

PPP over Ethernet 개요

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World Class Value Provider on the Net



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PPP 개요

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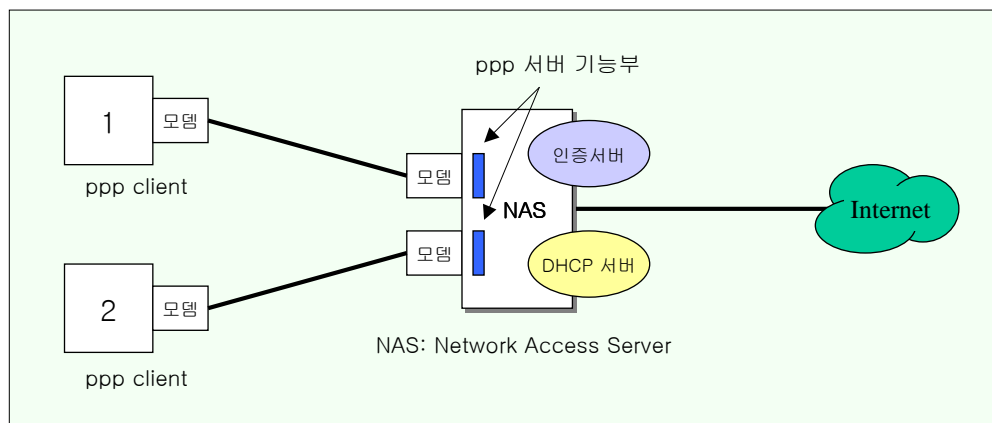


PPP의 필요성

❖ 사용자에게 대한 개별적인 인증

- ✓ 과금
- ✓ 사용자별 서비스 제어

❖ 동적인 IP 주소 할당



공중망에서의 PPP 활용 (ADSL 모뎀 환경)

PPP의 구성 및 동작

❖ PPPoE Discovery

- ✓ PPPoE의 경우 이 과정을 먼저 수행
- ✓ PPP 서버의 MAC 주소를 찾아냄

❖ LCP (Link Control Protocol)

- ✓ 송수신단 간의 최대 프레임 길이 결정
- ✓ 인증 프로토콜 종류 결정

❖ PAP/CHAP

- ✓ User ID와 PW를 사용해서 인증 과정 수행
- ✓ PAP: Password Authentication Protocol
- ✓ CHAP: Challenge Handshaking Authentication Protocol

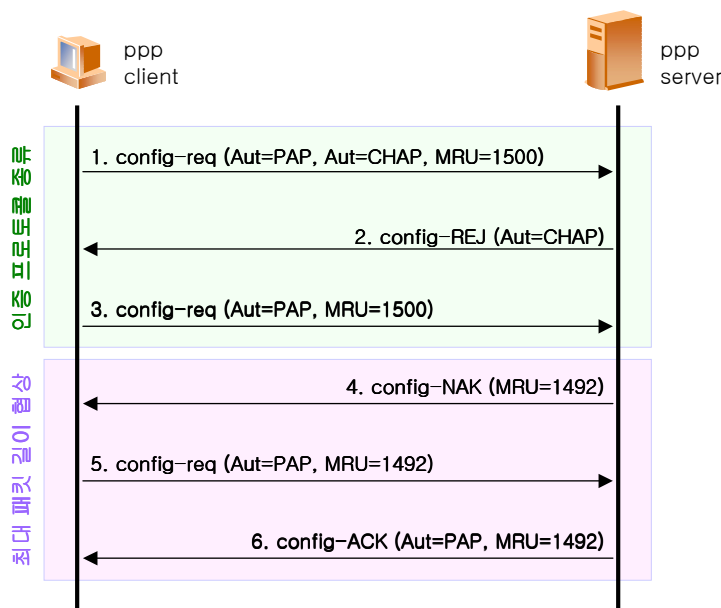
❖ IPCP (IP Control Protocol)

- ❖ Network Layer 프로토콜에 대한 설정값 할당
- ❖ 서버로부터 동적 IP, DNS, Default Gateway 할당 받음

LCP 절차

❖ 인증 프로토콜 종류 및 최대 프레임 길이 협상

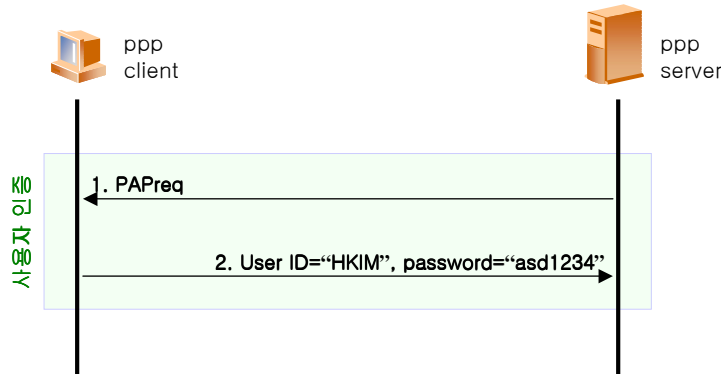
- ✓ Configuration Request, NACK, Reject, ACK 사용



PAP 절차

❖ User ID와 PW 사용해서 인증 절차 수행

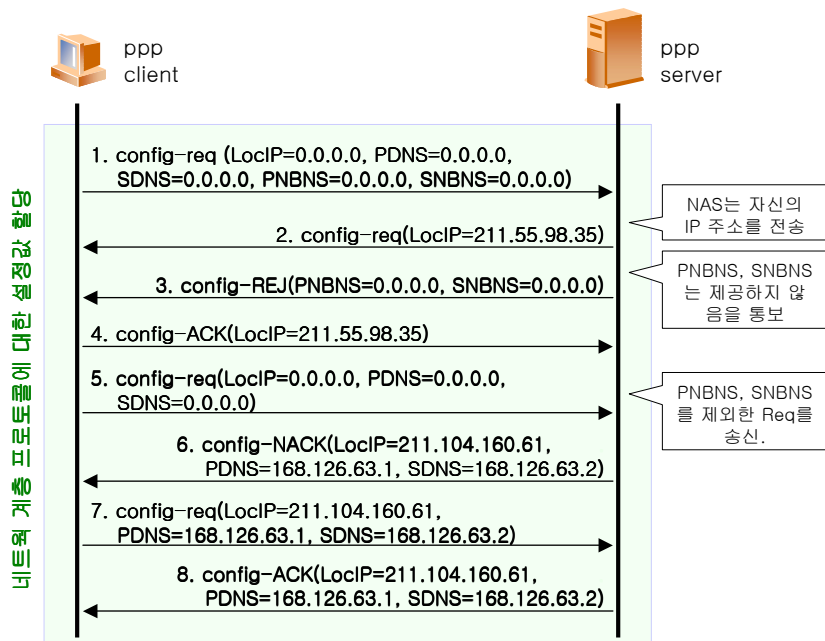
- ✓ Plain Text PW 사용
- ✓ 점대점 연결에서 사용하기 때문에 보안 문제 없음



