



Principle and Configuration of HDLC and PPP



Foreword

- Serial has in recent years been slowly phased out in many parts of all networks in favor of Ethernet technology, however still remains active as a legacy technology in a great number of enterprise networks alongside Ethernet. Serial has traditionally provided solutions for communication over long distances and therefore remains a prominent technology for Wide Area Network (WAN) communication, for which many protocols and legacy WAN technologies remain in operation at the enterprise edge. A thorough knowledge of these technologies is required to support many aspects of WAN operation.

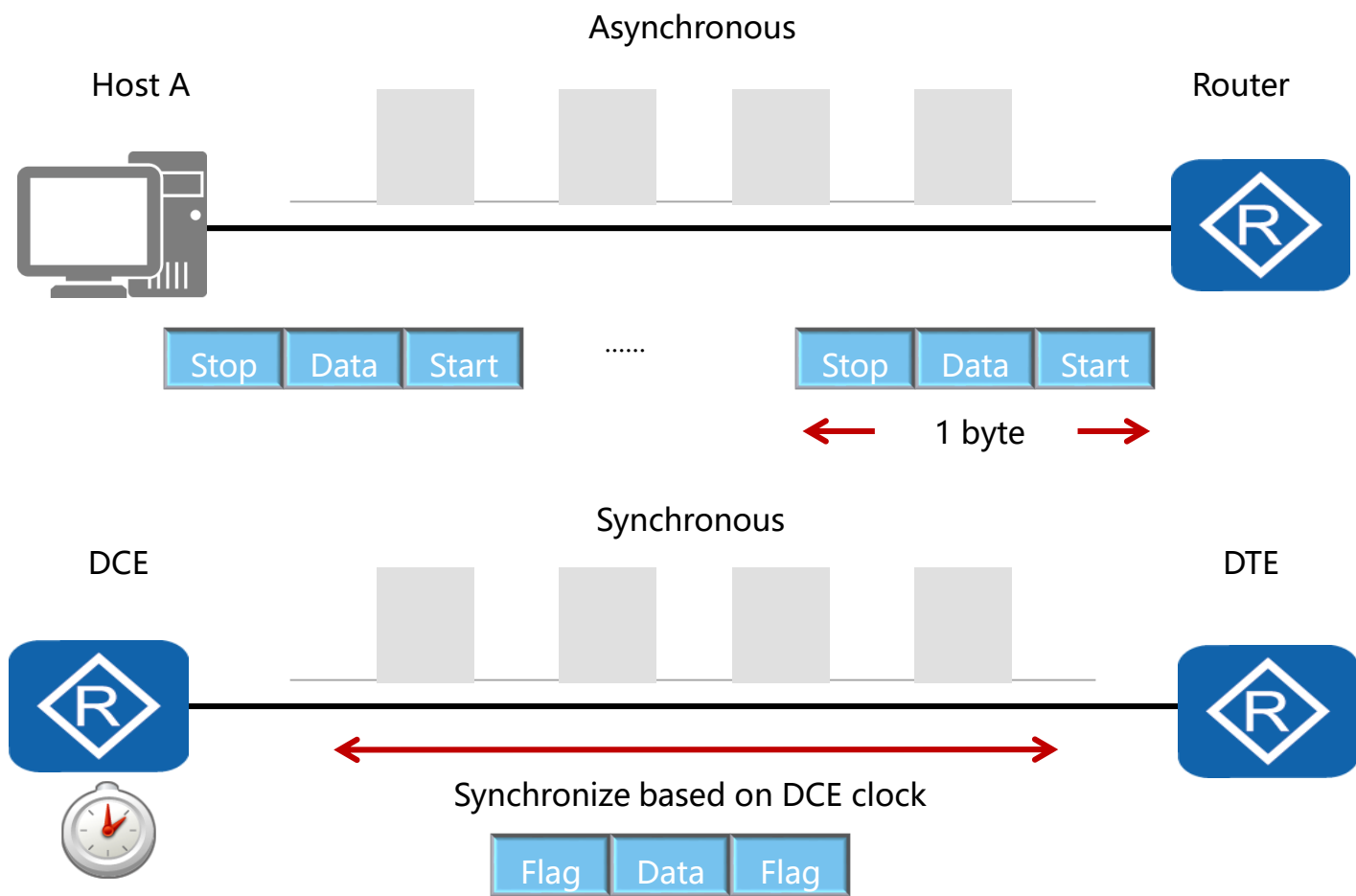


Objectives

- Upon completion of this section, you will be able to:
 - Explain how data is carried over a serial based medium.
 - Configure link layer protocols for serial links.



Serial Signaling





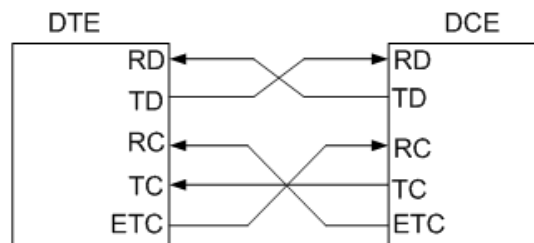
Serial Signaling – Interfacce Seriali

- Le interfacce seriali sincrone possono lavorare come:
 - DTE – data terminal equipment
 - DCE – data circuit-terminating equipment
- Sono di solito associate a protocolli di livello data-link come:
 - PPP
 - HDLC
 - FR (frame relay)
- Sono associate a protocolli di rete come:
 - IP
 - IPV6



Serial Signaling – Interfacce Seriali

La configurazione sul simulatore è MOLTO LIMITATA.



Parametri supportati:

- Physical-mode sync –abilita l' interfaccia in modo sincrono;
- Baudrate – default 64kbps, imposta la velocità di trasferimento (DCE);

Template:

