

Computer Networking : Principles, Protocols and Practice

Part 1 : Introduction

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<http://inl.info.ucl.ac.be/>

Module 1 : Basics

- Contents

- • Introduction

- Services in computer networks
 - Connectionless service
 - Connection oriented service
- Layered reference models

A network ...

- A network is ...
 - a set of hardware and software that allows to transmit information from one sender to one or more receivers
- Current networks
 - Plain Old Telephone System (POTS)
 - Mobile Telephone
 - Broadcast networks
 - television, radio
 - Computer networks
 - Internet
 - Proprietary networks

Network classification

- Based on their geographical coverage
 - 0.1-1 m : Internal bus/network
 - 10 m - 1 km : Local Area Network (LAN)
 - 1 km - 100 km : Metropolitan Area Network (MAN)
 - 100 km ->... : Wide Area Network (WAN)
 - and more ... : Satellite networks

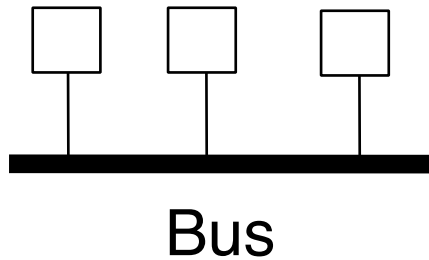
Interplanetary network

Network classification (2)

- Based on their topologies

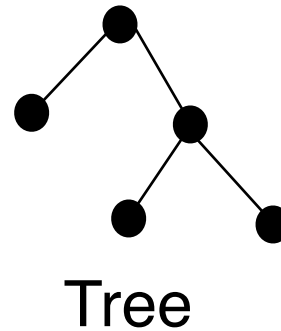
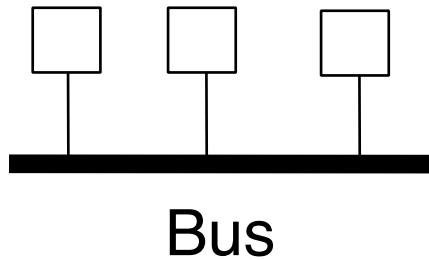
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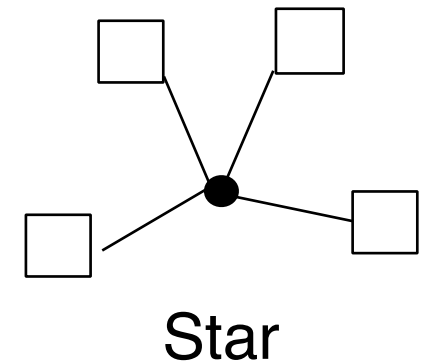
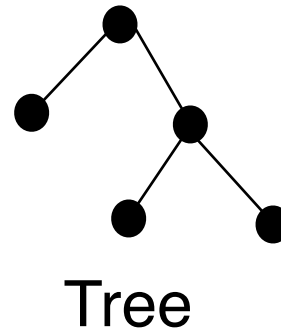
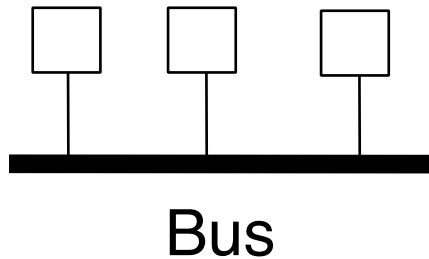
Network classification (2)

- Based on their topologies



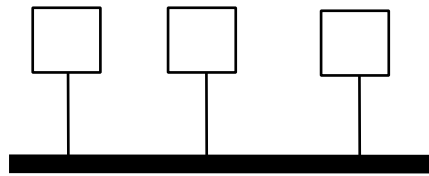
Network classification (2)

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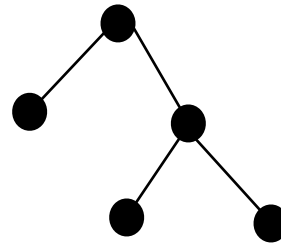


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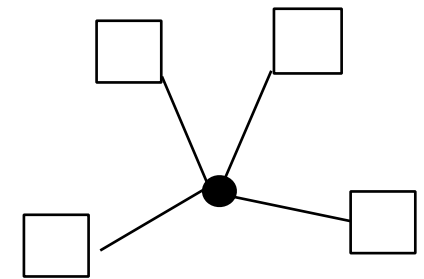
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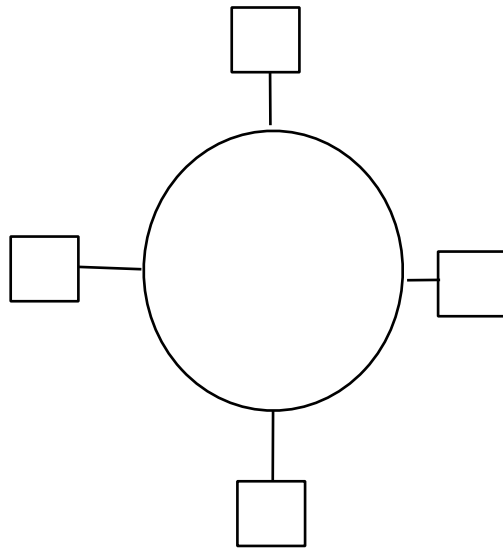
Bus



Tree



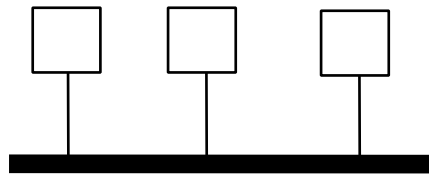
Star



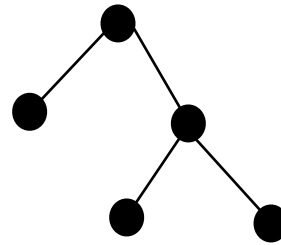
Ring

Network classification (2)