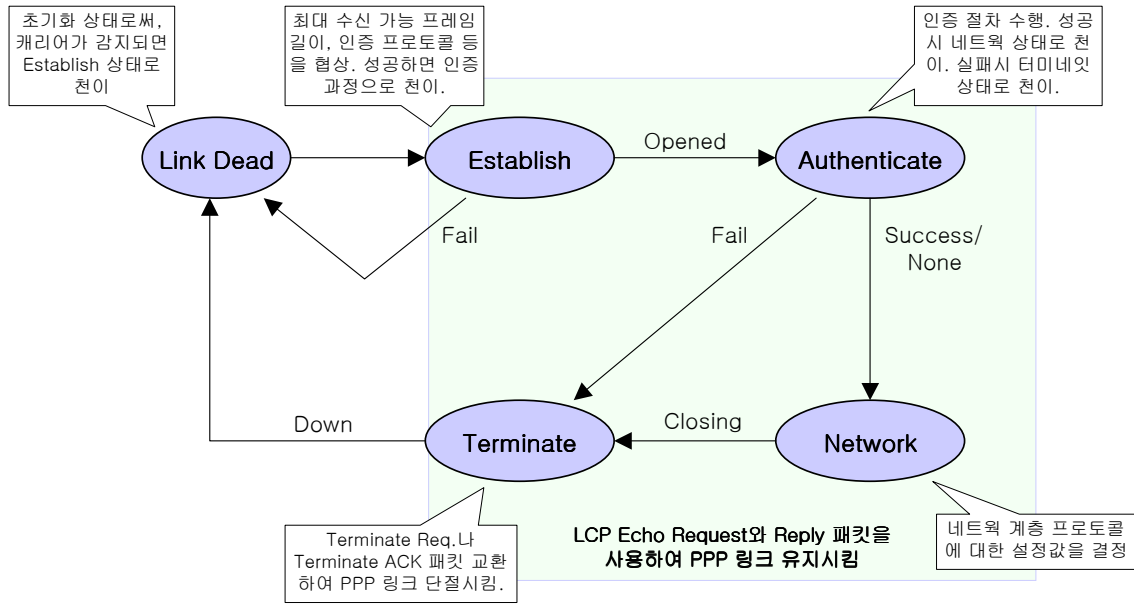
IPCP 절차

❖ Network Layer에 대한 설정값 할당

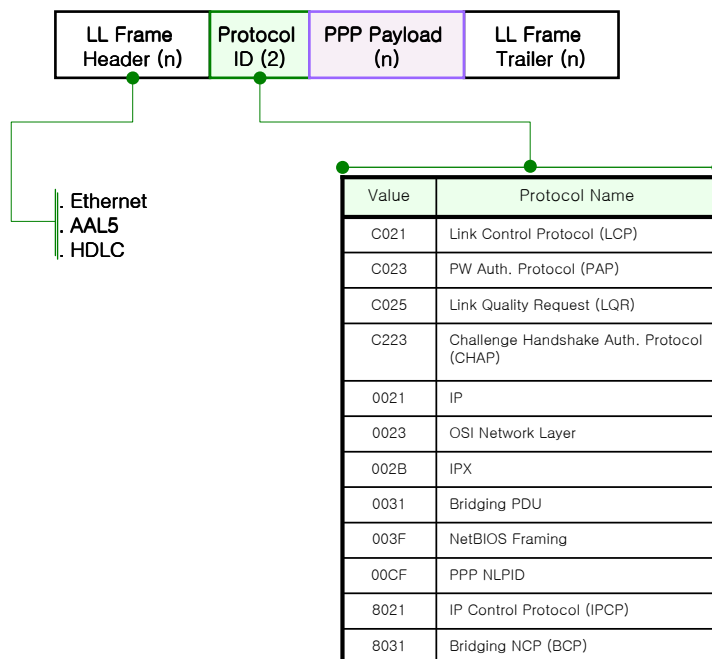
- ✓ Dynamic IP, DNS, Default Gateway



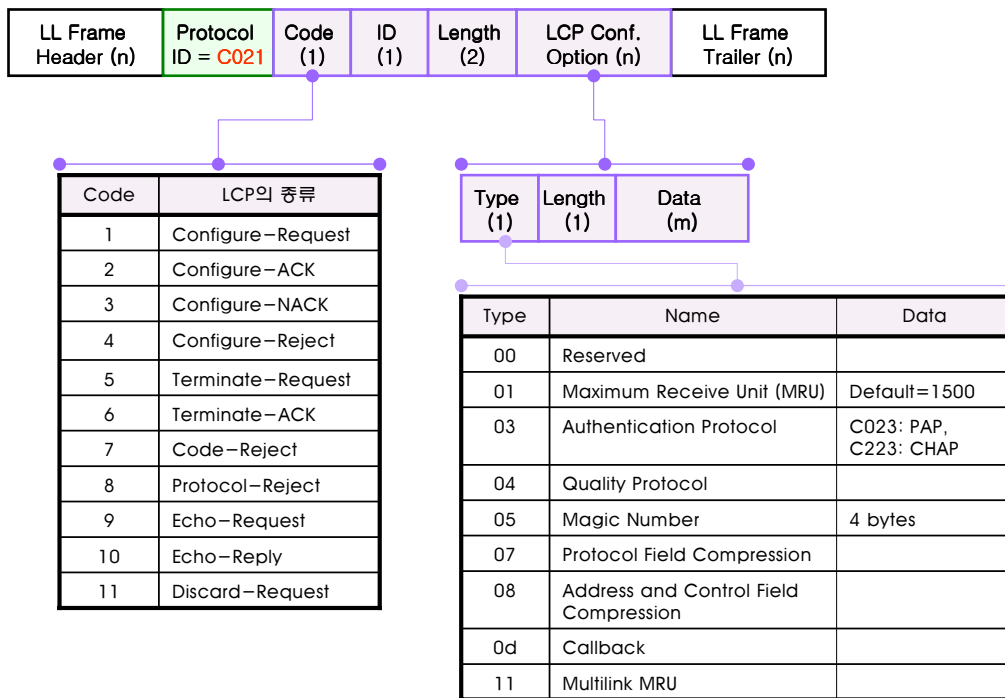
PPP 상태 천이도



PPP 패킷의 형식

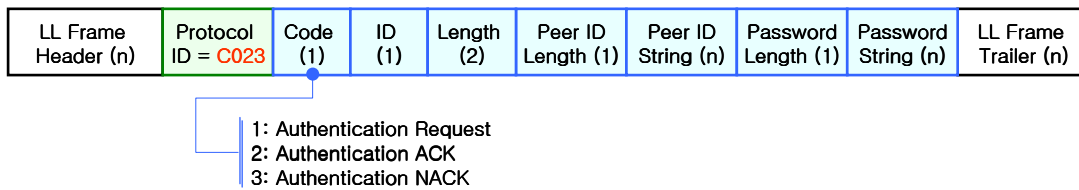


LCP 패킷 형식

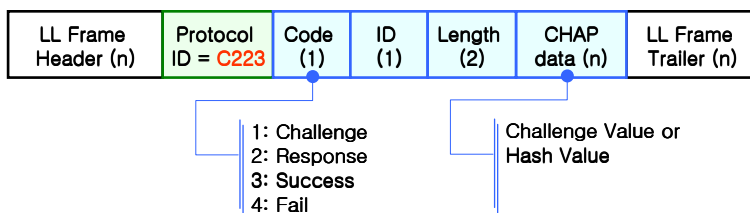


PAP 및 CHAP 형식

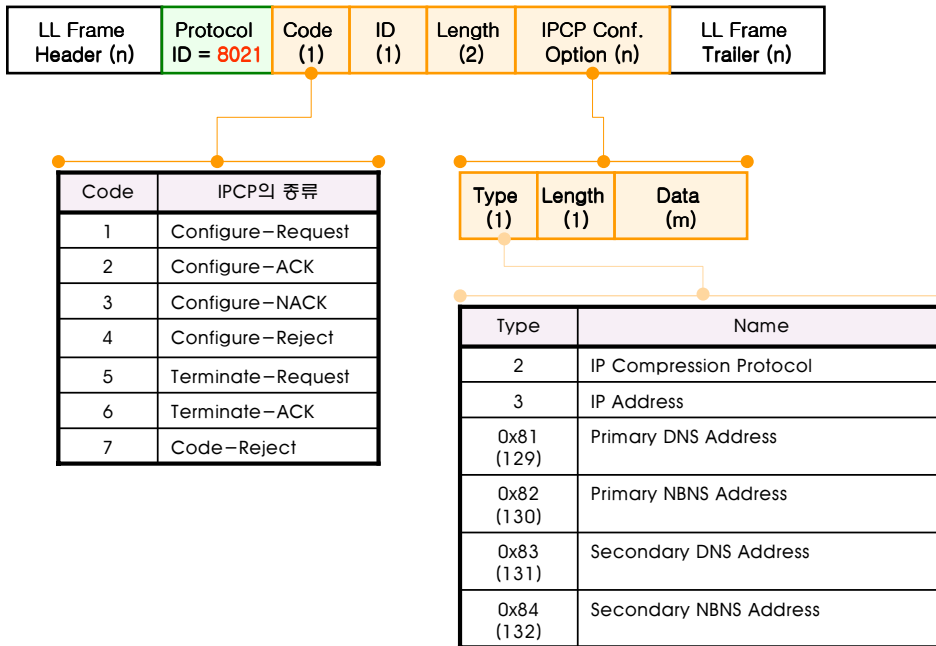
❖ PAP 패킷 형식



❖ CHAP 패킷 형식



IPCP 패킷 형식



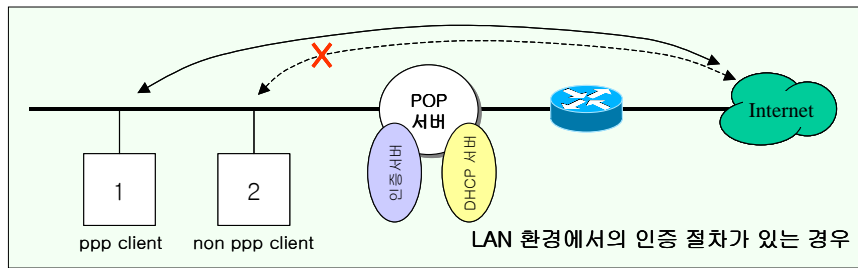
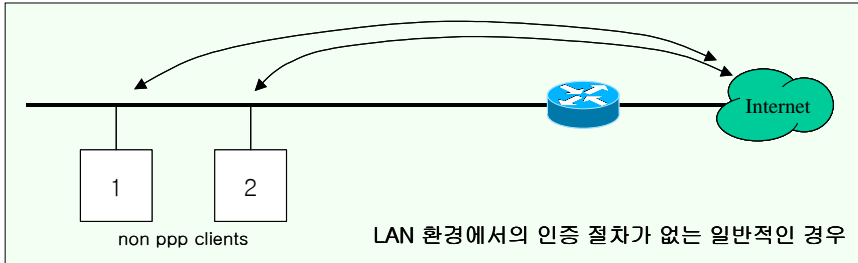
■ ■ PPPoE 개요 및 실험