Interface Serial x/y/z

link-protocol <hdlc | ppp | fr>

mtu <mtu_size>

Physical-mode <sync | async >

baudrate <baudrate>



Serial Signaling – Interfacce Seriali

```
<Huawei>dis int ser 2/0/0
Serial2/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2017-07-14 13:12:45 UTC-08:00
Description:HUAWEI, AR Series, Serial2/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 192.168.1.2/24
Link layer protocol is PPP
LCP opened, IPCP opened
Last physical up time   : 2017-07-14 13:12:43 UTC-08:00
Last physical down time : 2017-07-14 13:12:21 UTC-08:00
Current system time: 2017-07-14 13:33:59-08:00
Physical layer is synchronous, Virtualbaudrate is 64000 bps
Interface is DTE, Cable type is V11, Clock mode is TC
Last 300 seconds input rate 6 bytes/sec 48 bits/sec 0 packets/sec
Last 300 seconds output rate 2 bytes/sec 16 bits/sec 0 packets/sec

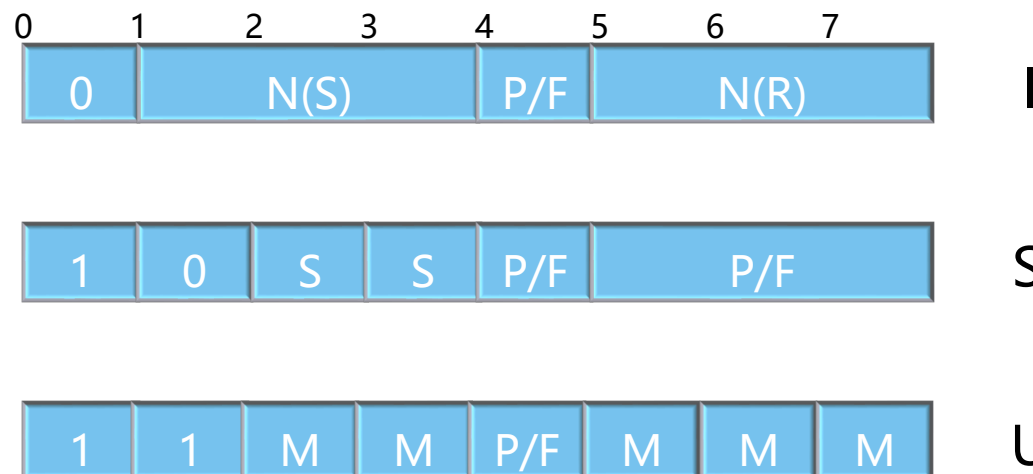
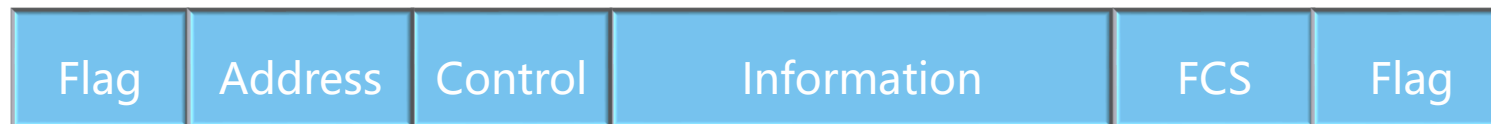
Input: 321 packets, 10326 bytes
  Broadcast:           0,  Multicast:           0
  Errors:              0,  Runt:                 0
  Giants:              0,  CRC:                  0

  Alignments:          0,  Overruns:             0
  Dribbles:            0,  Aborts:               0
  No Buffers:          0,  Frame Error:          0

Output: 321 packets, 3910 bytes
  Total Error:         0,  Overruns:             0
  Collisions:          0,  Deferred:         0
    Input bandwidth utilization :    0%
    Output bandwidth utilization :    0%
```



The HDLC Protocol



- Only the information frame (I) format is used on AR2200 series.



Basic Configuration of HDLC



```
[RTA]interface Serial 1/0/0
```

```
[RTA-Serial1/0/0]link-protocol hdlc
```

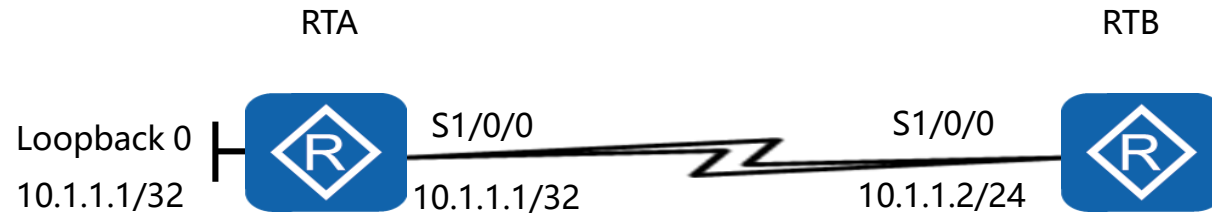
Warning: The encapsulation protocol of the link will be changed.

Continue? [Y/N]:y

```
[RTA-Serial1/0/0]ip address 10.0.1.1 30
```



Assigning Unnumbered Addresses in HDLC



```
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed.
Continue? [Y/N]:y
[RTA-Serial1/0/0]ip address unnumbered interface loopBack 0
```

- IP addresses can be borrowed from another interface in order to establish connectivity over the serial link.



HDLC – Static Route 1 /24

Attenzione alla assegnazione degli IP sulle loopback0.



Su R1 e R2

ip route-static 192.168.1.0 24 serial 2/0/0 -> NO

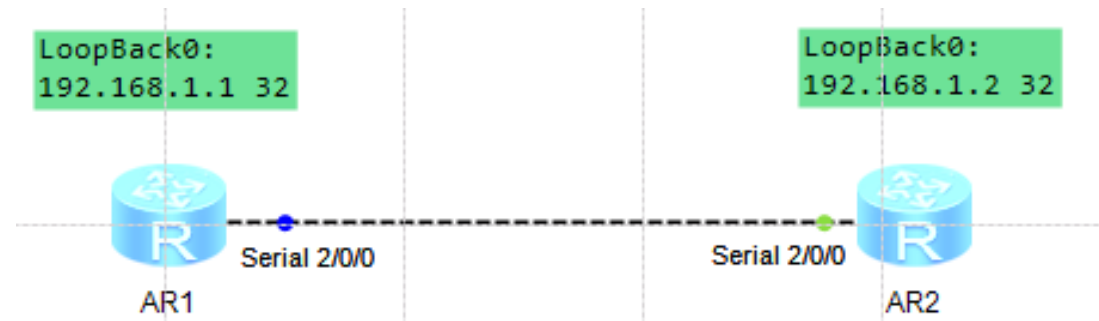
R1: ip route-static 192.168.1.2 32 Serial 2/0/0

R2: ip route-static 192.168.1.1 32 Serial 2/0/0 -> OK



HDLC – Dynamic Route 1

Attenzione alla assegnazione degli IP sulle loopback0.



R1 – R2

ospf 1 router-id x.x.x.x

area 0

network 192.168.1.0 0.0.0.255 -> OK

network 192.168.1.x 0.0.0.0 -> OK



Configuration Validation

```
[RTA]display ip interface brief
*down: administratively down ^down: standby (l): loopback
(s): spoofing
.....
Interface                IP Address/Mask      Physical    Protocol
LoopBack0                10.1.1.1/32          up          up(s)
Serial1/0/0              10.1.1.1/32          up          up
Serial1/0/1              unassigned            up          down
```

- The IP address is shown to have been borrowed from the loopback interface and assigned to interface serial 1/0/0.



