describes a case study of a failure in which voice calls on the Hikari Denwa IP telephone service were being disconnected due to DHCP (Dynamic Host Configuration Protocol) conflicts. This is the eighty-fourth article in a series on telecommunication technologies.

Keywords: IP telephone, packet analysis, MAC address, DHCP

1. Introduction

Broadband services are now widely used in homes and offices, and Internet protocol (IP) telephone services using optical fiber account for 75% of total fixed-line telephone (landline) services in Japan [1]. The Hikari Denwa service provided by NTT EAST and WEST is a service for IP telephones that uses IP packets to transmit voice (over the optical-fiber broadband service). If a customer has a contract for both Internet connection and Hikari Denwa services, the customer's home network equipment is shared between both services.

The Network Interface Engineering Group of Technical Assistance and Support Center (TASC), NTT EAST, provides technical support, such as on-site analysis of problems related to customer equipment and NTT equipment. This article describes a case study of a failure in which voice calls on the Hikari Denwa service were being disconnected due to Dynamic Host Configuration Protocol (DHCP) conflicts.

2. Details of failure and configuration of customer's equipment

We received a request for trouble shooting from a customer using the Hikari Denwa service that they are unable to hear the other party's voice after a few minutes of the call. They also said that this failure started occurring at a certain point in time, but other than voice calls, no problems with Internet communication occurred at that time.

The configuration of the customer's equipment is shown in **Fig. 1**. A switching hub is connected to downstream of an optical network unit (ONU) of the Hikari Denwa network, and the signal from the ONU is branched into a Hikari Denwa router and Internet-access router (referred to as the commercial router). This Hikari Denwa router has four analog ports, but only two are used to connect to analog telephones. Multiple personal computers (PCs) for Internet communication are connected to the commercial router.

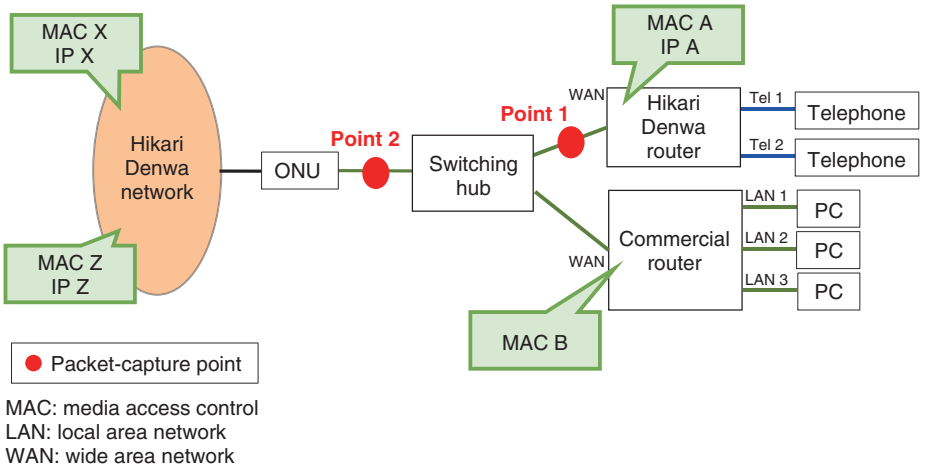

Fig. 1. Configuration of customer's equipment and capture points.

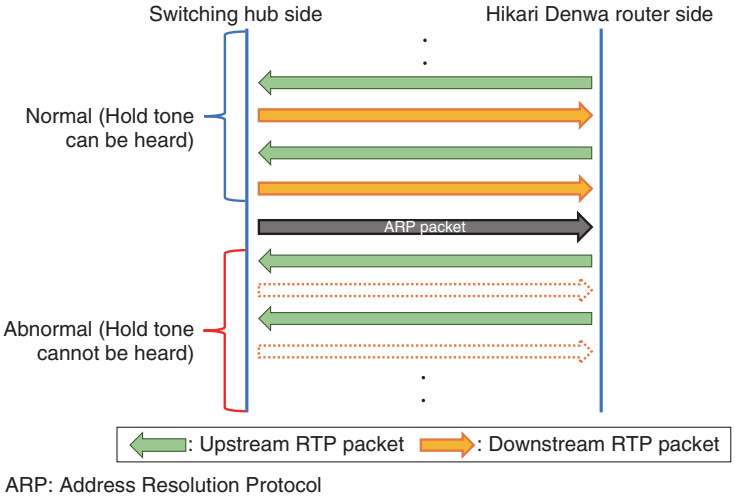

Fig. 2. Flow of Hikari Denwa packets at point 1.

3. Details of investigation

To investigate this failure, we made a test call and sent a hold tone from a test terminal to check the voice status. At that time, we captured Hikari Denwa packets and Internet-communication packets at points 1 and 2 in Fig. 1 and analyzed the status of Real-time Transport Protocol (RTP) packets.