- PPPoE의 필요성
- PPPoE의 프레임 형식
- PPPoE Discovery 과정
- PPPoE 실험 환경
- PPPoE 실험 결과 및 패킷 구조

PPPoE의 필요성

❖ LAN에서 사용자의 엄격한 관리가 필요한 경우

- ✓ 외부로의 과도한 트래픽을 발생시키는 사용자
- ✓ 해킹을 하는 불법 사용자를 색출하기 원할 때
- ✓ 사용자 별로 차별화된 서비스를 제공하고자 할 때



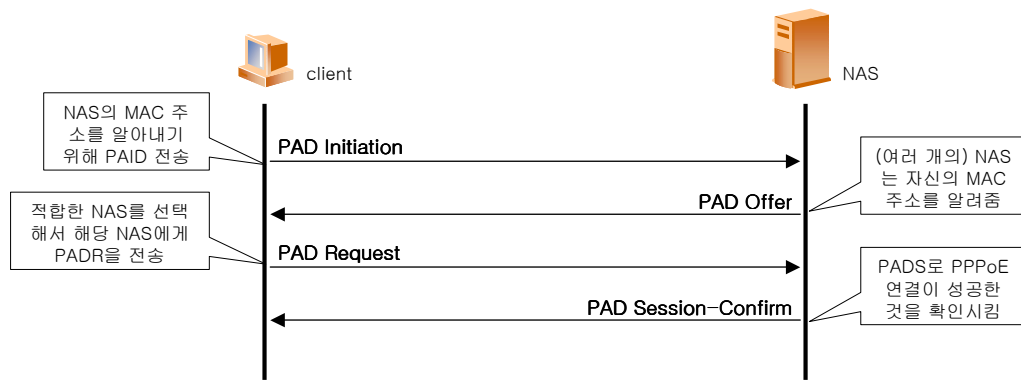
PPPoE의 프레임 형식

Dest MAC Add (6)	Src MAC Add (6)	EtherType (2)	Ver=1 (4b)	Type=1 (4b)	Code (2)	Session ID (2)	PPPoE Payload Length (2)	TagType (2)	TagValue Length (2)	...
------------------	-----------------	---------------	------------	-------------	----------	----------------	--------------------------	-------------	---------------------	-----

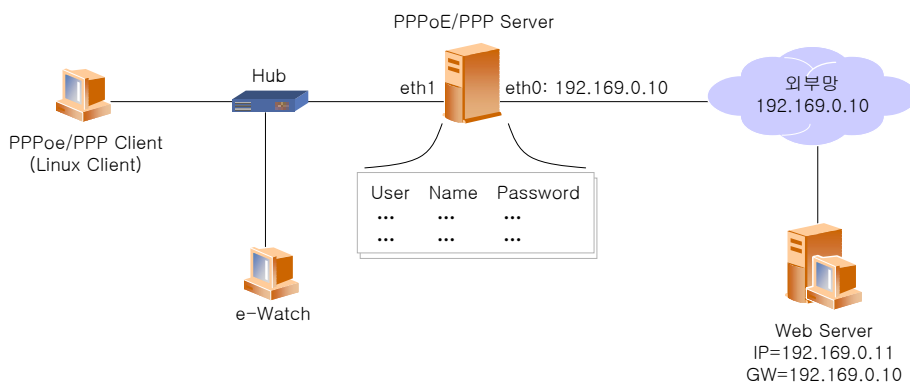
8863: Discovery 과정에서 사용
8864: Session 상태에서 사용

09 = PPPoE Active Discovery Initiation (PADI)
07 = PPPoE Active Discovery Offer (PADO)
19 = PPPoE Active Discovery Request (PADR)
65 = PPPoE Active Discovery Session-Confirm (PADS)
00 = PPPoE Session

PPPoE Discovery



PPPoE 실험 환경



Page	No.	Delta	Length	SrcIP	DestIP	Protocol	Summary	SrcMAC
1(-107)	9	5.000	60	----	----	PPPoEDISCV	Initiate(PADO) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	10	10.000	60	----	----	PPPoEDISCV	Initiate(PADO) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	11	-215...	63	----	----	PPPoEDISCV	Offer(PADO) sessionId=0x0000 AC-Name=ACT1 ServiceName= AC-Cookie=7...	005FCE3F065
	12	0ms...	60	----	----	PPPoEDISCV	Request(PADR) sessionId=0x0000 ServiceName= HostUniq=B3140000 AC...	000B7908571
	13	215ms...	60	----	----	PPPoEDISCV	Session-configure(PADS) sessionId=0x0001 ServiceName= HostUniq=B3140...	005FCE3F065
	14	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	15	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	16	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	17	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	18	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	19	1.015...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0x4315	005FCE3F065
	20	0ms...	60	----	----	PPPoLCP	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0x4315	000B7908571
	21	31ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	22	0ms...	60	----	----	PPPoLCP	Code=ConfigureAck ID=1MRU=1402Magic-Number=0x3d1e	005FCE3F065
	23	0ms...	60	----	----	PPPoLCP	Code=EchReq ID=0	005FCE3F065


```

MAC
  Destination Address(FF-FF-FF-FF-FF-FF)←Source Address(00-08-B7-90-85-71)
  Ether Type = 0x8863
  PPPoE-PPP over Ethernet(RFC2516) - Discovery Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = PPPoE Active Discovery Initiation(PADI) (0x0000)
    Session ID = 0
    Payload Length = 12
  Service-Name Tag
    Type = Service-Name (0x0101)
    Value Length = 0 -> No Service-Name
  Host-Uniq Tag
    Type = Host-Uniq (0x0103)
    Value Length = 4
    Value = B3 14 00 00
    
```

PPPoE Discovery는 4 단계로 구성되며 처음에 클라이언트가 PAD Initiation 패킷을 보냄으로써 시작된다. PPPoE Discovery 과정이 끝나기 전까지는 세션이 설정되지 않아 Session ID=0 상태가 유지된다. 세션이 설정될 때마다 Session ID는 1씩 증가한다.

Page	No.	Delta	Length	SrcIP	DestIP	Protocol	Summary	SrcMAC
1(-107)	9	5.000	60	----	----	PPPoEDISCV	Initiate(PADO) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	10	10.000	60	----	----	PPPoEDISCV	Initiate(PADO) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	11	-215...	63	----	----	PPPoEDISCV	Offer(PADO) sessionId=0x0000 AC-Name=ACT1 ServiceName= AC-Cookie=7...	005FCE3F065
	12	0ms...	60	----	----	PPPoEDISCV	Request(PADR) sessionId=0x0000 ServiceName= HostUniq=B3140000 AC...	000B7908571
	13	215ms...	60	----	----	PPPoEDISCV	Session-configure(PADS) sessionId=0x0001 ServiceName= HostUniq=B3140...	005FCE3F065
	14	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	15	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	16	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	17	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	18	0ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	19	1.015...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0x4315	005FCE3F065
	20	0ms...	60	----	----	PPPoLCP	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0x4315	000B7908571
	21	31ms...	60	----	----	PPPoLCP	Code=ConfigureReq ID=1MRU=1402Magic-Number=0x3d1e	000B7908571
	22	0ms...	60	----	----	PPPoLCP	Code=ConfigureAck ID=1MRU=1402Magic-Number=0x3d1e	005FCE3F065
	23	0ms...	60	----	----	PPPoLCP	Code=EchReq ID=0	005FCE3F065


```

MAC
  Destination Address(00-08-B7-90-85-71)←Source Address(00-50-FC-E3-FD-05)
  Ether Type = 0x8863
  PPPoE-PPP over Ethernet(RFC2516) - Discovery Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = PPPoE Active Discovery Offer(PADO) (0x0001)
    Session ID = 0
    Payload Length = 43
  AC-Name Tag
    Type = AC-Name (0x0102)
    Value Length = 3
    Value = ACT1
  Service-Name Tag
    Type = Service-Name (0x0101)
    Value Length = 0 -> No Service-Name
  AC-Cookie Tag
    Type = AC-Cookie (0x0104)
    Value Length = 20
    Value = 79 E9 77 3C E2 7E 8B A6 29 2F 4B 76 63 F3 5F 5E CE 11 00 00
  Host-Uniq Tag
    Type = Host-Uniq (0x0103)
    Value Length = 4
    Value = B3 14 00 00
    
```

클라이언트의 PADI에 대해 AC 서버는 PAD Offer 패킷으로 응답한다. PADO 패킷에는 AC 서버의 이름과 AC-Cookie Tag 값이 포함되어 있다. AC-Cookie Tag 값은 AC가 Denial of Service (DoS) 공격을 피하기 위해 사용한다. 즉, 클라이언트가 PAD Request 패킷만은 포함하지 않고 있으면, 허락되지 않은 Request로 간주하여 폐기하게 된다. 만약 이런 과정을 거치지 않으면 악의적인 사용자가 엄청난 양의 PAD Request 패킷만을 전송함으로써 AC 서버가 다른 서비스를 거부하게 되는 (DoS) 현상을 일으킬 수 있게 된다.