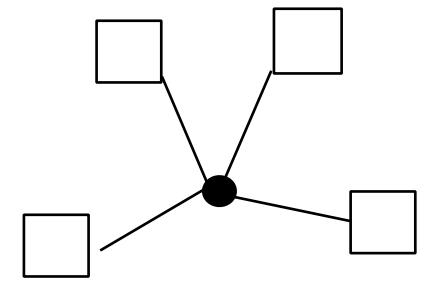
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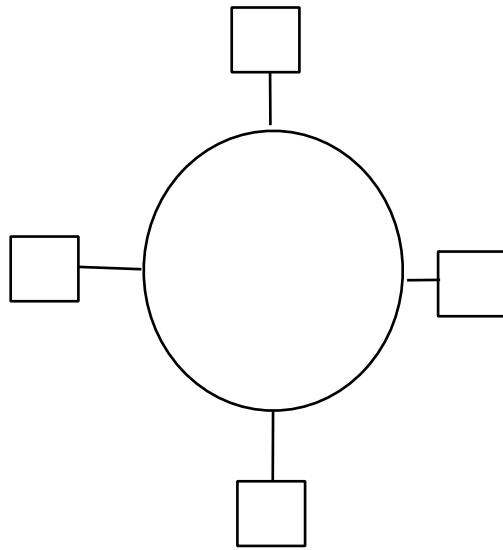
Bus



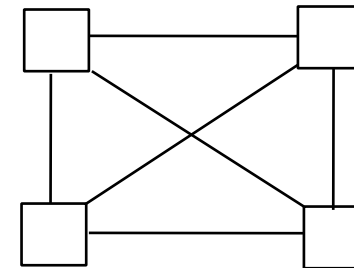
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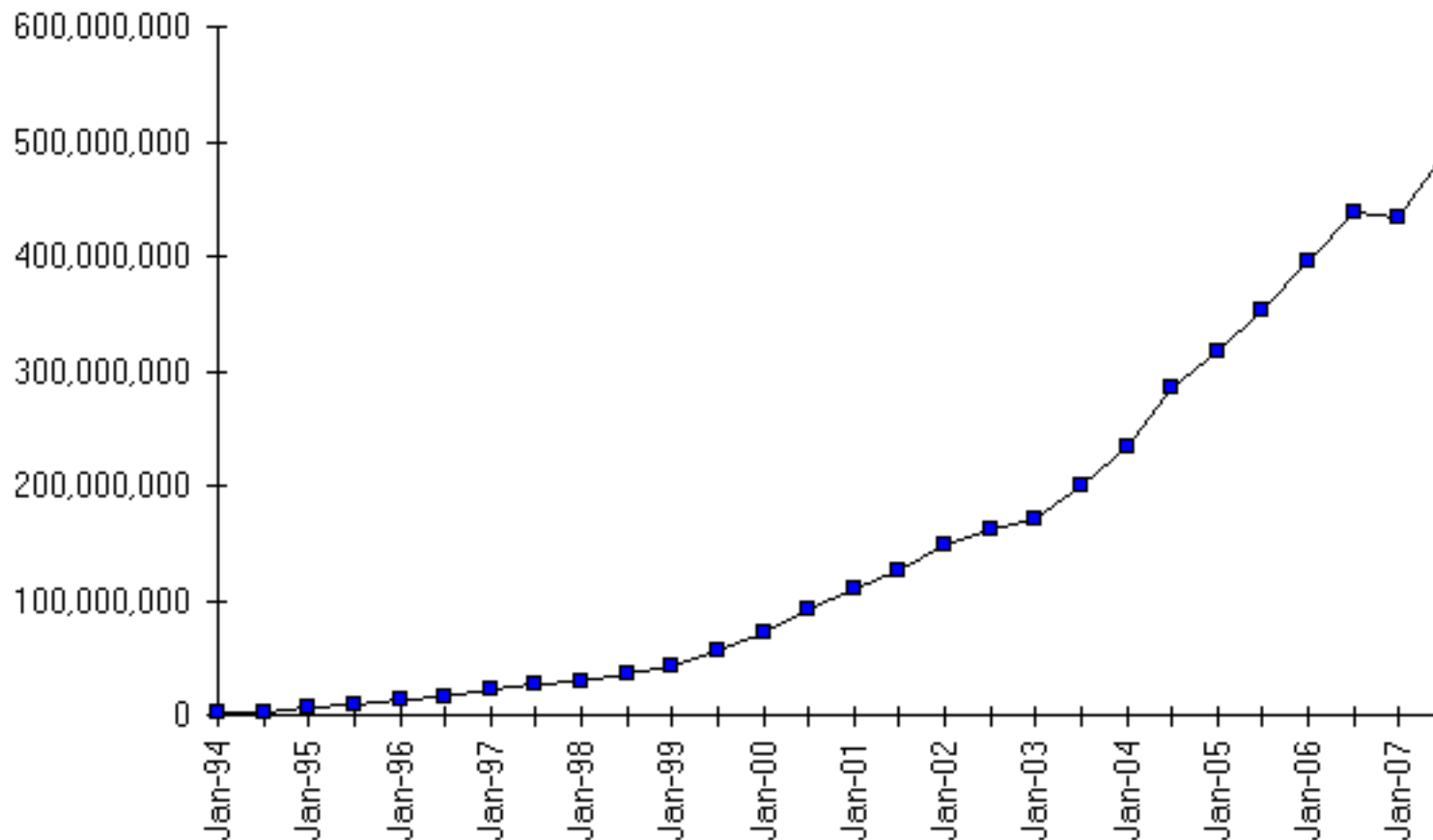
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Full-mesh