Basic Configuration of HDLC

→	22	102.313000	192.168.1.2	192.168.1.1	I
←	23	102.313000	192.168.1.1	192.168.1.2	I
	24	102.797000	192.168.1.2	192.168.1.1	I
	25	102.813000	192.168.1.1	192.168.1.2	I
	26	103.297000	192.168.1.2	192.168.1.1	I
	27	103.313000	192.168.1.1	192.168.1.2	I
	28	103.360000	N/A	N/A	S

> Frame 22: 88 bytes on wire (704 bits), 88 bytes captured (704 bits) on interface 0

▼ Cisco HDLC

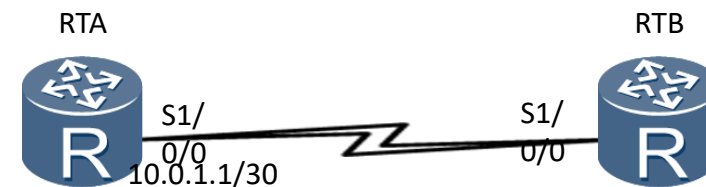
Address: Unicast (0x0f)

Control: 0x00

Protocol: IP (0x0800)

> Internet Protocol Version 4, Src: 192.168.1.2, Dst: 192.168.1.1

> Internet Control Message Protocol



→	22	102.313000	192.168.1.2	192.168.1.1	ICMP
←	23	102.313000	192.168.1.1	192.168.1.2	ICMP
	24	102.797000	192.168.1.2	192.168.1.1	ICMP
	25	102.813000	192.168.1.1	192.168.1.2	ICMP
	26	103.297000	192.168.1.2	192.168.1.1	ICMP
	27	103.313000	192.168.1.1	192.168.1.2	ICMP
	28	103.360000	N/A	N/A	SLARP

> Frame 23: 88 bytes on wire (704 bits), 88 bytes captured (704 bits) on interface 0

▼ Cisco HDLC

Address: Unicast (0x0f)

Control: 0x00

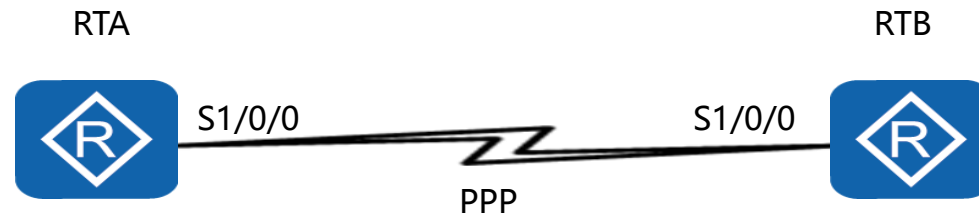
Protocol: IP (0x0800)

> Internet Protocol Version 4, Src: 192.168.1.1, Dst: 192.168.1.2

> Internet Control Message Protocol



PPP Protocol Application



- A multiprotocol standard used as with HDLC to define the link layer operation over a serial medium.



Components of PPP

Name	Function
PPP Encapsulation Method	Defines the format to be used when supporting encapsulation of upper layer protocols such as IP, IPX etc.
Link Control Protocol	Defines the method of establishing, configuring, and testing the data-link connection.
Network Control Protocol	Defines a set of protocols for establishing a connection and negotiating parameters for different network-layer protocols.

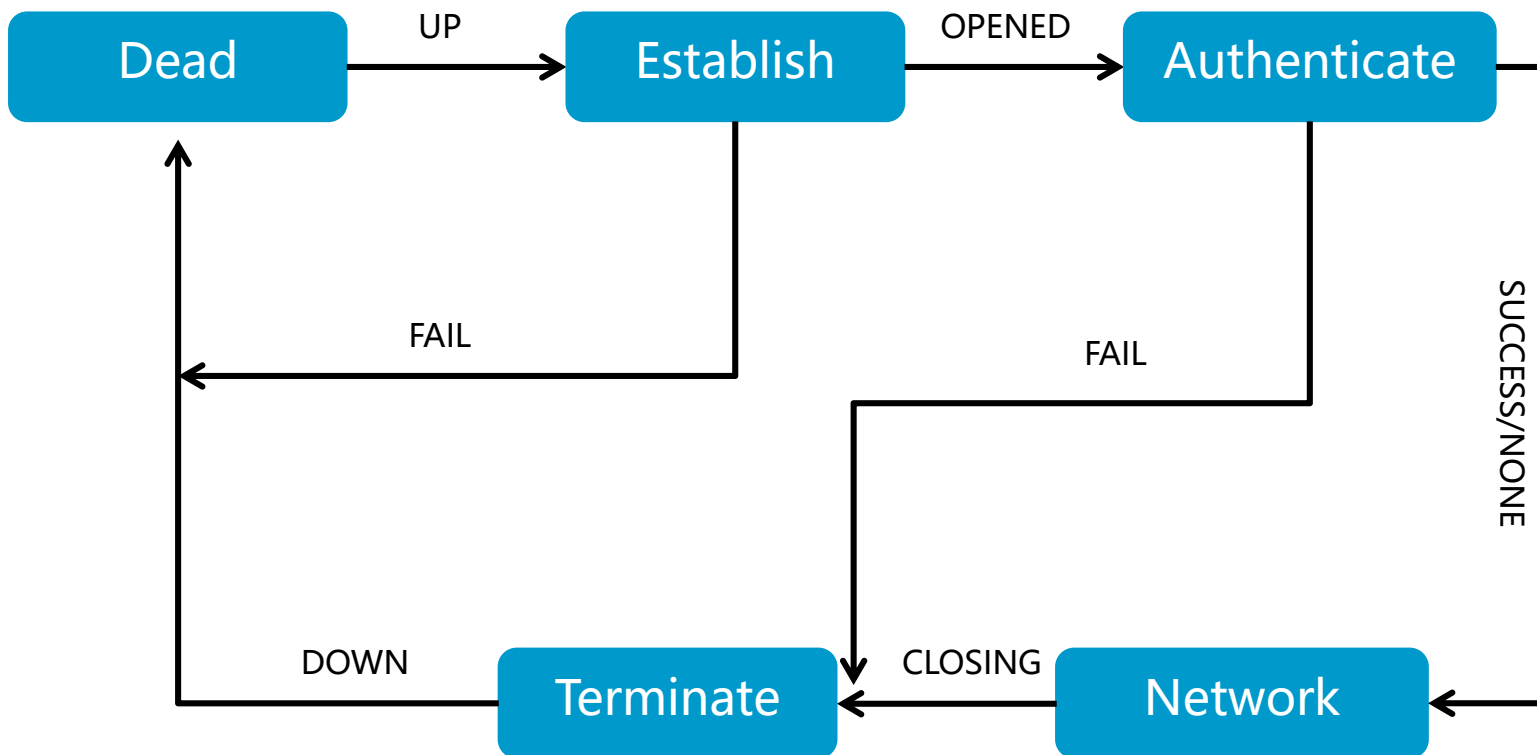


PPP Protocol Application

- LCP (Link Control Protocol) si occupa di:
 - Stabilire il link;
 - Verificare i parametri di connessione
(incapsulamento, MRU, loop-detection, errori di configurazione)
 - Mantenere il link
- Protocollo versatile in grado di supportare diversi payload L3 grazie ad NCP (Network Control Protocol)
 - IPCP – IPXCP



PPP Link Establishment Process





PPP Link Establishment Process - LCP

N/A	N/A	PPP LCP	18 Configuration Request
N/A	N/A	PPP LCP	18 Configuration Request
N/A	N/A	PPP LCP	18 Configuration Ack
N/A	N/A	PPP LCP	18 Configuration Ack
N/A	N/A	PPP IPCP	14 Configuration Request
N/A	N/A	PPP IPCP	14 Configuration Request
N/A	N/A	PPP IPCP	14 Configuration Ack
N/A	N/A	PPP IPCP	14 Configuration Ack
N/A	N/A	PPP LCP	12 Echo Request
N/A	N/A	PPP LCP	12 Echo Reply
N/A	N/A	PPP LCP	12 Echo Request
N/A	N/A	PPP LCP	12 Echo Reply