Page	No.	Delta	Length	Src:IP	Dst:IP/Assoc.	Protocol	Summary	Src:MAC
1(-107)	9	5.000...	60	----	----	PPPoE:GCV	Initiation(PAD) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	10	10.00...	60	----	----	PPPoE:GCV	Initiation(PAD) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	11	-215...	63	----	----	PPPoE:GCV	Offer(PADO) sessionId=0x0000 AC-Name=AC1 ServiceName= ACcookie=7	0050CE3F065
	12	0ms...	60	----	----	PPPoE:GCV	Request(PADR) sessionId=0x0000 ServiceName= HostUniq=B3140000 AC...	000B7908571
	13	219s...	60	----	----	PPPoE:GCV	Session-confirm(PACG) sessionId=0x0001 ServiceName= HostUniq=B3140...	0050CE3F065
	14	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	15	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	16	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	17	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	18	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	19	1.015...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0c4315	0050CE3F065
	20	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0c4315	000B7908571
	21	31ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	22	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureAck ID=1MRU=1492Magic-Number=0c3d1e	0050CE3F065
	23	0ms...	60	----	----	PPPoE:GCV	Code=EchoReq ID=0	0050CE3F065


```

MAC
  Destination Address(00-50-FC-E3-F0-65) ← Source Address(00-00-B7-90-85-71)
  Ether Type = 0x8863
  PPPoE-PPP over Ethernet(RFC2516) - Discovery Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = PPPoE Active Discovery Request(PADR) (0x12)
    Session ID = 0
    Payload Length = 36
  Service-Name Tag
    Type = Service-Name (0x0101)
    Value Length = 0 → No Service-Name
  Host-Uniq Tag
    Type = Host-Uniq (0x0103)
    Value Length = 4
    Value = B3 14 00 00
  AC-Cookie Tag
    Type = AC-Cookie (0x0104)
    Value Length = 20
    Value = 79 E8 77 2C E2 7E 86 A6 29 2F 4B 7B 63 F3 9F 95 CE 11 00 00
    
```

PADO 과정에서 AC 서버가 클라이언트에게 제공한 AC-Cookie Tag 값이 그대로 포함되어 있다. 이 값이 없는 PADR 패킷이 도착하면, 서버는 그대로 버림으로써 만일에 발생할 수 있는 DoS 공격을 막게 된다.

Page	No.	Delta	Length	Src:IP	Dst:IP/Assoc.	Protocol	Summary	Src:MAC
1(-107)	9	5.000...	60	----	----	PPPoE:GCV	Initiation(PAD) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	10	10.00...	60	----	----	PPPoE:GCV	Initiation(PAD) sessionId=0x0000 ServiceName= HostUniq=B3140000	000B7908571
	11	-215...	63	----	----	PPPoE:GCV	Offer(PADO) sessionId=0x0000 AC-Name=AC1 ServiceName= ACcookie=7	0050CE3F065
	12	0ms...	60	----	----	PPPoE:GCV	Request(PADR) sessionId=0x0000 ServiceName= HostUniq=B3140000 AC...	000B7908571
	13	219s...	60	----	----	PPPoE:GCV	Session-confirm(PACG) sessionId=0x0001 ServiceName= HostUniq=B3140...	0050CE3F065
	14	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	15	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	16	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	17	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	18	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	19	1.015...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0c4315	0050CE3F065
	20	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0c4315	000B7908571
	21	31ms...	60	----	----	PPPoE:GCV	Code=ConfigureReq ID=1MRU=1492Magic-Number=0c3d1e	000B7908571
	22	0ms...	60	----	----	PPPoE:GCV	Code=ConfigureAck ID=1MRU=1492Magic-Number=0c3d1e	0050CE3F065
	23	0ms...	60	----	----	PPPoE:GCV	Code=EchoReq ID=0	0050CE3F065


```

MAC
  Destination Address(00-00-B7-90-85-71) ← Source Address(00-50-FC-E3-F0-65)
  Ether Type = 0x8863
  PPPoE-PPP over Ethernet(RFC2516) - Discovery Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = PPPoE Active Discovery Session-confirmation(PACST) (0x08)
    Session ID = 1
    Payload Length = 12
  Service-Name Tag
    Type = Service-Name (0x0101)
    Value Length = 0 → No Service-Name
  Host-Uniq Tag
    Type = Host-Uniq (0x0103)
    Value Length = 4
    Value = B3 14 00 00
    
```

PPPoE Session 상태로 진입했으므로 Session ID가 0이 아닌 값이 됐다. 실험에서는 세션이 생길 때마다 세션 ID 값이 1씩 증가하는 것을 확인할 수 있었다.

MRU Decision Request

LCP 과정

Page	No.	Delta	Length	SrcIP	DstIP	Protocol	Summary	SrcMAC
1(-107)	9	5.000	60	----	----	PPPoEDGCV	Initiation(PAD) sessionid=0.0000 ServiceName= HostLink-B3140000	00C0B7908571
	10	10.000	60	----	----	PPPoEDGCV	Initiation(PAD) sessionid=0.0000 ServiceName= HostLink-B3140000	00C0B7908571
	11	-215	60	----	----	PPPoEDGCV	Offer(PAD) sessionid=0.0000 AC-Name=AC1 ServiceName= ACcookie=7...	0050FCE3F065
	12	0ms	60	----	----	PPPoEDGCV	Request(PADR) sessionid=0.0000 ServiceName= HostLink=00140000 AC...	00C0B7908571
	13	215ms	60	----	----	PPPoEDGCV	Session-confirm(PADS) sessionid=0.0001 ServiceName= HostLink-B3140...	0050FCE3F065
	14	0ms	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	15	0ms	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	16	0ms	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	17	0ms	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	18	0ms	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	19	1.015	60	----	----	PPPLCP	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0x43f5	0050FCE3F065
	20	0ms	60	----	----	PPPLCP	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0x43f5	00C0B7908571
	21	31ms	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	22	0ms	60	----	----	PPPLCP	Code=ConfigureAck ID=1MRU=1492Magic-Number=0x3dfe	0050FCE3F065
	23	0ms	60	----	----	PPPLCP	Code=EchoReq ID=0	0050FCE3F065

```

MAC
  Destination Address(00-90-FC-E3-F0-05) ← Source Address(00-D0-B7-90-05-71)
  Ether Type = 0x8864
PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
  Version(4bits) = 1
  Type(4bits) = 1
  Code = 0
  SESSION ID = 1
  Length = 16
  PPP Protocol-ID = 0xc021 → Link Control Protocol(LCP)
LCP-Link Control Protocol
  Code = Configure-request (0x01)
  Identifier = 0x01
  Length = 14
  LCP Data = Maximum-Receive-Unit
    Type = Maximum-Receive-Unit (1)
    [1]Length = 4
    Maximum-Receive-Unit = 1492
  LCP Data = Magic-Number
    Type = Magic-Number (5)
    [2]Length = 6
    Magic-Number = 0x9ab63dfe
    
```

LCP 과정은 MRU (Maximum Receive Unit)과 인증 프로토콜을 결정하는 것으로 구성된다. 먼저 클라이언트는 자신의 MRU를 서버에 알리게 된다.

MRU Decision ACK

LCP 과정

Page	No.	Delta(CaptureTime)	Length	SrcIP	DstIP	Protocol	Summary	SrcMAC
1(-107)	14	0ms (14.42.49.57989)	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	15	0ms (14.42.49.58889)	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	16	0ms (14.42.50.55889)	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	17	0ms (14.42.51.54889)	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	18	0ms (14.42.52.53889)	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	19	1.015s (14.42.54.530)	60	----	----	PPPLCP	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0x43f5	0050FCE3F065
	20	0ms (14.42.55.52004)	60	----	----	PPPLCP	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0x43f5	00C0B7908571
	21	31ms (14.42.56.510)	60	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3dfe	00C0B7908571
	22	0ms (14.42.57.50005)	60	----	----	PPPLCP	Code=ConfigureAck ID=1MRU=1492Magic-Number=0x3dfe	0050FCE3F065
	23	0ms (14.42.58.48005)	60	----	----	PPPLCP	Code=EchoReq ID=0	0050FCE3F065
	24	0ms (14.42.59.49005)	60	----	----	PPPoEch	Code=EchoReq ID=0	0050FCE3F065

```

MAC
  Destination Address(00-D0-B7-90-05-71) ← Source Address(00-90-FC-E3-F0-05)
  Ether Type = 0x8864
PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
  Version(4bits) = 1
  Type(4bits) = 1
  Code = 0
  SESSION ID = 1
  Length = 16
  PPP Protocol-ID = 0xc021 → Link Control Protocol(LCP)
LCP-Link Control Protocol
  Code = Configure-ack (0x02)
  Identifier = 0x01
  Length = 14
  LCP Data = Maximum-Receive-Unit
    Type = Maximum-Receive-Unit (1)
    [1]Length = 4
    Maximum-Receive-Unit = 1492
  LCP Data = Magic-Number
    Type = Magic-Number (5)
    [2]Length = 6
    Magic-Number = 0x9ab63dfe
    
```

AC 서버가 MRU를 1492로 해도 좋음을 클라이언트에게 알린다.