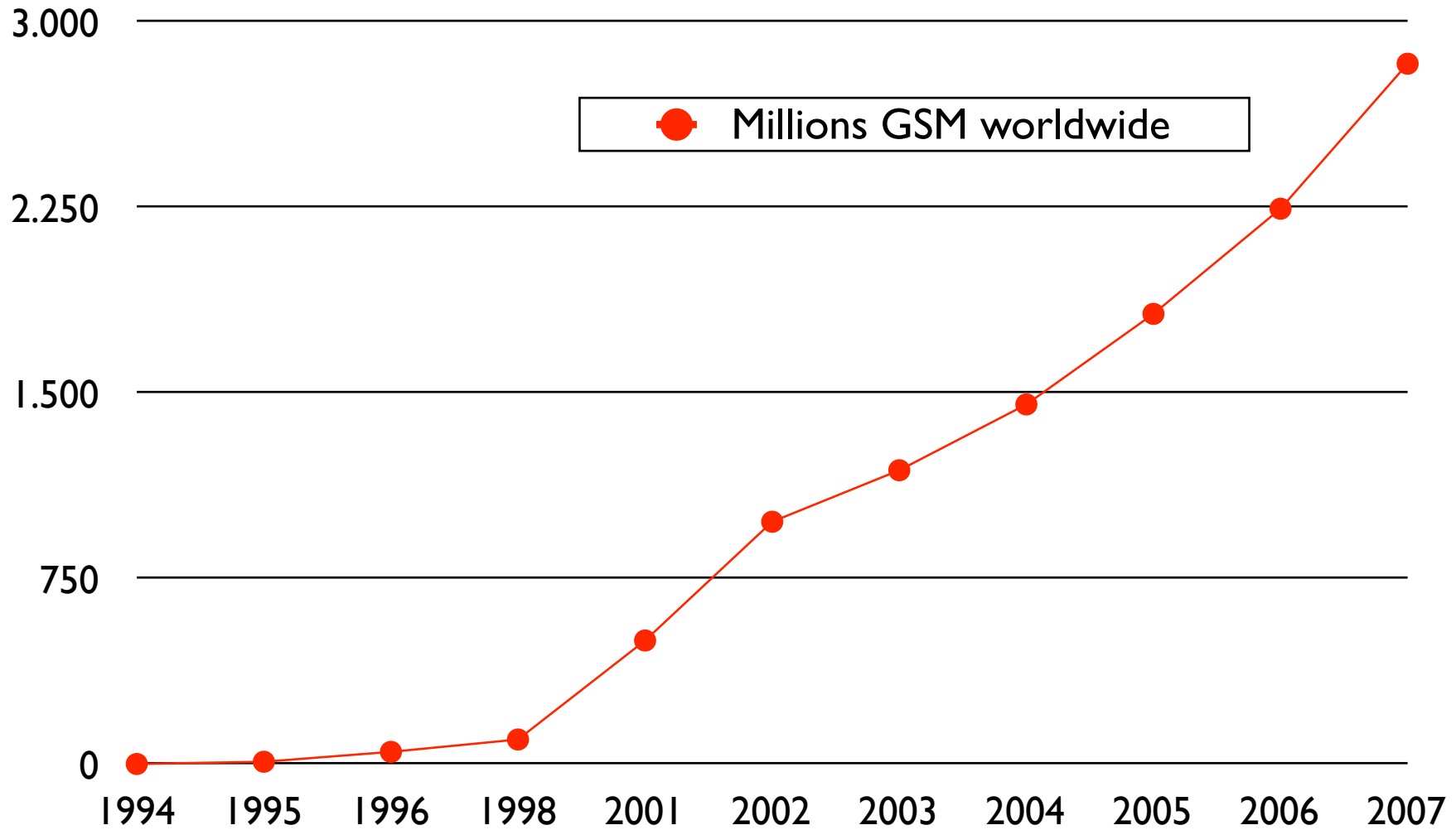
Internet growth

Internet Domain Survey Host Count

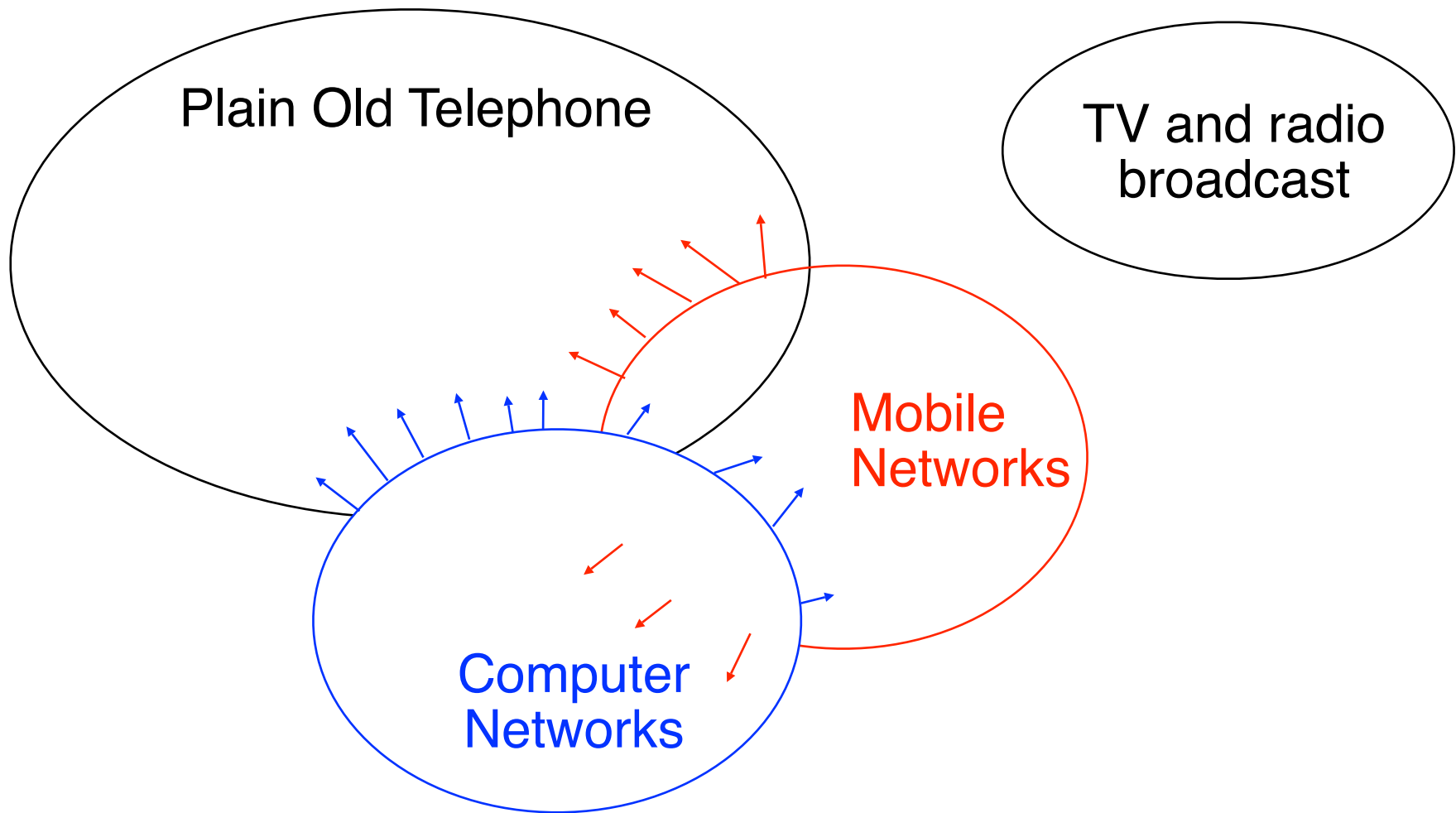


Source: Internet Systems Consortium (www.isc.org)

Mobile GSM telephone networks



Evolution of networks



The future

- Most specialists expect
 - A strong convergence between all technologies
 - Triple play
 - Quadruple play
- New services will probably be deployed first (and perhaps exclusively) on data networks
 - Television service provided by telecom operators
 - Mobile data services
 - Mobile television services
 - Voice or video over IP
 - New services