> Frame 17: 18 bytes on wire (144 bits), 18 bytes captured (144 bits) on interface 0

▼ Point-to-Point Protocol

Address: 0xff

Control: 0x03

Protocol: Link Control Protocol (0xc021)

▼ PPP Link Control Protocol

Code: Configuration Request (1)

Identifier: 1 (0x01)

Length: 14

▼ Options: (10 bytes), Maximum Receive Unit, Magic Number

▼ Maximum Receive Unit: 1500

Type: Maximum Receive Unit (1)

Length: 4

Maximum Receive Unit: 1500

▼ Magic Number: 0x327ecc06

Type: Magic Number (5)

Length: 6

Magic Number: 0x327ecc06

> Frame 18: 18 bytes on wire (144 bits), 18 bytes captured (144 bits) on interface 0

▼ Point-to-Point Protocol

Address: 0xff

Control: 0x03

Protocol: Link Control Protocol (0xc021)

▼ PPP Link Control Protocol

Code: Configuration Request (1)

Identifier: 6 (0x06)

Length: 14

▼ Options: (10 bytes), Maximum Receive Unit, Magic Number

▼ Maximum Receive Unit: 1500

Type: Maximum Receive Unit (1)

Length: 4

Maximum Receive Unit: 1500

▼ Magic Number: 0x327ee268

Type: Magic Number (5)

Length: 6

Magic Number: 0x327ee268



PPP Link Establishment Process - NCP

> Frame 21: 14 bytes on wire (112 bits), 14 bytes captured (112 bits) on interface 0

▼ Point-to-Point Protocol

Address: 0xff

Control: 0x03

Protocol: Internet Protocol Control Protocol (0x8021)

▼ PPP IP Control Protocol

Code: Configuration Request (1)

Identifier: 1 (0x01)

Length: 10

▼ Options: (6 bytes), IP address

▼ IP address: 192.168.1.1

Type: IP address (3)

Length: 6

IP Address: 192.168.1.1

> Frame 22: 14 bytes on wire (112 bits), 14 bytes captured (112 bits) on interface 0

▼ Point-to-Point Protocol

Address: 0xff

Control: 0x03

Protocol: Internet Protocol Control Protocol (0x8021)

▼ PPP IP Control Protocol

Code: Configuration Request (1)

Identifier: 1 (0x01)

Length: 10

▼ Options: (6 bytes), IP address

▼ IP address: 192.168.1.2

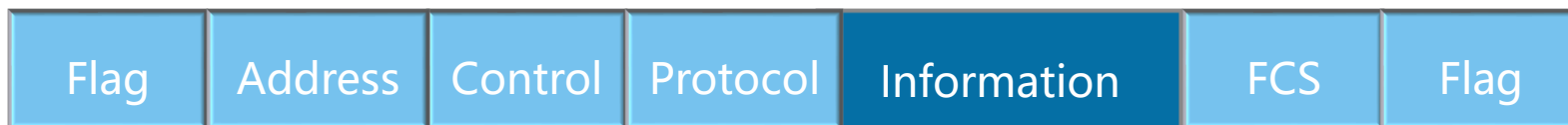
Type: IP address (3)

Length: 6

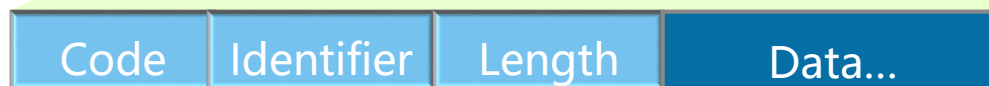
IP Address: 192.168.1.2



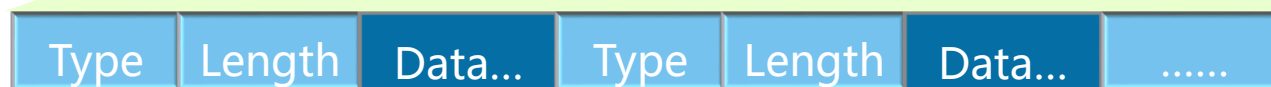
PPP Frame



LCP Packet Format

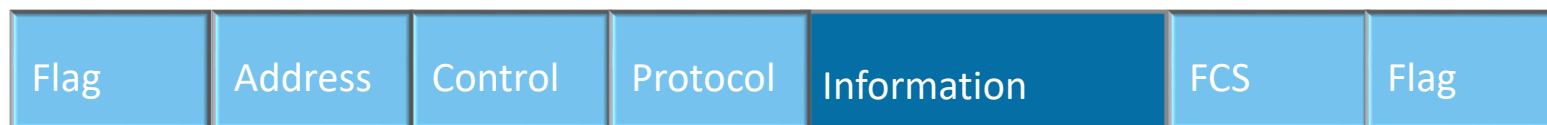


LCP Configuration Option Format





PPP Frame



LCP Packet Format



▼ Point-to-Point Protocol

Address: 0xff
Control: 0x03
Protocol: Link Control Protocol (0xc021)

▼ PPP Link Control Protocol

Code: Configuration Request (1)
Identifier: 1 (0x01)
Length: 14

▼ Options: (10 bytes), Maximum Receive Unit, Magic Number

▼ Maximum Receive Unit: 1500

Type: Maximum Receive Unit (1)
Length: 4
Maximum Receive Unit: 1500

▼ Magic Number: 0x327ecc06

Type: Magic Number (5)
Length: 6
Magic Number: 0x327ecc06





Packet Types Used in LCP Negotiation

Packet Type	Function
Configure-Request	Include the parameters for link establishment and link configuration.
Configure-Ack	Confirmation sent once all Configure-Request parameters have been validated.
Configure-Nak	The parameters included in Configure-Request are recognized but not all accepted.
Configure-Reject	The parameters included in Configure-Request from the peer are not all recognized.