CHAP Decision Request

LCP 과정

Page	No.	Date/Capture Time	Length	Src IP	Dest IP	Protocol	Summary	Src MAC
1(=107)	9	5.800s (14.43.33.525)	80	----	----	PPPOEDISCV	Initiate(PAD) sessionId=0x0000 ServiceName= HostName=03140000	00:0B:79:05:71
	10	10.000s (14.43.44.81)	80	----	----	PPPOEDISCV	Initiate(PAD) sessionId=0x0000 ServiceName= HostName=03140000	00:0B:79:05:71
	11	219ms (14.43.45.80)	83	----	----	PPPOEDISCV	Offer(PADO) sessionId=0x0000 AC Name=AC1 ServiceName= ACCode=T	00:0B:79:05:71
	12	9ms (14.43.46.9274)	80	----	----	PPPOEDISCV	Request(PADR) sessionId=0x0000 ServiceName= HostName=03140000 AC	00:0B:79:05:71
	13	215ms (14.43.47.58)	80	----	----	PPPOEDISCV	Session-confirm(PADS) sessionId=0x0001 ServiceName= HostName=03140	00:0B:79:05:71
	14	9ms (14.43.48.57989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	15	9ms (14.43.48.59989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	16	9ms (14.43.50.55989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	17	9ms (14.43.51.54989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	18	9ms (14.43.52.53989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	19	1.815s (14.43.54.530)	80	----	----	PPPLCP	Code=ConfigureReq ID=1AUIType=CHAPMagic-Number=0x4395	00:0B:79:05:71
	20	9ms (14.43.55.52004)	80	----	----	PPPLCP	Code=ConfigureAck ID=1AUIType=CHAPMagic-Number=0x4395	00:0B:79:05:71
	21	31ms (14.43.56.510)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	22	9ms (14.43.57.50025)	80	----	----	PPPLCP	Code=ConfigureAck ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71


```

MAC
  Destination Address(00-00-B7-90-85-71) ← Source Address(00-50-FC-E3-F0-6E)
  Ether Type = 0x8864
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 17
  PPP Protocol-ID = 0xc021 → Link Control Protocol(LCP)
  LCP-Link Control Protocol
    Code = Configure-request(0x0001)
    Identifier = (0x01)
    Length = 15
  LCP Data = Authentication-Type
    Type = Authentication-Type (3)
    [1]Length = 5
    Authentication Type = CHAP(0xc223)
    CHAP Information(1 bytes)
  LCP Data = Magic-Number
    Type = Magic-Number (5)
    [2]Length = 6
    Magic-Number = 0x50ea4395
  
```

서버는 자신이 CHAP 인증을 사용할 것을 클라이언트에게 알린다.

CHAP Decision ACK

LCP 과정

Page	No.	Date/Capture Time	Length	Src IP	Dest IP	Protocol	Summary	Src MAC
1(=107)	13	215ms (14.43.47.58)	80	----	----	PPPOEDISCV	Session-confirm(PADS) sessionId=0x0001 ServiceName= HostName=03140	00:0B:79:05:71
	14	9ms (14.43.48.57989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	15	9ms (14.43.48.59989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	16	9ms (14.43.50.55989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	17	9ms (14.43.51.54989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	18	9ms (14.43.52.53989)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	19	1.815s (14.43.54.530)	80	----	----	PPPLCP	Code=ConfigureReq ID=1AUIType=CHAPMagic-Number=0x4395	00:0B:79:05:71
	20	9ms (14.43.55.52004)	80	----	----	PPPLCP	Code=ConfigureAck ID=1AUIType=CHAPMagic-Number=0x4395	00:0B:79:05:71
	21	31ms (14.43.56.510)	80	----	----	PPPLCP	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71
	22	9ms (14.43.57.50025)	80	----	----	PPPLCP	Code=ConfigureAck ID=1MRU=1492Magic-Number=0x30fe	00:0B:79:05:71


```

MAC
  Destination Address(00-50-FC-E3-F0-6E) ← Source Address(00-00-B7-90-85-71)
  Ether Type = 0x8864
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 17
  PPP Protocol-ID = 0xc021 → Link Control Protocol(LCP)
  LCP-Link Control Protocol
    Code = Configure-ack(0x0002)
    Identifier = (0x01)
    Length = 15
  LCP Data = Authentication-Type
    Type = Authentication-Type (3)
    [1]Length = 5
    Authentication Type = CHAP(0xc223)
    CHAP Information(1 bytes)
  LCP Data = Magic-Number
    Type = Magic-Number (5)
    [2]Length = 6
    Magic-Number = 0x50ea4395
  
```

클라이언트가 인증 방식에 대해 ACK를 보낸다.

CHAP Server Request

LCP 과정

Page	No.	Date/Time	Length	SrcIP	DestIP	Protocol	Summary	SrcMAC	DestMAC
1(-107)	14	Dec (14 43 40 57989)	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3ffe	000B7908571	
	15	Dec (14 43 40 58089)	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3ffe	000B7908571	
	16	Dec (14 43 50 55089)	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3ffe	000B7908571	
	17	Dec (14 43 51 54089)	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3ffe	000B7908571	
	18	Dec (14 43 52 53089)	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3ffe	000B7908571	
	19	1 Dec (14 43 54 53000)	60	----	----	PPPoE	Code=ConfigureReq ID=1AuthType=CHAPMagic-Number=0x3ffe	0050CE3F065	
	20	Dec (14 43 55 52004)	60	----	----	PPPoE	Code=ConfigureAck ID=1AuthType=CHAPMagic-Number=0x3ffe	000B7908571	
	21	31 Dec (14 43 56 51000)	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492Magic-Number=0x3ffe	000B7908571	
	22	Dec (14 43 57 50005)	60	----	----	PPPoE	Code=ConfigureAck ID=1MRU=1492Magic-Number=0x3ffe	0050CE3F065	
	23	Dec (14 43 58 49005)	60	----	----	PPPoE	Code=EchoReq ID=0	0050CE3F065	
	24	Dec (14 43 59 48005)	60	----	----	PPPoE	Code=Challenge ID=1	0050CE3F065	
	25	Dec (14 44 0 47005)	60	----	----	PPPoE	Code=EchoReq ID=0	000B7908571	
	26	Dec (14 44 1 46005)	60	----	----	PPPoE	Code=EchoReply ID=0	000B7908571	
	27	Dec (14 44 2 45005)	60	----	----	PPPoE	Code=EchoReply ID=0	0050CE3F065	
	28	Dec (14 44 3 44005)	60	----	----	PPPoE	Code=Response ID=1	000B7908571	
	29	Dec (14 44 4 43005)	60	----	----	PPPoE	Code=Success ID=1	0050CE3F065	
	30	Dec (14 44 5 42005)	60	----	----	PPPoE	Code=Configure-request ID=1 Lcp=10.0.0.1	0050CE3F065	
	31	Dec (14 44 6 41005)	60	----	----	PPPoE	Code=Configure-request ID=1 Lcp=10.0.0.1	0050CE3F065	


```

MAC
  Destination Address(00-D0-B7-90-85-71)←Source Address(00-50-FC-E3-FD-65)
  Ether Type = 0x8864
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    - Version(4bits) = 1
    - Type(4bits) = 1
    - Code = 0
    - SESSION ID = 1
    - Length = 32
  PPP Protocol-ID = Dcc223 -> Challenge Handshake Authentication Protocol(CHAP)
  CHAP-Challenge Handshake Authentication Protocol (RFC1994)
    - Code = Challenge(1)
    - Id = 01H
    - Length = 30
  CHAP Data (26 bytes)
    - CHAP Value Field
      - Value Length = 20 bytes
      - Value (Hash Value) = AD 14 7B F9 B2 11 42 5F 28 F4 C8 64 60 4C D0 C8 D1 4A B8 F5
      - Message = "sams"
  
```

서버는 Challenge Value (CV)를 클라이언트에 보내면서 ID와 PW를 요청하게 된다.