Transmission modes

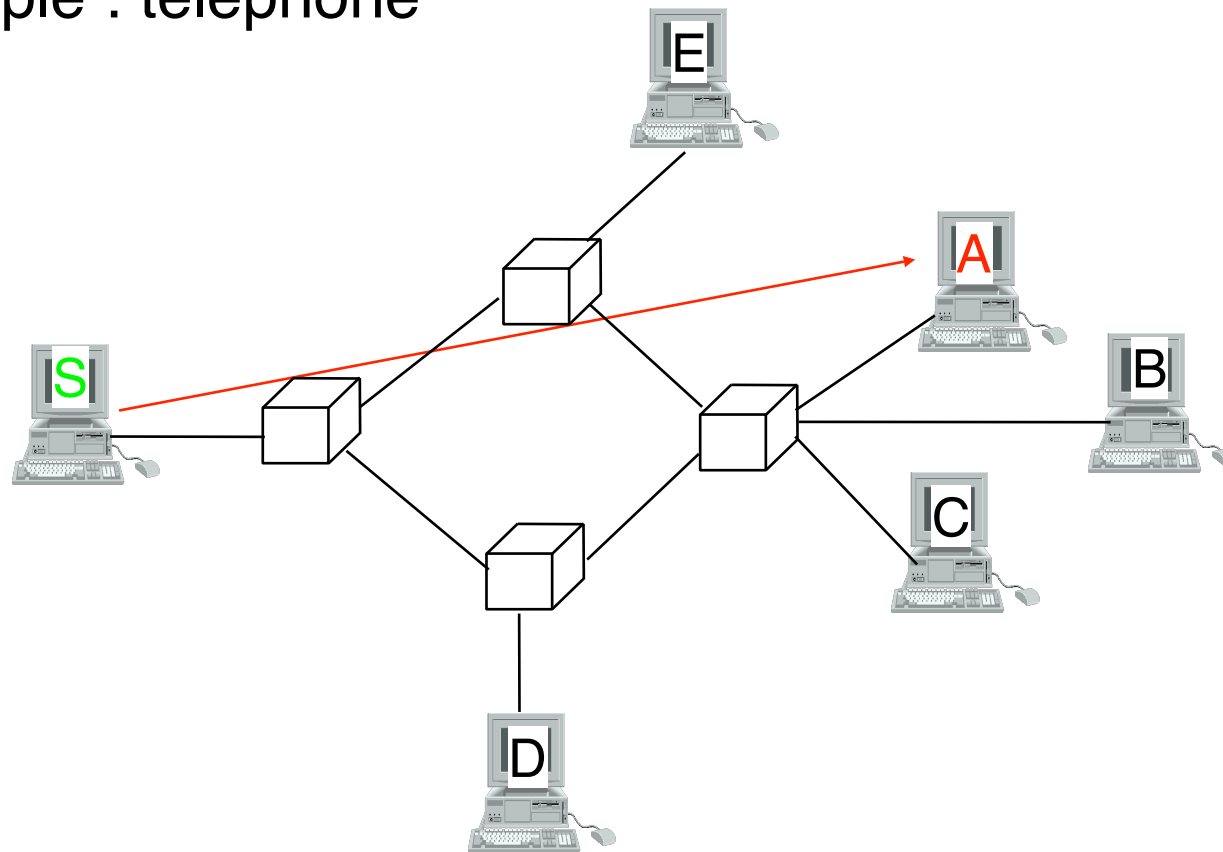
Unicast

Unicast or point-to-point

one sender

one receiver

example : telephone



Transmission modes

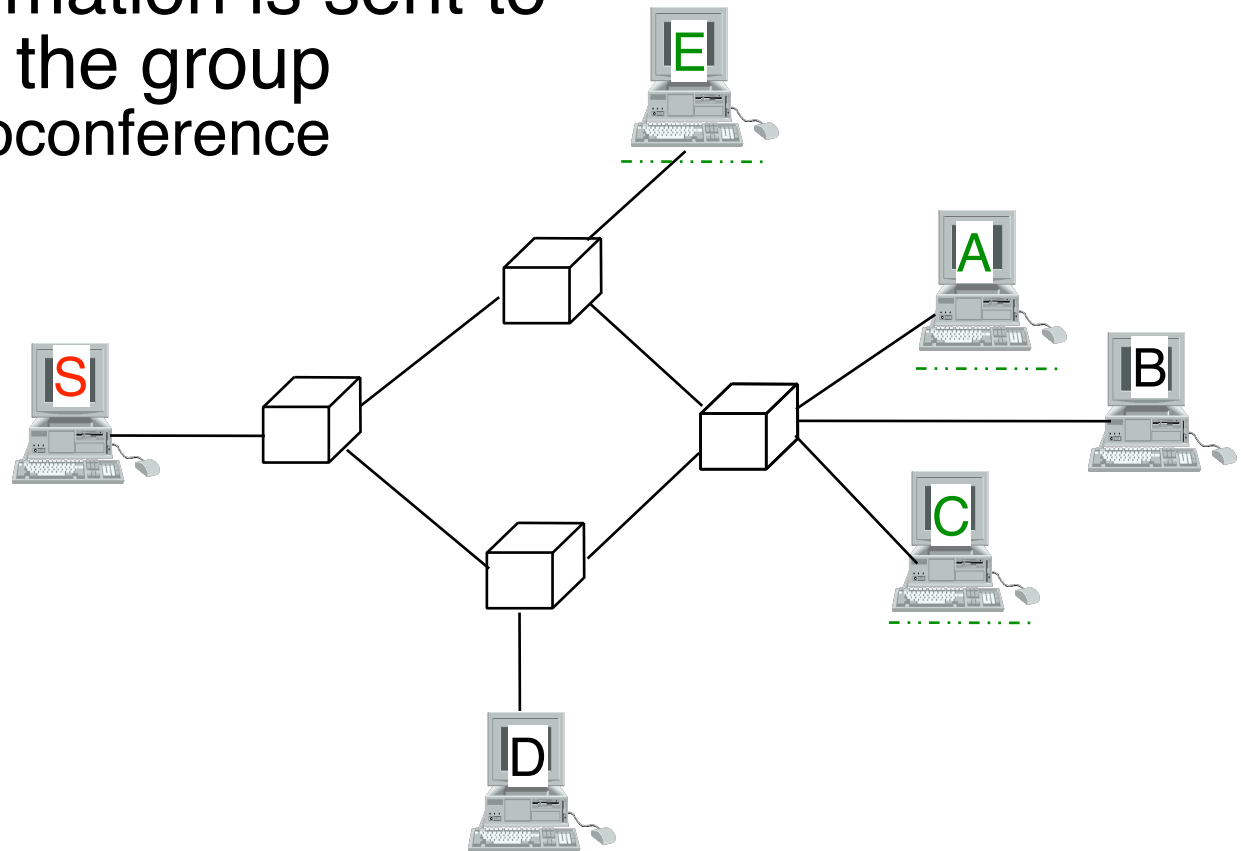
Multicast

Multicast or point-to-multipoints

one **sender**

a **group of receivers**

The same information is sent to