4. Analysis results of RTP packets

4.1 Point 1 (between switching hub and Hikari Denwa router)

As a result of our analysis of the RTP packets at point 1 (**Fig. 2**), we confirmed that both upstream and downstream RTP packets flowed normally at the start of the test call. However, three minutes later, the downstream RTP packets (the hold tone from test terminal) stopped, but the upstream RTP packets (the voice from the customer's telephone) were flowing normally.

A detailed analysis of the IP packets before and

About 3 minutes later

Destination MAC address	Source MAC address	Destination IP address	Source IP address	Protocol	Information	
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law	①
MAC A	MAC X	IP A	IP X	RTP	G.711 PCM μ-law	
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law	
MAC A	MAC X	IP A	IP X	RTP	G.711 PCM μ-law	
Broadcast	MAC B	—	—	ARP (request)	**Sender MAC: MAC B** **Sender IP: IP A** Target IP: IPZ *1	②
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law	③
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law	
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law	

*1 Inform MAC B (IP A) of the MAC address of IP Z.

MAC A: MAC address of Hikari Denwa router
MAC B: MAC address of commercial router
MAC X: MAC address of network-side terminal
MAC Z: MAC address of network-side terminal
IP A: IP address of Hikari Denwa router
IP X: IP address of network-side terminal
IP Z: IP address of network-side terminal

Fig. 3. Details of packets at point 1.

after the hold tone stopped flowing (**Fig. 3**) revealed the following steps: (1) upstream and downstream RTP packets flow from the start of the call ("normal" state) and (2) when Address Resolution Protocol (ARP) packets were sent from the commercial router during the call, (3) the downstream RTP packets stopped flowing ("abnormal" state) immediately after the ARP packets began flowing.

An ARP packet is used to map an IP address to a media access control (MAC) address. Normally, an ARP packet specifies its own IP address as the reply destination (sender IP). The ARP packets sent by the commercial router (as confirmed in step (2)) specified the same IP address as the Hikari Denwa router as the sender IP.

4.2 Point 2 (between ONU and switching hub)

As a result of our analysis of the RTP packets at point 2 (**Fig. 4**), we confirmed that both upstream and downstream RTP packets flowed normally at the start of the call and, about three minutes later, ARP packets with the same content as those from the commercial router at point 1 had been observed.

At point 2, unlike point 1, both upstream and downstream RTP packets were flowing normally after the ARP packets were sent. Further analysis of the downstream RTP packets revealed that the destination MAC addresses were different before and after the ARP packets. That is, the destination MAC address of the ARP packets was changed from the Hikari Denwa router to the commercial router.

5. Cause of failure

On the basis of the above results of the investigation, it is concluded that the cause of this failure was the change of the destination MAC address of the downstream RTP packets from the Hikari Denwa router to the commercial router. Therefore, the downstream RTP packets are sent to the commercial router, the RTP packets do not reach the Hikari Denwa router, and the voice becomes disconnected (**Fig. 5**).

The Hikari Denwa router operates as a DHCP client and obtains an IP address from the Hikari Denwa network when it starts up. DHCP is a protocol for automatically assigning IP addresses to devices connected to a network.

At the customer's equipment, the commercial router was connected to the switching hub in parallel with the Hikari Denwa router. The DHCP client function of the commercial router used for the Internet connection should be disabled; however, for some reason, the commercial router was also operating as a DHCP client, so the same IP address as that of the Hikari Denwa router was issued from the Hikari Denwa network, which resulted in sharing the same IP address.

We were able to reproduce the phenomenon of the

About 3 minutes later

Destination MAC address	Source MAC address	Destination IP address	Source IP address	Protocol	Information
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law
MAC A	MAC X	IP A	IP X	RTP	G.711 PCM μ-law
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law
MAC A	MAC X	IP A	IP X	RTP	G.711 PCM μ-law
Broadcast	MAC B	—	—	ARP (request)	**Sender MAC: MAC B** **Sender IP: IP A** Target IP: IP Z *2
MAC B	MAC X	—	—	ARP (reply)	Sender MAC: MAC Z Sender IP: IP Z **Target MAC : MAC B** **Target IP: IP A**
MAC X	MAC A	IP X	IP A	RTP	G.711 PCM μ-law
MAC B	MAC X	**IP A**			
MAC X	MAC A	IP X			
MAC B	MAC X	**IP A**			
MAC X	MAC A	IP X			

After ARP resolution is completed, the destination MAC address of the downstream voice packet is MAC B (commercial router), and the destination IP address is IP A (Hikari Denwa router).

*2 Inform MAC B (IP A) of the MAC address of IP Z.