CHAP Client Response

LCP 과정

Page	No.	Date	Length	SrcIP	DestIP	Protocol	Summary	SrcMAC	DestMAC
1(-107)	20	Dec ...	60	----	----	PPPoE	Code=ConfigureReq ID=1MRU=1492	000B7908571	0050CE3F065
	22	Dec ...	60	----	----	PPPoE	Code=ConfigureAck ID=1MRU=1492	0050CE3F065	000B7908571
	23	Dec ...	60	----	----	PPPoE	Code=EchoReq ID=0	0050CE3F065	000B7908571
	24	Dec ...	60	----	----	PPPoE	Code=Challenge ID=1	0050CE3F065	000B7908571
	25	Dec ...	60	----	----	PPPoE	Code=EchoReq ID=0	000B7908571	0050CE3F065
	26	Dec ...	60	----	----	PPPoE	Code=EchoReply ID=0	000B7908571	0050CE3F065
	27	Dec ...	60	----	----	PPPoE	Code=EchoReply ID=0	0050CE3F065	000B7908571
	28	Dec ...	60	----	----	PPPoE	Code=Response ID=1	000B7908571	0050CE3F065
	29	Dec ...	60	----	----	PPPoE	Code=Success ID=1	0050CE3F065	000B7908571
	30	Dec ...	60	----	----	PPPoE	Code=Configure-request ID=1 LcpP	0050CE3F065	000B7908571
	31	Dec ...	60	----	----	PPPoE	Code=Configure-request ID=1 LcpP	000B7908571	0050CE3F065
	32	Dec ...	60	----	----	PPPoE	Code=Configure-request ID=1 LcpP	0050CE3F065	000B7908571


```

MAC
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    - Version(4bits) = 1
    - Type(4bits) = 1
    - Code = 0
    - SESSION ID = 1
    - Length = 30
  PPP Protocol-ID = Dcc223 -> Challenge Handshake Authentication Protocol(CHAP)
  CHAP-Challenge Handshake Authentication Protocol (RFC1994)
    - Code = Response(2)
    - Id = 01H
    - Length = 26
  CHAP Data (24 bytes)
    - CHAP Value Field
      - Value Length = 16 bytes
      - Value (Hash Value) = CC DC 28 7E D1 6F 7B 43 2D 96 CF 5E BA 4B 6F 7B
      - Message = "samsung"
  
```

ID는 상성이며, 사용자 PW, CHAP challenge value (CV), ID Value를 MD5를 사용해서 Hash Value를 만든다.

Page	No.	Time/Capture Time	Length	SrcIP	DestIP	Protocol	Summary	SrcMAC	DestMAC
11-107	14	0ms (14.43.48.5780)	80	----	----	PPPLCP	Code=ConfigureReq, D=1MRU=1482Magic-Number=0x30fe	00007900571	0050f0e3f065
	15	0ms (14.43.48.5800)	80	----	----	PPPLCP	Code=ConfigureReq, D=1MRU=1482Magic-Number=0x30fe	00007900571	0050f0e3f065
	16	0ms (14.43.58.5280)	80	----	----	PPPLCP	Code=ConfigureReq, D=1MRU=1482Magic-Number=0x30fe	00007900571	0050f0e3f065
	17	0ms (14.43.59.5480)	80	----	----	PPPLCP	Code=ConfigureReq, D=1MRU=1482Magic-Number=0x30fe	00007900571	0050f0e3f065
	18	0ms (14.43.52.5280)	80	----	----	PPPLCP	Code=ConfigureReq, D=1MRU=1482Magic-Number=0x30fe	00007900571	0050f0e3f065
	19	1.015s (14.43.54.538)	80	----	----	PPPLCP	Code=ConfigureReq, D=1AuthType=CHAPMagic-Number=0x4385	0050f0e3f065	00007900571
	20	0ms (14.43.55.5280)	80	----	----	PPPLCP	Code=ConfigureAck, D=1AuthType=CHAPMagic-Number=0x4385	00007900571	0050f0e3f065
	21	31ms (14.43.56.510)	80	----	----	PPPLCP	Code=ConfigureReq, D=1MRU=1482Magic-Number=0x30fe	00007900571	0050f0e3f065
	22	0ms (14.43.57.5000)	80	----	----	PPPLCP	Code=ConfigureAck, D=1MRU=1482Magic-Number=0x30fe	00007900571	00007900571
	23	0ms (14.43.58.4800)	80	----	----	PPPLCP	Code=EchoReq, D=0	00007900571	00007900571
	24	0ms (14.43.58.4800)	80	----	----	PPPLCP	Code=Challenge, D=1	00007900571	00007900571
	25	0ms (14.44.0.4700)	80	----	----	PPPLCP	Code=EchoReq, D=0	00007900571	0050f0e3f065
	26	0ms (14.44.1.4600)	80	----	----	PPPLCP	Code=EchoReply, D=0	00007900571	0050f0e3f065
	27	0ms (14.44.2.4500)	80	----	----	PPPLCP	Code=EchoReply, D=0	00007900571	00007900571
	28	0ms (14.44.3.4400)	80	----	----	PPPLCP	Code=Response, D=1	00007900571	0050f0e3f065
	29	0ms (14.44.4.4300)	80	----	----	PPPLCP	Code=Success, D=1	00007900571	00007900571
	30	0ms (14.44.5.4200)	80	----	----	PPPLCP	Code=Configure-request, D=1 LcpP=10.0.0.1	00007900571	00007900571
	31	0ms (14.44.6.4100)	80	----	----	PPPLCP	Code=Configure-request, D=1 LcpP=10.0.0.1	00007900571	00007900571


```

MAC
  Destination Address(00-00-B7-90-85-71) ← Source Address(00-50-FC-E3-FD-E5)
  Ether Type = 0x8864
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 23
  PPP Protocol ID = 0xc223 -> Challenge Handshake Authentication Protocol(CHAP)
  CHAP-Challenge Handshake Authentication Protocol(RFC1949)
    Code = Success(3)
    Id = 018
    Length = 21
  CHAP Message Field (17 bytes)
    Message = "Welcome to hoots."
  
```

인증 성공

Page	No.	Time/Capture Time	Length	SrcIP	DestIP	Protocol	Summary	SrcMAC
11-107	28	0ms (14.44.3.4400)	80	----	----	PPPLCP	Code=Response, D=1	00007900571
	29	0ms (14.44.4.4300)	80	----	----	PPPLCP	Code=Success, D=1	0050f0e3f065
	30	0ms (14.44.5.4200)	80	----	----	PPPLCP	Code=Configure-request, D=1 LcpP=10.0.0.1	0050f0e3f065
	31	0ms (14.44.6.4100)	80	----	----	PPPLCP	Code=Configure-request, D=1 LcpP=0.0.0.0 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	00007900571
	32	0ms (14.44.7.4000)	80	----	----	PPPLCP	Code=Configure-reject, D=1 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0050f0e3f065
	33	0ms (14.44.8.3800)	80	----	----	PPPLCP	Code=Configure-ack, D=1 LcpP=10.0.0.1	00007900571
	34	0ms (14.44.9.3600)	80	----	----	PPPLCP	Code=Configure-request, D=2 LcpP=0.0.0.0	00007900571
	35	0ms (14.44.10.3700)	80	----	----	PPPLCP	Code=Configure-nak, D=2 LcpP=168.219.137.18	0050f0e3f065
	36	0ms (14.44.11.3600)	80	----	----	PPPLCP	Code=Configure-request, D=3 LcpP=168.219.137.18	00007900571
	37	0ms (14.44.12.3500)	80	----	----	PPPLCP	Code=Configure-ack, D=3 LcpP=168.219.137.18	0050f0e3f065
	38	10.000s (14.44.23.54)	80	----	----	PPPLCP	Code=EchoReq, D=1	0050f0e3f065


```

MAC
  Destination Address(00-00-B7-90-85-71) ← Source Address(00-50-FC-E3-FD-E5)
  Ether Type = 0x8864
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 12
  PPP Protocol ID = 0xb021 -> Internet Protocol Control Protocol(IPCP)
  IPCP-Internet Protocol Control Protocol(RFC1332/RFC1877)
    Code = Configure-Request(0x01)
    Identifier = 0x01
    Length = 10
  IPCP Data = IP Address
    Type = IP Address(3)
    Length = 6
    Desired local address = 10.0.0.1
  
```

서버가 자신의 Local IP 주소가 10.0.0.1임을 알려준다.