all members of the group
example : videoconference



Broadcast

The same information is sent to everyone

Transmission modes

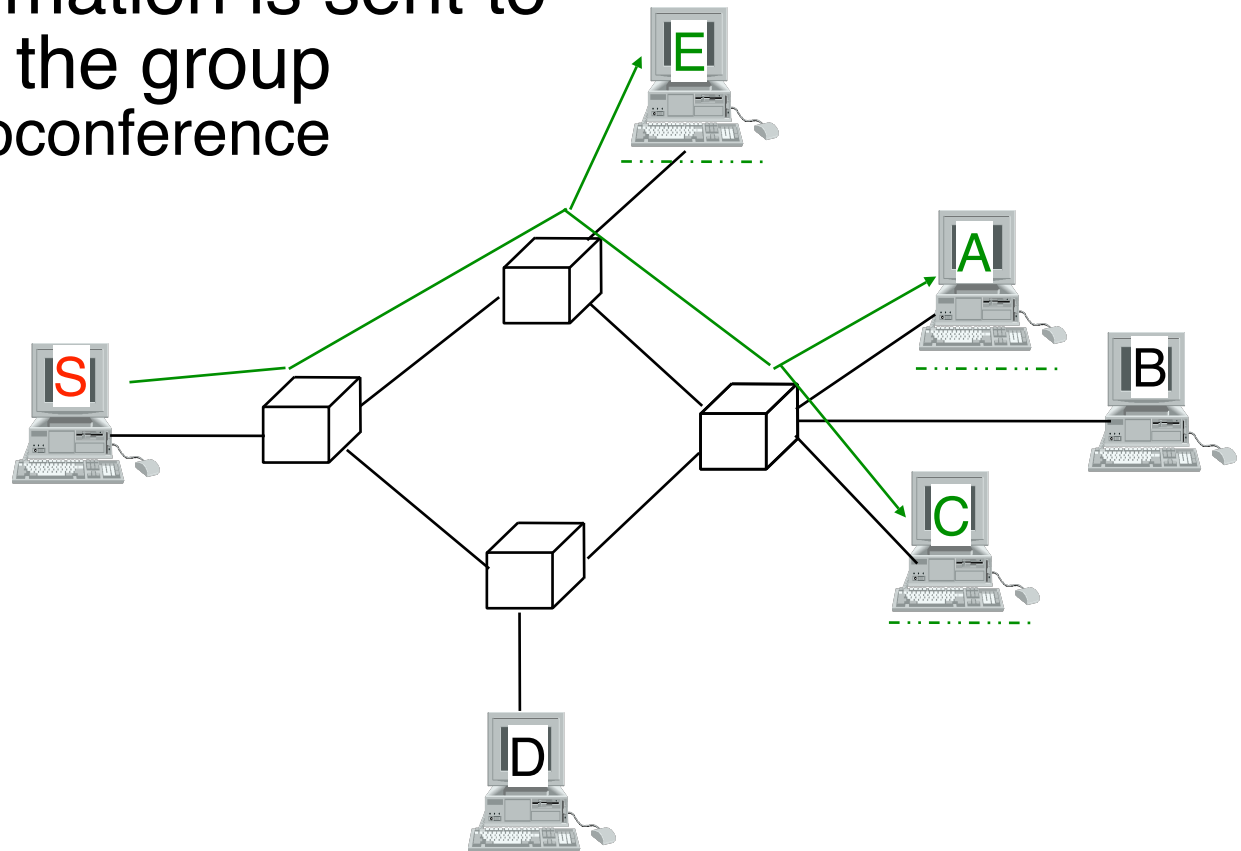
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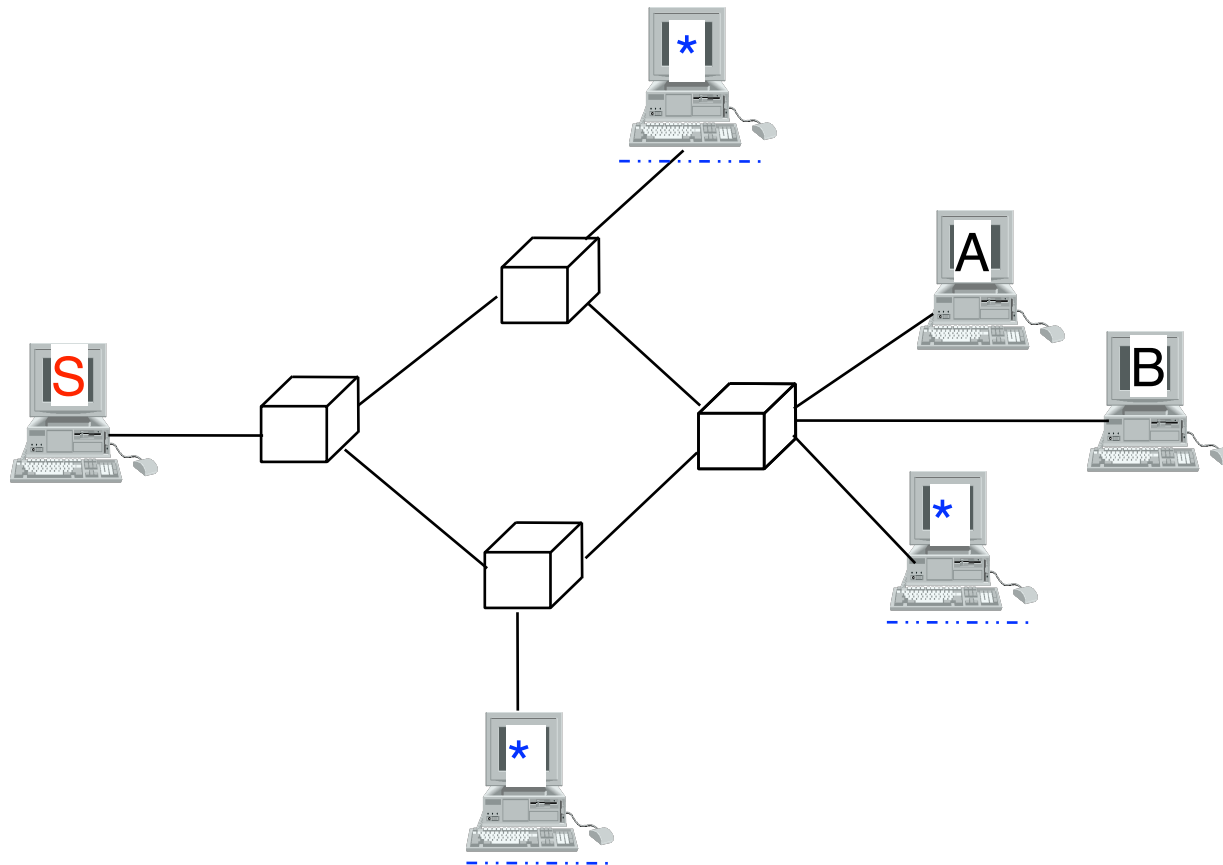
The same information is sent to everyone