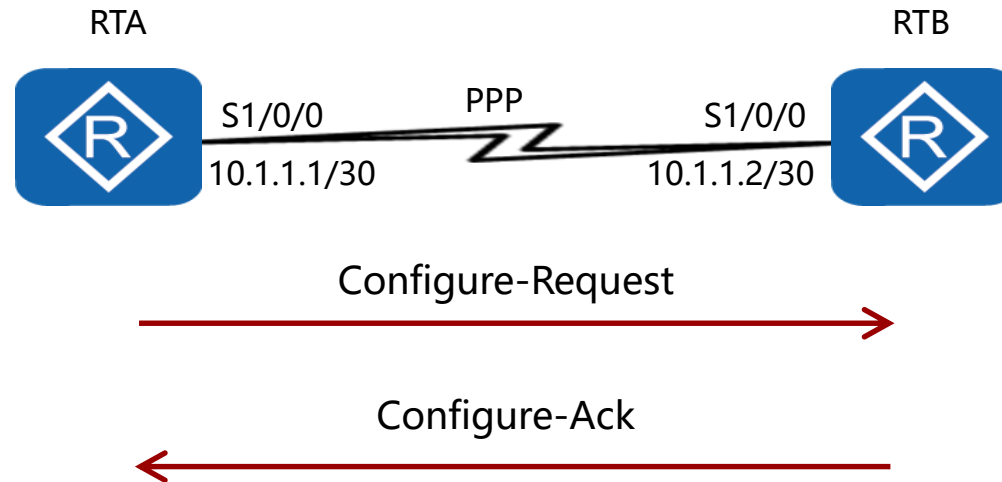


Common Link Parameters of LCP Negotiation

Parameter	Function	Default
Maximum Receive Unit	The total length of the Information and Padding field for the PPP frame.	1500
Authentication protocol	Authentication protocol used by the peer.	No Authentication
Magic-Number	Magic-Number is generated randomly, used for link loop detection.	Enable



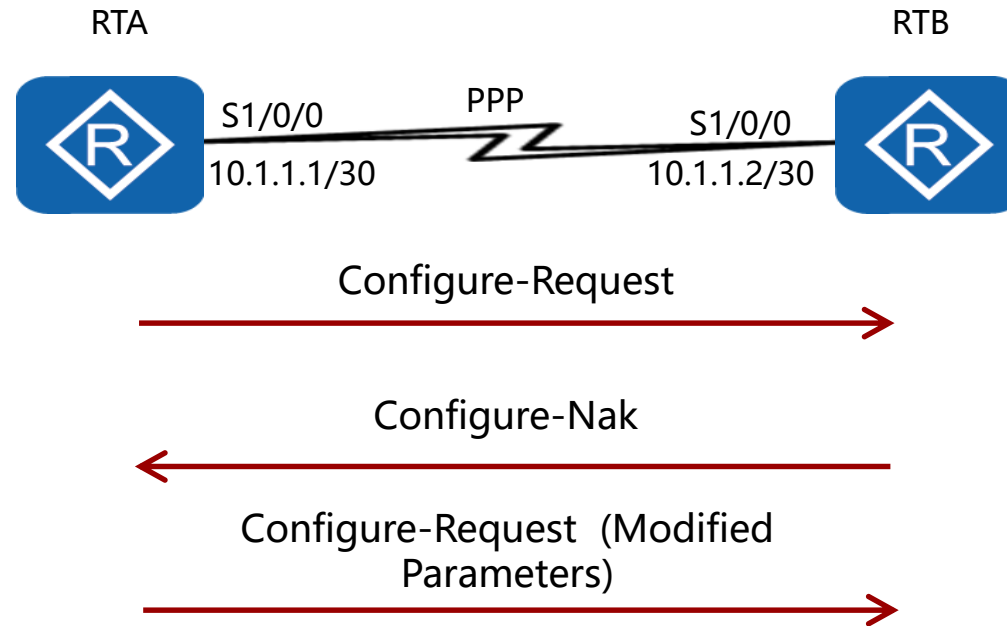
LCP Link Parameters Negotiation



- Successful PPP negotiations result in a Configure-Ack reply to a Configure-Request packet.



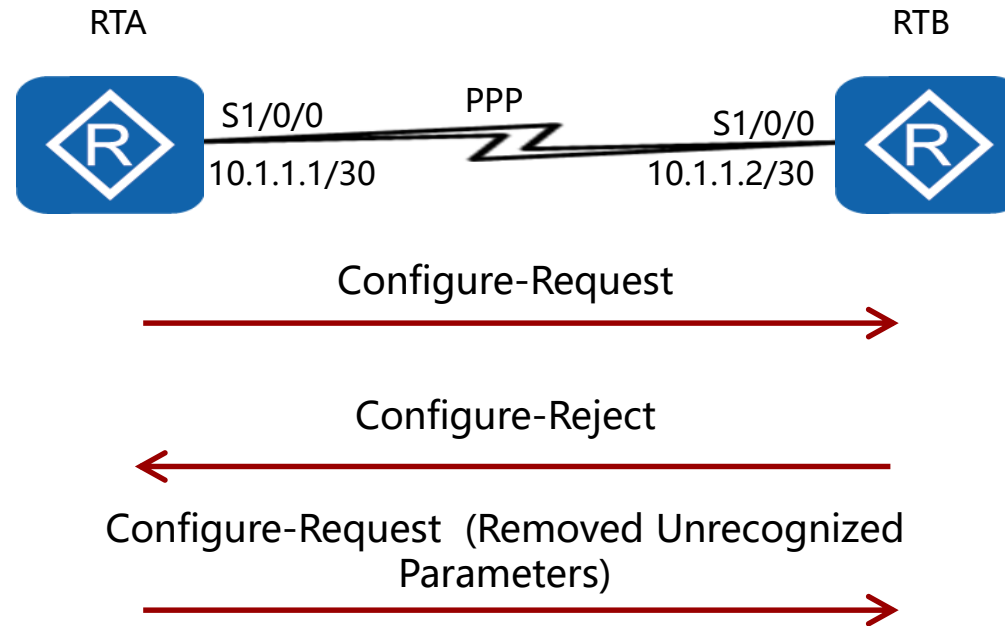
LCP Link Parameters Negotiation



- Configure-Nak packets are generated where parameters are recognized but not all are accepted.



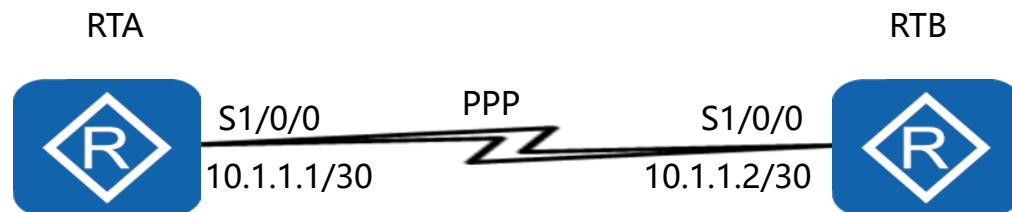
LCP Link Parameters Negotiation



- Configure-Reject packets are generated where not all parameters are recognized by the peer.