Client의 L3 Conf. Info. Request

IPCP 과정

Page	No.	Date/Capture Time	Length	Src IP	Dest IP/Port	Protocol	Summary	Src MAC
1(-187)	28	0ms (14:44:3.44235)	80	----	----	PPPCHAP	Code=Response, ID=1	0000B7908571
	29	0ms (14:44:4.43835)	80	----	----	PPPCHAP	Code=Success, ID=1	0050FCE3F085
	30	0ms (14:44:5.42935)	80	----	----	PPP/PCP	Code=Configure-request, ID=1 LocIP=10.0.0.1	0050FCE3F085
	31	0ms (14:44:6.41035)	80	----	----	PPP/PCP	Code=Configure-request, ID=1 LocIP=0.0.0.0 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0000B7908571
	32	0ms (14:44:7.40635)	80	----	----	PPP/PCP	Code=Configure-reject, ID=1 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0050FCE3F085
	33	0ms (14:44:8.39835)	80	----	----	PPP/PCP	Code=Configure-ack, ID=1 LocIP=10.0.0.1	0000B7908571
	34	0ms (14:44:9.39035)	80	----	----	PPP/PCP	Code=Configure-request, ID=2 LocIP=0.0.0.0	0000B7908571
	35	0ms (14:44:10.37035)	80	----	----	PPP/PCP	Code=Configure-request, ID=2 LocIP=168.219.137.18	0050FCE3F085
	36	0ms (14:44:11.36035)	80	----	----	PPP/PCP	Code=Configure-request, ID=3 LocIP=168.219.137.18	0000B7908571
	37	0ms (14:44:12.35035)	80	----	----	PPP/PCP	Code=Configure-ack, ID=3 LocIP=168.219.137.18	0050FCE3F085
	38	10.000s (14:44:23.34...)	80	----	----	PPP/LCP	Code=EchoReq ID=1	0050FCE3F085

```

MAC
- Destination Address(00-50-FC-E3-F0-85) ← Source Address(00-D0-B7-90-85-71)
Ether Type = 0x8864
PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
- Version(4bits) = 1
- Type(4bits) = 1
- Code = 0
SESSION ID = 1
Length = 24
PPP Protocol ID = 0x0021 -> Internet Protocol Control Protocol(IPCP)
IPCP-Internet Protocol Control Protocol (RFC1332/RFC1877)
Code = Configure-Request (0x0001)
Identifier = 0x01
Length = 32
IPCP Data = IP Address
- Type = IP Address (3)
- (1)Length = 6
Desired local address = 0.0.0.0
IPCP Data = Primary DNS address
- Type = Primary DNS address (129)
- (2)Length = 6
Primary DNS address = 0.0.0.0
IPCP Data = Secondary DNS address
- Type = Secondary DNS address (131)
- (3)Length = 6
Secondary DNS address = 0.0.0.0
    
```

클라이언트가 자신의 Local IP, PDNS, SDNS를 요청한다. 서버는 PDNS와 SDNS에 대해 리젝트 응답한다.

Client의 Local IP 요청 및 Server의 NACK

IPCP 과정

Page	No.	Date/Capture Time	Length	Src IP	Dest IP/Port	Protocol	Summary	Src MAC
1(-187)	29	0ms (14:44:4.43035)	80	----	----	PPPCHAP	Code=Success, ID=1	0050FCE3F085
	30	0ms (14:44:5.42035)	80	----	----	PPP/PCP	Code=Configure-request, ID=1 LocIP=10.0.0.1	0050FCE3F085
	31	0ms (14:44:6.41035)	80	----	----	PPP/PCP	Code=Configure-request, ID=1 LocIP=0.0.0.0 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0000B7908571
	32	0ms (14:44:7.40035)	80	----	----	PPP/PCP	Code=Configure-reject, ID=1 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0050FCE3F085
	33	0ms (14:44:8.39035)	80	----	----	PPP/PCP	Code=Configure-ack, ID=1 LocIP=10.0.0.1	0000B7908571
	34	0ms (14:44:9.38035)	80	----	----	PPP/PCP	Code=Configure-request, ID=2 LocIP=0.0.0.0	0000B7908571
	35	0ms (14:44:10.37035)	80	----	----	PPP/PCP	Code=Configure-req, ID=2 LocIP=168.219.137.18	0050FCE3F085
	36	0ms (14:44:11.36035)	80	----	----	PPP/PCP	Code=Configure-request, ID=3 LocIP=168.219.137.18	0000B7908571
	37	0ms (14:44:12.35035)	80	----	----	PPP/PCP	Code=Configure-ack, ID=3 LocIP=168.219.137.18	0050FCE3F085
	38	10.000s (14:44:23.34...)	80	----	----	PPP/LCP	Code=EchoReq ID=1	0050FCE3F085
	39	0ms (14:44:24.33035)	80	----	----	PPP/LCP	Code=EchoReply ID=1	0000B7908571
	40	10.000s (14:44:35.32...)	80	----	----	PPP/LCP	Code=EchoReq ID=1	0000B7908571

```

MAC
- Destination Address(00-D0-B7-90-85-71) ← Source Address(00-50-FC-E3-F0-85)
Ether Type = 0x8864
PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
- Version(4bits) = 1
- Type(4bits) = 1
- Code = 0
SESSION ID = 1
Length = 12
PPP Protocol ID = 0x0021 -> Internet Protocol Control Protocol(IPCP)
IPCP-Internet Protocol Control Protocol (RFC1332/RFC1877)
Code = Configure-Nak (0x0002)
Identifier = 0x02
Length = 10
IPCP Data = IP Address
- Type = IP Address (3)
- (1)Length = 6
Desired local address = 168.219.137.18
    
```

클라이언트는 다시 Local IP를 요청하고 그에 대한 응답으로 168.219.137.18을 할당받는다.

Client의 Local IP Request 및 Server의 Confirm IPCP 과정

Page	No.	Date/Capture Time	Length	Src IP	Dst IP/Port	Protocol	Summary	Src MAC
11-107	29	0ms (14:44:4.43035)	80	----	----	PPPCHAP	Code=Success, ID=1	0050FCE3F066
	30	0ms (14:44:5.42035)	80	----	----	PPPMP	Code=Configure-request, ID=1 LocP=10.0.0.1	0050FCE3F066
	31	0ms (14:44:6.41035)	80	----	----	PPPMP	Code=Configure-request, ID=1 LocP=0.0.0.1 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0000B7909571
	32	0ms (14:44:7.40035)	90	----	----	PPPMP	Code=Configure-reject, ID=1 1stDNS=0.0.0.0 2ndDNS=0.0.0.0	0050FCE3F066
	33	0ms (14:44:8.39035)	80	----	----	PPPMP	Code=Configure-ack, ID=1 LocP=10.0.0.1	0000B7909571
	34	0ms (14:44:9.38035)	80	----	----	PPPMP	Code=Configure-request, ID=2 LocP=0.0.0.0	0000B7909571
	35	0ms (14:44:10.37035)	80	----	----	PPPMP	Code=Configure-nak, ID=2 LocP=168.219.137.18	0050FCE3F066
	36	0ms (14:44:11.36035)	90	----	----	PPPMP	Code=Configure-request, ID=3 LocP=168.219.137.18	0000B7909571
	37	0ms (14:44:12.35035)	80	----	----	PPPMP	Code=Configure-ack, ID=3 LocP=168.219.137.18	0050FCE3F066
	38	10.000s (14:44:23.34...)	80	----	----	PPPMP	Code=EchoReq ID=1	0050FCE3F066
	39	0ms (14:44:24.33035)	80	----	----	PPPMP	Code=EchoReply ID=1	0000B7909571
	40	10.000s (14:44:35.32...)	80	----	----	PPPMP	Code=EchoReq ID=1	0000B7909571

```

MAC
  Destination Address(00-50-FC-E3-FD-66) ← Source Address(00-00-B7-90-85-71)
  Ether Type = 0x8664
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 12
  PPP Protocol ID = 0x0021 → Internet Protocol Control Protocol(IPCP)
  IPCP-Internet Protocol Control Protocol (RFC1332/RFC1877)
    Code = Configure-Request (0x01)
    Identifier = 0x03
    Length = 10
  IPCP Data = IP Address
    Type = IP Address (3)
    [1] Length = 5
    Desired local address = 10.0.0.1
  
```

서버로부터 할당받은 Local IP 주소가 맞으며 사용해도 되는지를 다시 확인한다.

ECHO Request and Reply

LCP 과정

Page	No.	Date/Capture Time	Length	Src IP	Dst IP/Port	Protocol	Summary	Src MAC
11-107	34	0ms (14:44:9.38035)	80	----	----	PPPMP	Code=Configure-request, ID=2 LocP=0.0.0.0	0000B7909571
	35	0ms (14:44:10.37035)	80	----	----	PPPMP	Code=Configure-nak, ID=2 LocP=168.219.137.18	0050FCE3F066
	36	0ms (14:44:11.36035)	80	----	----	PPPMP	Code=Configure-request, ID=3 LocP=168.219.137.18	0000B7909571
	37	0ms (14:44:12.35035)	80	----	----	PPPMP	Code=Configure-ack, ID=3 LocP=168.219.137.18	0050FCE3F066
	38	10.000s (14:44:23.34...)	80	----	----	PPPMP	Code=EchoReq ID=1	0050FCE3F066
	39	0ms (14:44:24.33035)	80	----	----	PPPMP	Code=EchoReply ID=1	0000B7909571
	40	10.000s (14:44:35.32...)	80	----	----	PPPMP	Code=EchoReq ID=1	0000B7909571
	41	0ms (14:44:36.31035)	80	----	----	PPPMP	Code=EchoReply ID=2	0050FCE3F066
	42	0ms (14:44:37.30035)	80	----	----	PPPMP	Code=EchoReply ID=1	0050FCE3F066
	43	0ms (14:44:38.29035)	80	----	----	PPPMP	Code=EchoReply ID=2	0000B7909571
	44	1.422s (14:44:40.284...)	80	----	----	PPPMP	Code=TerminateReq ID=2	0000B7909571
	45	0ms (14:44:41.27457)	80	----	----	PPPMP	Code=TerminateAck ID=2	0050FCE3F066
	46	159ms (14:44:42.26...)	100	----	----	PPPOEDISCV	Terminate(PADT) sessionId=0x0001 HostLink=03140000 Generic-Error AC	0000B7909571

```

MAC
  Destination Address(00-00-B7-90-85-71) ← Source Address(00-50-FC-E3-FD-66)
  Ether Type = 0x8664
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 10
  PPP Protocol ID = 0x0021 → Link Control Protocol(LCP)
  LCP-Link Control Protocol
    Code = Echo-request (0x00)
    Identifier = 0x00
    Length = 8
    Echo Data (4 bytes) = 9B EA 43 F5
  
```

PPP 세션이 설정되면 Echo Request와 Reply를 주기적으로 보냄으로써 세션이 살아있음을 알리게 된다.