Anycast

Anycast

Information is sent from **one sender** to **one receiver** among a group of possible receivers

- Example :find server hosting popular content

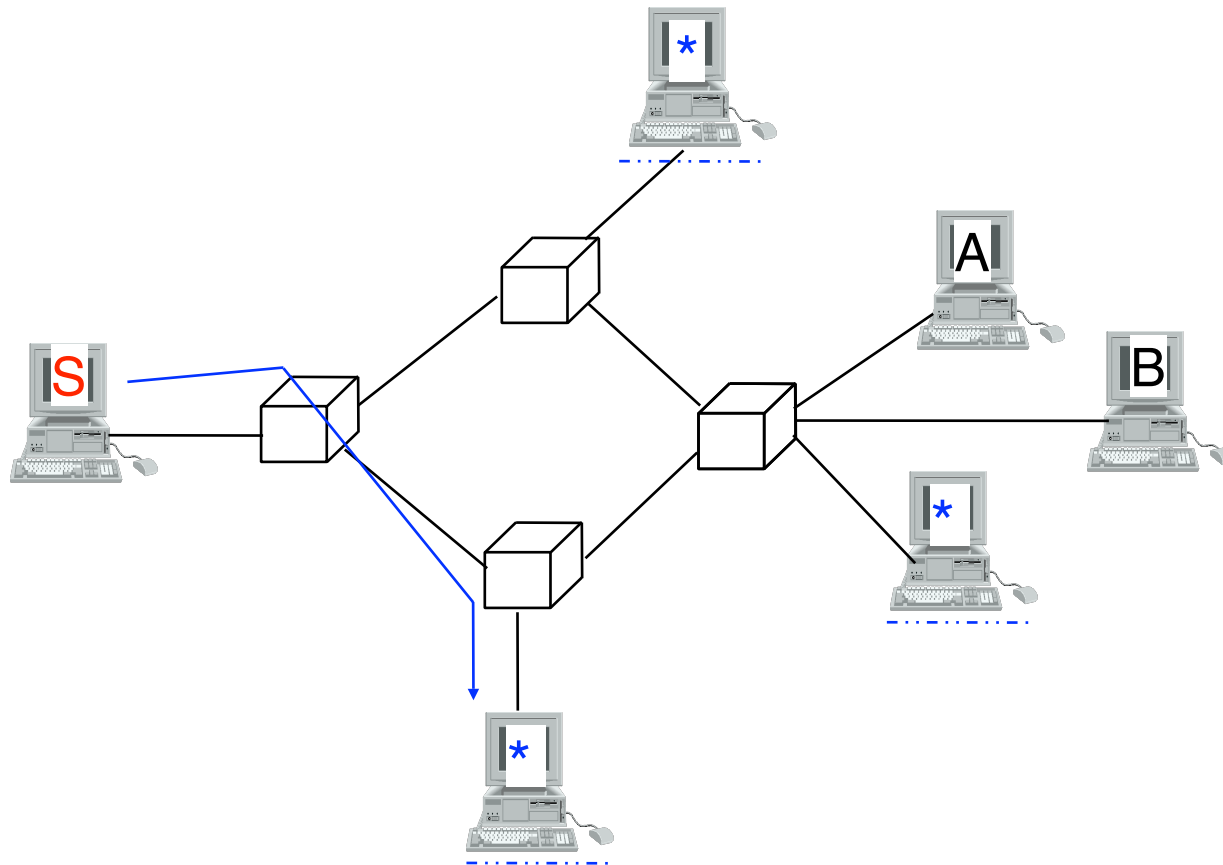