PPP Basic Configuration



```
[RTA]interface Serial 1/0/0
```

```
[RTA-Serial1/0/0]link-protocol ppp
```

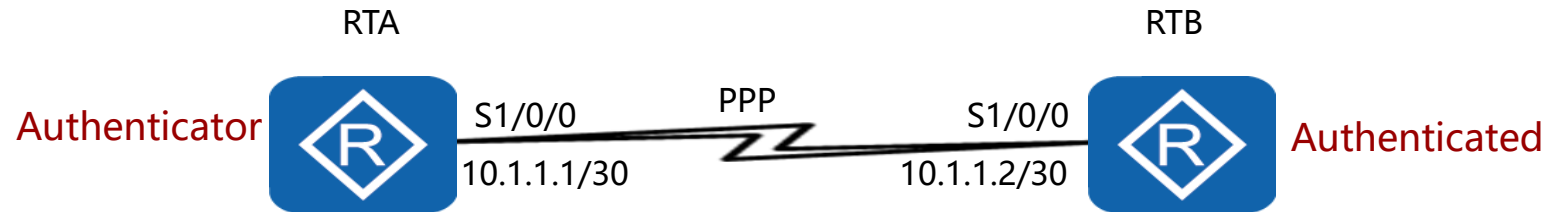
Warning: The encapsulation protocol of the link will be changed.

```
Continue? [Y/N]:y
```

```
[RTA-Serial1/0/0]ip address 10.0.1.1 30
```



PPP Authentication Mode - PAP

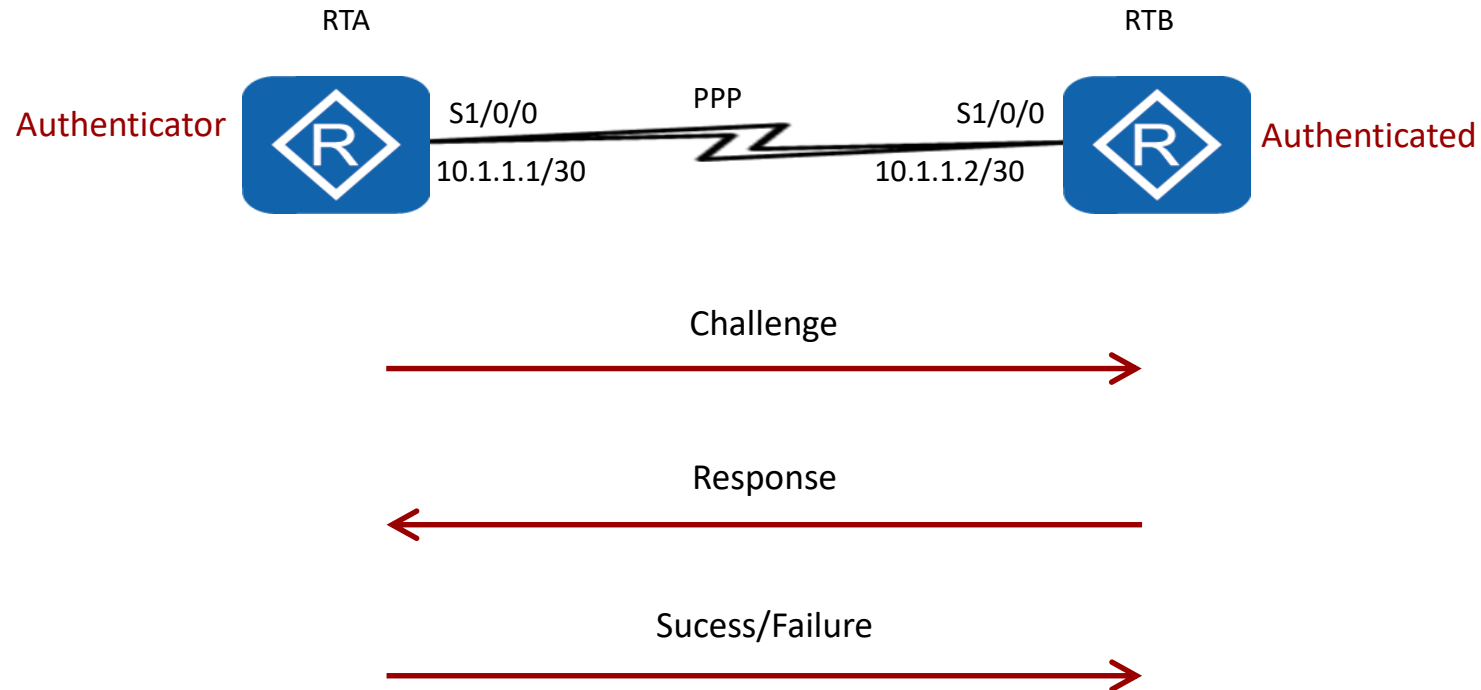


Authenticate-Request
Send user name and password in plain text
←
Authenticate-Ack/Authenticate-Nak
Authenticate successfully/ unsuccessfully
→

- The Password Authentication Protocol relies on the transmission of a password over the link for peer authentication.



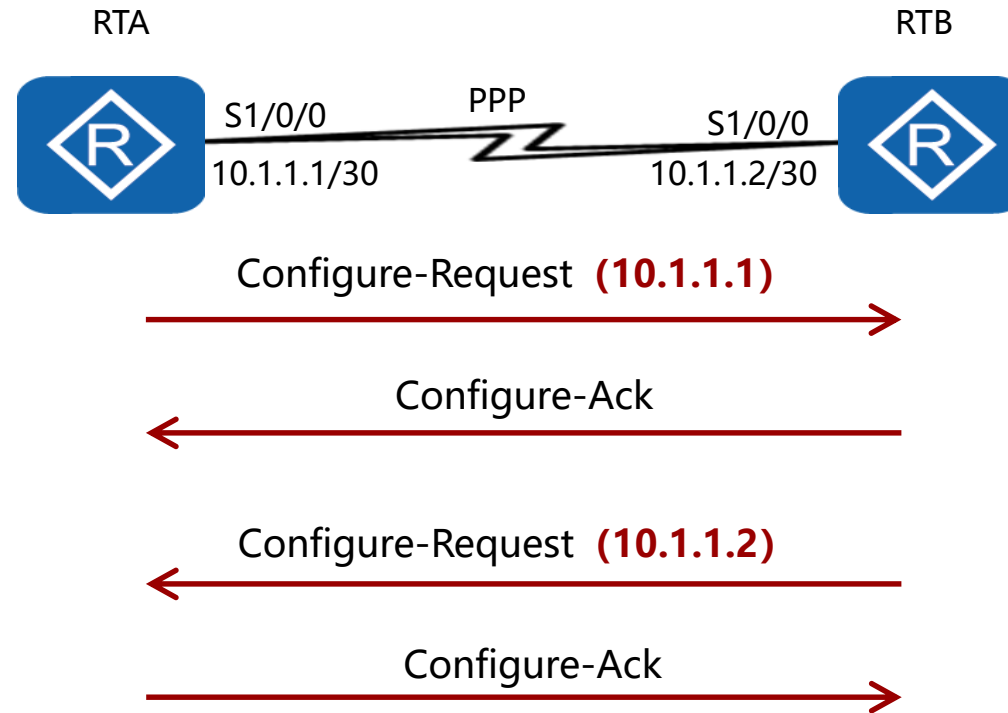
PPP Authentication Mode - CHAP



- The Challenge Handshake Authentication Protocol relies on a challenge and challenge response for peer authentication.



IPCP Static Address Negotiation



- The Internet Protocol Control Protocol (IPCP) is the Network Control Protocol (NCP) used for establishing and configuring IP.