Terminate Request and Reply

LCP 과정

Page	No.	Delta/CaptureTime	Length	SrcIP	DstIP	Protocol	Summary	SrcMAC
107	34	0ms (14.44.0.30035)	60	----	----	PPPoECP	Code=Configure-request, ID=2 LocP=0.0.0.0	0000B7908571
	35	0ms (14.44.10.37035)	60	----	----	PPPoECP	Code=Configure-nak, ID=2 LocP=193.219.137.18	0050FCE3F065
	36	0ms (14.44.11.36035)	60	----	----	PPPoECP	Code=Configure-request, ID=3 LocP=168.219.137.18	0000B7908571
	37	0ms (14.44.12.35035)	60	----	----	PPPoECP	Code=Configure-ack, ID=3 LocP=168.219.137.18	0050FCE3F065
	38	10.000s (14.44.23.34...)	60	----	----	PPPoELCP	Code=EchoReq ID=1	0050FCE3F065
	39	0ms (14.44.24.33035)	60	----	----	PPPoELCP	Code=EchoReply ID=1	0000B7908571
	40	10.000s (14.44.35.32...)	60	----	----	PPPoELCP	Code=EchoReq ID=1	0000B7908571
	41	0ms (14.44.36.31035)	60	----	----	PPPoELCP	Code=EchoReply ID=2	0050FCE3F065
	42	0ms (14.44.37.30035)	60	----	----	PPPoELCP	Code=EchoReply ID=1	0050FCE3F065
	43	0ms (14.44.38.29035)	60	----	----	PPPoELCP	Code=EchoReply ID=2	0000B7908571
	44	1.422s (14.44.40.284...)	60	----	----	PPPoELCP	Code=TerminateReq ID=2	0000B7908571
	45	0ms (14.44.41.27457)	60	----	----	PPPoELCP	Code=TerminateAck ID=2	0050FCE3F065
	46	-159ms (14.44.42.26...)	100	----	----	PPPoEDISCV	Terminate(PADT) sessionId=0x0001 HostUniq=B3140000 Generic-Error AC...	0000B7908571

```

MAC
  Destination Address(00-50-FC-E3-F0-65) ← Source Address(00-D0-B7-90-85-71)
  Ether Type = 0x8864
  PPPoE-PPP over Ethernet(RFC2516) - PPP Session Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = 0
    SESSION ID = 1
    Length = 18
  PPP Protocol-ID = 0xc021 → Link Control Protocol(LCP)
  LCP-Link Control Protocol
    Code = Terminate-request (0x05)
    Identifier = 0x02
    Length = 16
    Data (12 bytes) = 55 T3 65 72 20 72 65 71 75 65 73 74
  
```

사용자가 PPP 세션을 종료하고자 하면 Terminate Request를 보내게 되고 그에 대한 ACK를 통해 세션이 종료된다. 세션의 종료는 중요한 과정이므로 클라이언트와 서버 사이에서 특수한 데이터를 사용하게 된다.

PADT (PAD Terminate)

PPPoE Discovery 과정

Page	No.	Delta/CaptureTime	Length	SrcIP	DstIP	Protocol	Summary	SrcMAC
107	40	10.000s (14.44.35.32...)	60	----	----	PPPoELCP	Code=EchoReq ID=1	0000B7908571
	41	0ms (14.44.36.31035)	60	----	----	PPPoELCP	Code=EchoReply ID=2	0050FCE3F065
	42	0ms (14.44.37.30035)	60	----	----	PPPoELCP	Code=EchoReply ID=1	0050FCE3F065
	43	0ms (14.44.38.29035)	60	----	----	PPPoELCP	Code=EchoReply ID=2	0000B7908571
	44	1.422s (14.44.40.284...)	60	----	----	PPPoELCP	Code=TerminateReq ID=2	0000B7908571
	45	0ms (14.44.41.27457)	60	----	----	PPPoELCP	Code=TerminateAck ID=2	0050FCE3F065
	46	-159ms (14.44.42.26...)	100	----	----	PPPoEDISCV	Terminate(PADT) sessionId=0x0001 HostUniq=B3140000 Generic-Error AC...	0000B7908571
	47	202ms (14.44.43.25...)	60	----	----	PPPoEDISCV	Terminate(PADT) sessionId=0x0001 Generic-Error	0050FCE3F065
	48	7.719s (14.44.51.252...)	60	----	----	PPPoEDISCV	Initiation(PADO) sessionId=0x0000 ServiceName= HostUniq=F1140000	0000B7908571
	49	-241ms (14.44.52.23...)	63	----	----	PPPoEDISCV	Offer(PADO) sessionId=0x0000 AC-Name=ACT ServiceName= AC-Cookie=...	0050FCE3F065
	50	0ms (14.44.53.22967)	63	----	----	PPPoEDISCV	Offer(PADO) sessionId=0x0000 AC-Name=ACT ServiceName= AC-Cookie=7...	0050FCE3F065

```

MAC
  Destination Address(00-50-FC-E3-F0-65) ← Source Address(00-D0-B7-90-85-71)
  Ether Type = 0x8863
  PPPoE-PPP over Ethernet(RFC2516) - Discovery Stage
    Version(4bits) = 1
    Type(4bits) = 1
    Code = PPPoE Active Discovery Terminate(PADT) (0x04)
    Session ID = 1
    Payload Length = 63
  Host-Uniq Tag
    Type = Host-Uniq (0x0103)
    Value Length = 4
    Value = B3 14 00 00
  Generic-Error Tag
    Type = Generic-Error (0x0209)
    Value Length = 47
    Value = 52 50 20 50 50 50 6F 45 3A 20 53 79 73 74 65 6D 20 63 61 6C 6C 20 65 72 72 9F 72 3A 20 49 6E 70 75 74 2F 6F 75 74 70 75 74 20 65 72 72 9F 72
  AC-Cookie Tag
    Type = AC-Cookie (0x0104)
    Value Length = 20
    Value = 79 E8 77 2C E2 TE 86 A8 29 2F 4B 76 63 F3 9F 55 CE 11 00 00
  
```

여전히 처음의 PPPoE Discovery 과정에 사용된 값과 동일한 값을 사용하고 있다.

■ 요약 및 맺음말

■ PPPoE의 필요성

■ PPPoE의 프레임 형식

■ PPPoE Discovery 과정

■ PPPoE 실험 환경

■ PPPoE 실험 결과 및 패킷 구조



요약 및 맺음말

PPP는 클라이언트와 서버가 점대점(Point-to-Point)로 연결되는 환경에서 사용자 인증 및 동적 주소 할당과 같은 목적을 위해 개발된 프로토콜이다. 사용자 인증을 통해 과금은 물론, 사용자에게 따라 서비스에 대한 액세스 제어를 함으로써 차등화된 서비스를 제공할 수도 있다.

PPP는 LCP, PAP/CHAP, IPCP와 같은 세 개의 과정으로 구성된다. LCP 과정에서는 최대 프레임 크기 및 인증 방식을 결정하며, PAP/CHAP 과정에서는 인증 과정이 수행된다. IPCP 과정에서는 Local IP, DNS, NetBios Name Server와 같은 Network Layer 설정값을 서버로부터 할당받게 된다.

PPPoE는 Ethernet 환경에서 PPP를 사용하도록 한 것으로, LAN 환경에서 사용자의 내부/외부 네트워크 접속 권한 및 서비스 액세스를 제어할 수 있도록 해 준다. PPP 서버의 MAC 주소를 찾는 PPPoE Discovery 과정을 거친후, LCP, PAP/CHAP, IPCP의 과정을 거치게 된다. LAN 환경에서는 사용자 Password가 암호화되는 CHAP를 사용하는 것이 더욱 바람직하다.



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