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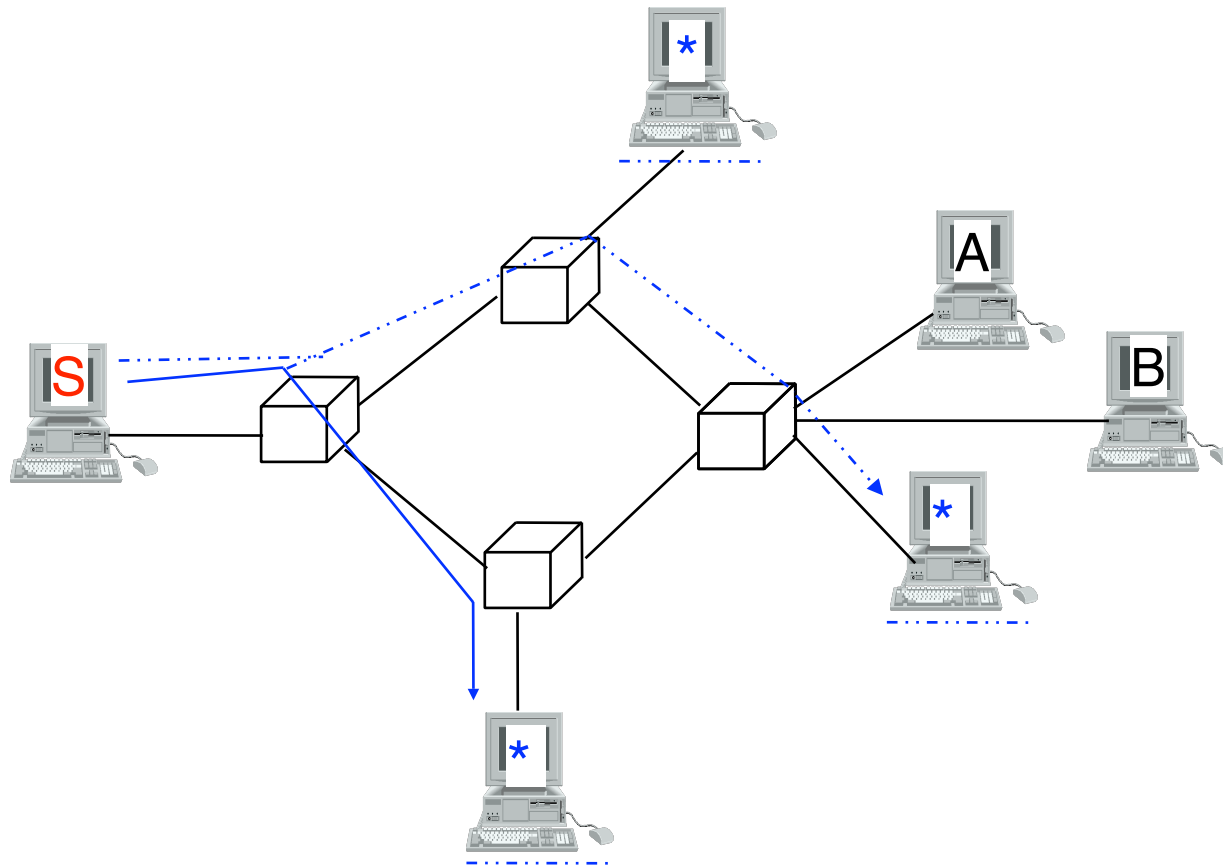


Anycast

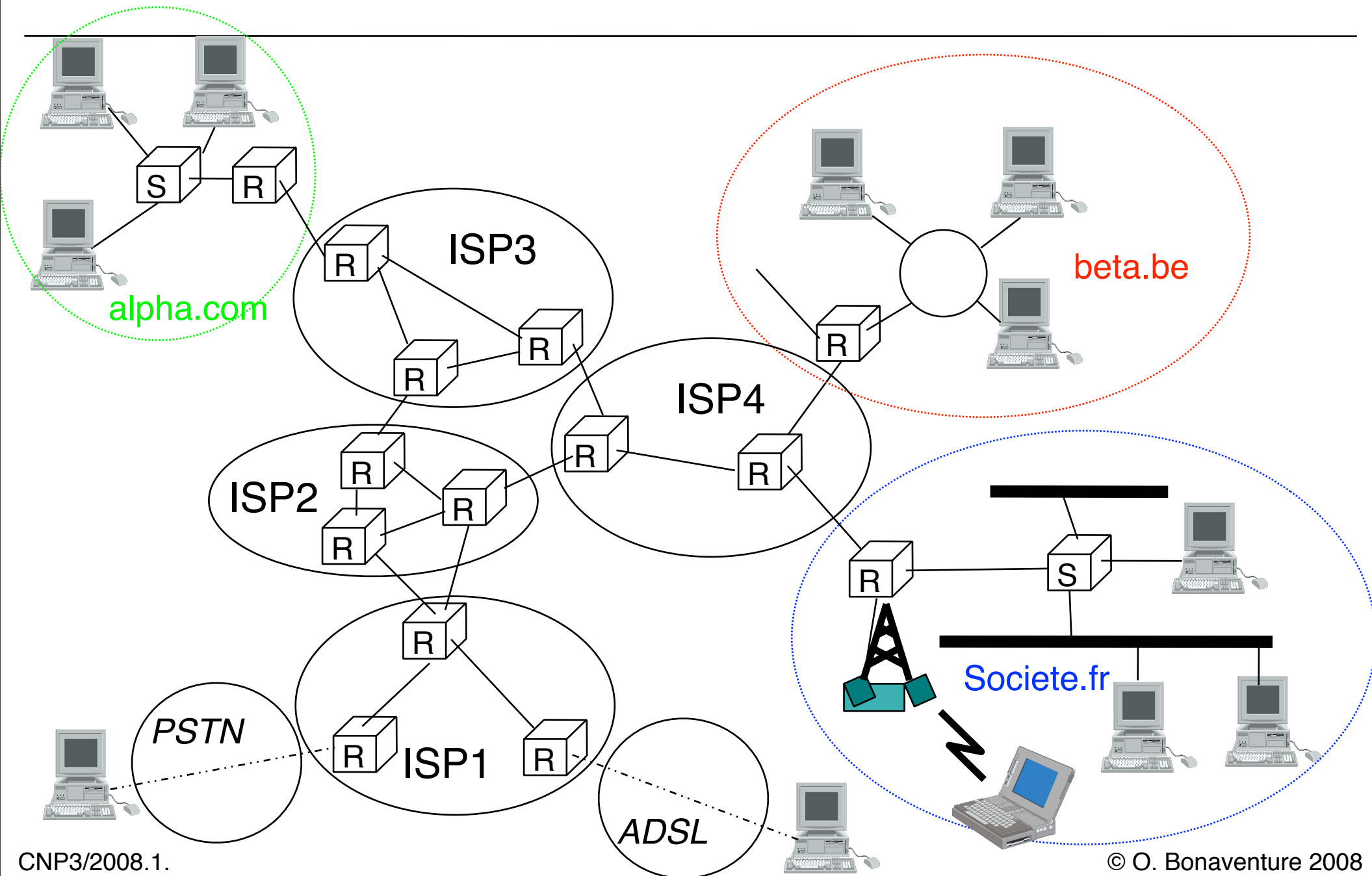
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- Example :find server hosting popular content