Fig. 4. Details of packets at point 2.

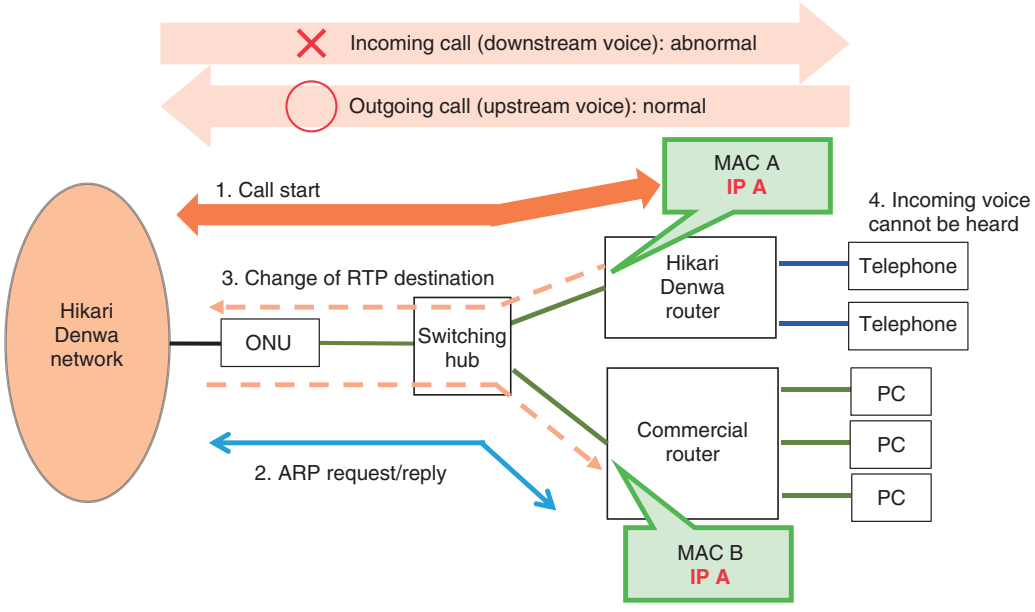

Fig. 5. Mechanism of occurrence of disconnected voice call.

same IP address being assigned to two different routers by connecting the switching hub to a verification line and connecting two Hikari Denwa routers to the downstream of the hub.

In the configuration in which two routers with the same IP address were located in the downstream of a

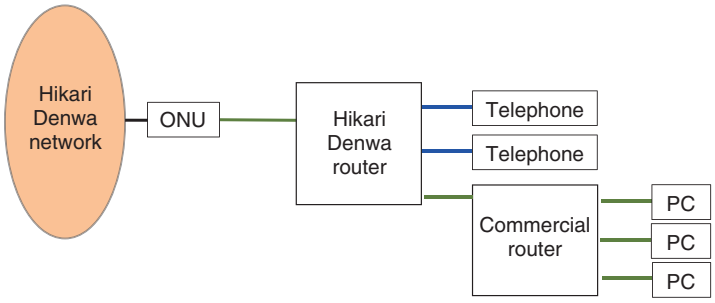

Fig. 6. Recommended configuration for customer's environment.

switching hub, an ARP packet was sent from the commercial router during the call; thus, the destination MAC address of the RTP packet sent from the network side was rewritten as the MAC address of the commercial router.

The switching hub learns the MAC addresses for each port and assigns the destination port to the Hikari Denwa router or commercial router on the basis of the destination MAC address. If the destination MAC address is rewritten, downstream RTP packets are no longer transmitted to the Hikari Denwa router; the result is a status in which the upstream voice can be heard, but the downstream voice cannot be.

6. Summary

The failure occurred for two reasons. (1) A commercial router was installed between the ONU and the Hikari Denwa router. (2) The Hikari Denwa router and commercial router were acting as DHCP clients. On speaking with the customer, this failure occurred after lightning struck a building near the customer's equipment. The DHCP client function of the commercial router was thereby unexpectedly enabled; thus, the same IP address was assigned twice. Considering this finding in regard to the Hikari Denwa service, we do not recommend the configuration in which the switching hub is installed between the Hikari Denwa router and ONU. Instead, we recommend installing the Hikari Denwa router and commercial router in the configuration shown in **Fig. 6**.

7. Concluding remarks

This article described a case study of a failure in which voice calls on the Hikari Denwa service were disconnected.

The Network Interface Engineering Group of TASC acquires and analyzes data using various tools to support the early resolution of problems with equipment, terminals, and networks.

Reference

[1] Ministry of Internal Affairs and Communications, "State of the Number of Subscriptions with Voice Communications Services," White Paper on Information and Communications in Japan, p. 69, 2023. https://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2023/pdf/01-chap4_sec2.pdf