IPCP Static Address Negotiation

Request

```
▼ PPP IP Control Protocol
  Code: Configuration Request (1)
  Identifier: 1 (0x01)
  Length: 10
  ▼ Options: (6 bytes), IP address
    ▼ IP address: 192.168.1.2
      Type: IP address (3)
      Length: 6
      IP Address: 192.168.1.2
```

```
▼ PPP IP Control Protocol
  Code: Configuration Request (1)
  Identifier: 1 (0x01)
  Length: 10
  ▼ Options: (6 bytes), IP address
    ▼ IP address: 192.168.1.1
      Type: IP address (3)
      Length: 6
      IP Address: 192.168.1.1
```

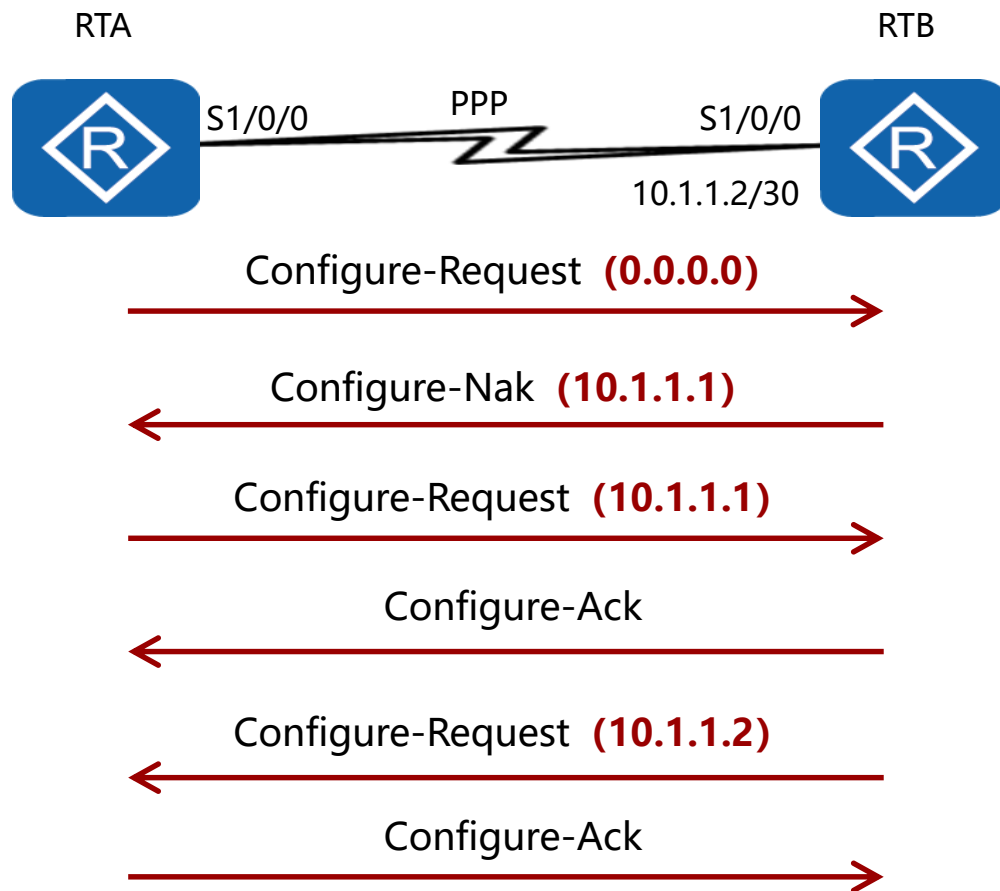
ACK

```
▼ PPP IP Control Protocol
  Code: Configuration Ack (2)
  Identifier: 1 (0x01)
  Length: 10
  ▼ Options: (6 bytes), IP address
    ▼ IP address: 192.168.1.1
      Type: IP address (3)
      Length: 6
      IP Address: 192.168.1.1
```

```
▼ PPP IP Control Protocol
  Code: Configuration Ack (2)
  Identifier: 1 (0x01)
  Length: 10
  ▼ Options: (6 bytes), IP address
    ▼ IP address: 192.168.1.2
      Type: IP address (3)
      Length: 6
      IP Address: 192.168.1.2
```




IPCP Dynamic Address Negotiation





IPCP Static Address Negotiation

```
[V200R003C00]
#
interface Serial2/0/0
 link-protocol ppp
 remote address 192.168.1.2
 ip address 192.168.1.1 255.255.255.0
#
return
[Huawei-Serial2/0/0]
```

```
[V200R003C00]
#
interface Serial2/0/0
 link-protocol ppp
 ip address ppp-negotiate
#
return
[Huawei-Serial2/0/0]
```

327	539.437000	N/A	N/A	PPP LCP	18 Configuration Request
328	542.437000	N/A	N/A	PPP LCP	18 Configuration Request
329	545.109000	N/A	N/A	PPP LCP	18 Configuration Request
330	545.109000	N/A	N/A	PPP LCP	18 Configuration Ack
331	545.437000	N/A	N/A	PPP LCP	18 Configuration Request
332	545.453000	N/A	N/A	PPP LCP	18 Configuration Ack
333	545.468000	N/A	N/A	PPP IPCP	14 Configuration Request
334	545.484000	N/A	N/A	PPP IPCP	14 Configuration Request
335	545.484000	N/A	N/A	PPP IPCP	14 Configuration Nak
336	545.484000	N/A	N/A	PPP IPCP	14 Configuration Ack
337	545.500000	N/A	N/A	PPP IPCP	14 Configuration Request
338	545.500000	N/A	N/A	PPP IPCP	14 Configuration Ack

LCP

NCP



IPCP Static Address Negotiation

Request

- ▼ PPP IP Control Protocol
 - Code: Configuration Request (1)
 - Identifier: 1 (0x01)
 - Length: 10
 - ▼ Options: (6 bytes), IP address
 - ▼ IP address: 0.0.0.0
 - Type: IP address (3)
 - Length: 6
 - IP Address: 0.0.0.0

NAK

- ▼ PPP IP Control Protocol
 - Code: Configuration Nak (3)
 - Identifier: 1 (0x01)
 - Length: 10
 - ▼ Options: (6 bytes), IP address
 - ▼ IP address: 192.168.1.2
 - Type: IP address (3)
 - Length: 6
 - IP Address: 192.168.1.2

Request

- ▼ PPP IP Control Protocol
 - Code: Configuration Request (1)
 - Identifier: 2 (0x02)
 - Length: 10
 - ▼ Options: (6 bytes), IP address
 - ▼ IP address: 192.168.1.2
 - Type: IP address (3)
 - Length: 6
 - IP Address: 192.168.1.2

- ▼ PPP IP Control Protocol
 - Code: Configuration Request (1)
 - Identifier: 1 (0x01)
 - Length: 10
 - ▼ Options: (6 bytes), IP address
 - ▼ IP address: 192.168.1.1
 - Type: IP address (3)
 - Length: 6
 - IP Address: 192.168.1.1

ACK

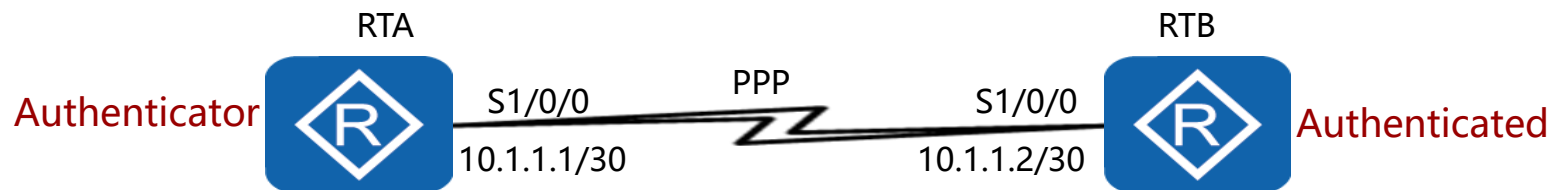
- ▼ PPP IP Control Protocol
 - Code: Configuration Ack (2)
 - Identifier: 1 (0x01)
 - Length: 10
 - ▼ Options: (6 bytes), IP address
 - ▼ IP address: 192.168.1.1
 - Type: IP address (3)
 - Length: 6
 - IP Address: 192.168.1.1

ACK

- ▼ PPP IP Control Protocol
 - Code: Configuration Ack (2)
 - Identifier: 2 (0x02)
 - Length: 10
 - ▼ Options: (6 bytes), IP address
 - ▼ IP address: 192.168.1.2
 - Type: IP address (3)
 - Length: 6
 - IP Address: 192.168.1.2



Configuring PAP Authentication



```
[RTA]aaa
[RTA-aaa]local-user huawei password cipher huawei123
[RTA-aaa]local-user huawei service-type ppp
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol ppp
[RTA-Serial1/0/0]ppp authentication-mode pap
[RTA-Serial1/0/0]ip address 10.1.1.1 30
```

```
[RTB]interface Serial 1/0/0
[RTB-Serial1/0/0]link-protocol ppp
[RTB-Serial1/0/0]ppp pap local-user huawei password cipher huawei123
[RTB-Serial1/0/0]ip address 10.1.1.2 30
```



PAP Configuration Validation

```
<RTB>debugging ppp pap all
Aug 20 2013 04:50:24.280.4+00:00 RTB PPP/7/debug2:
  PPP State Change:
    Serial1/0/0 PAP : Initial --> SendRequest
Aug 20 2013 04:50:24.290.3+00:00 RTB PPP/7/debug2:
  PPP State Change:
    Serial1/0/0 PAP : SendRequest --> ClientSuccess
.....
```



Configuring PAP Authentication

Request

▼ PPP Password Authentication Protocol

Code: Authenticate-Request (1)

Identifier: 1

Length: 21

▼ Data

Peer-ID-Length: 6

Peer-ID: huawei

Password-Length: 9

Password: huawei123

ACK

▼ PPP Password Authentication Protocol

Code: Authenticate-Ack (2)

Identifier: 1

Length: 48

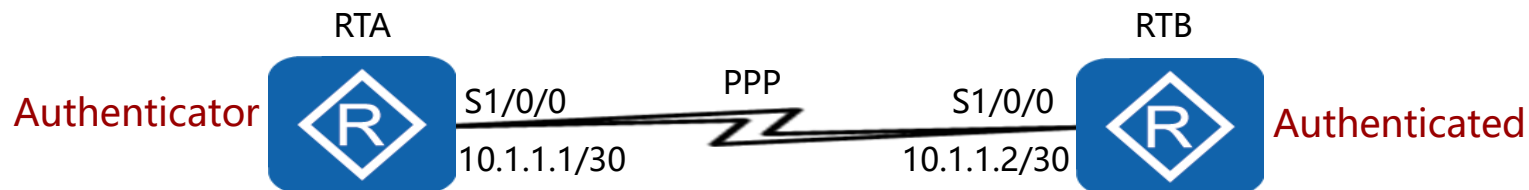
▼ Data

Message-Length: 43

Message: Welcome to use Quidway ROUTER, Huawei Tech.



Configuring CHAP Authentication



```
[RTA]aaa
[RTA-aaa]local-user huawei password cipher huawei123
[RTA-aaa]local-user huawei service-type ppp
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol ppp
[RTA-Serial1/0/0]ppp authentication-mode chap
```

```
[RTB]interface Serial 1/0/0
[RTB-Serial1/0/0]link-protocol ppp
[RTB-Serial1/0/0]ppp chap user huawei
[RTB-Serial1/0/0]ppp chap password cipher huawei123
```



CHAP Configuration Validation

```
<RTB>debugging ppp chap all
Aug 20 2013 05:15:54.230.1+00:00 RTB PPP/7/debug2:
PPP State Change:
    Serial1/0/0 CHAP : Initial --> ListenChallenge
Aug 20 2013 05:15:54.230.7+00:00 RTB PPP/7/debug2:
PPP State Change:
    Serial1/0/0 CHAP : ListenChallenge --> SendResponse
Aug 20 2013 05:15:54.250.3+00:00 RTB PPP/7/debug2:
PPP State Change:
    Serial1/0/0 CHAP : SendResponse --> ClientSuccess
.....
```




Configuring CHAP Authentication

```
PPP CHAP 25 Challenge (NAME='', VALUE=0x978daf01b614d73346550e051dba843e)
PPP CHAP 31 Response (NAME='huawei', VALUE=0x3e2a1696c844ed7a58669f390d3a934d)
PPP CHAP 20 Success (MESSAGE='Welcome to .')
```

Challenge

- ▼ Point-to-Point Protocol
 - Address: 0xff
 - Control: 0x03
 - Protocol: Challenge Handshake Authentication Protocol (0xc223)
- ▼ PPP Challenge Handshake Authentication Protocol
 - Code: Challenge (1)
 - Identifier: 1
 - Length: 21
 - ▼ Data
 - Value Size: 16
 - Value: 978daf01b614d73346550e051dba843e
- ▼ Point-to-Point Protocol
 - Address: 0xff
 - Control: 0x03
 - Protocol: Challenge Handshake Authentication Protocol (0xc223)
- ▼ PPP Challenge Handshake Authentication Protocol
 - Code: Success (3)
 - Identifier: 1
 - Length: 16
 - Message: Welcome to .

Response

- ▼ PPP Challenge Handshake Authentication Protocol
 - Code: Response (2)
 - Identifier: 1
 - Length: 27
 - ▼ Data
 - Value Size: 16
 - Value: 3e2a1696c844ed7a58669f390d3a934d
 - Name: huawei

Success



Summary

- Following a Configure-Request, what packet type is expected to be received before the PPP link layer can be successfully established?
- Which protocol is used to perform the negotiation of IP addresses, and during which phase is this negotiated?

The background of the image shows silhouettes of several groups of business professionals in a modern office environment. They are standing on a highly reflective floor, and their reflections are clearly visible. The entire scene is overlaid with a semi-transparent blue filter. In the center, the text "Thank You" is written in a large, white, sans-serif font, with the website address "www.huawei.com" in a smaller, white, sans-serif font directly below it.

Thank You

www.huawei.com