A small Internet



Module 1 : Basics

Contents

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→ Services in computer networks
Connectionless service
Connection oriented service

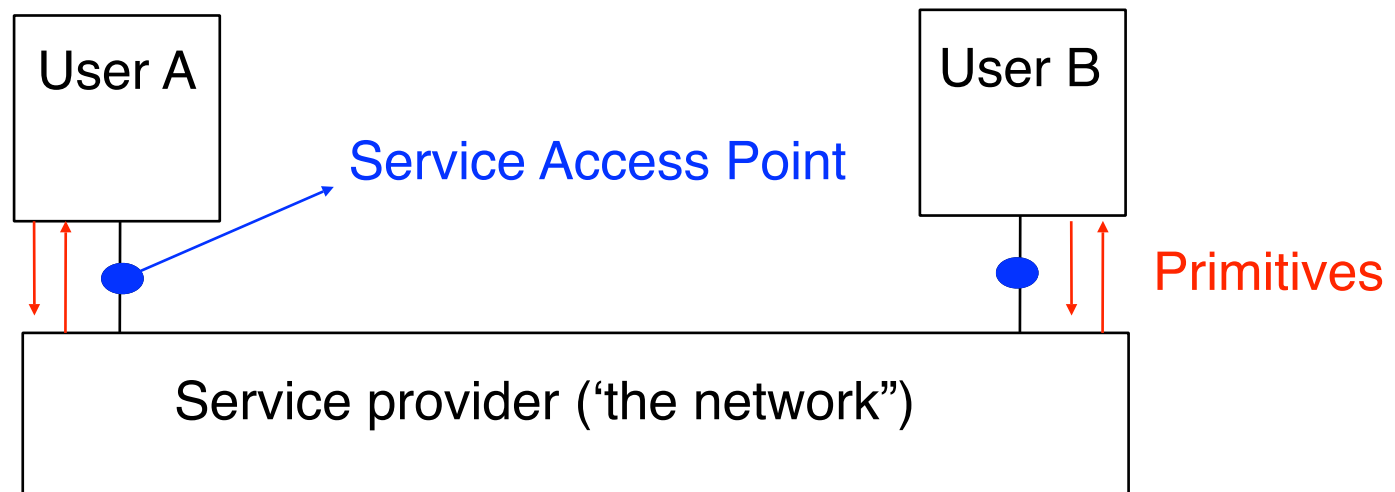
Layered reference models

Basic concepts

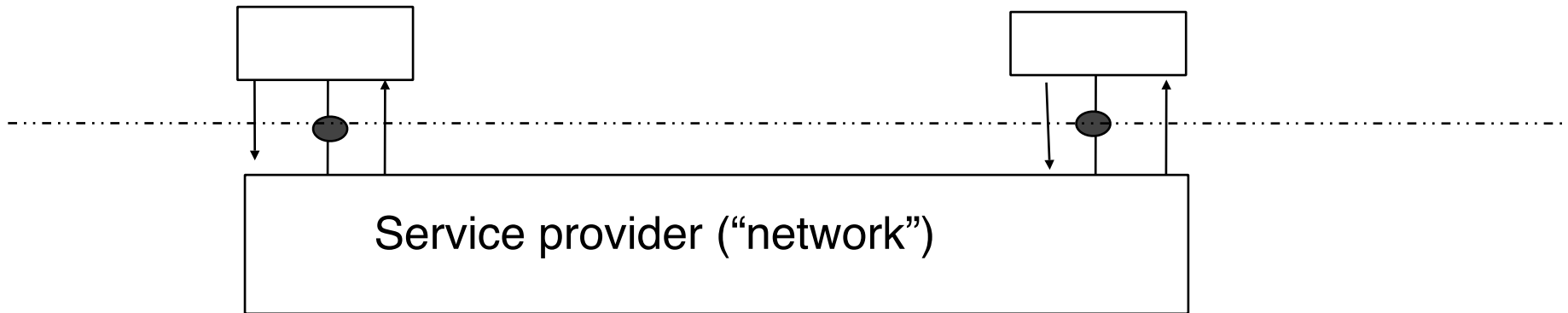
Abstract model of the network behaviour

Network is considered as a black box

Users interact with the network by using **primitives** that are exchanged through a **service access point** (SAP)



Types of primitives



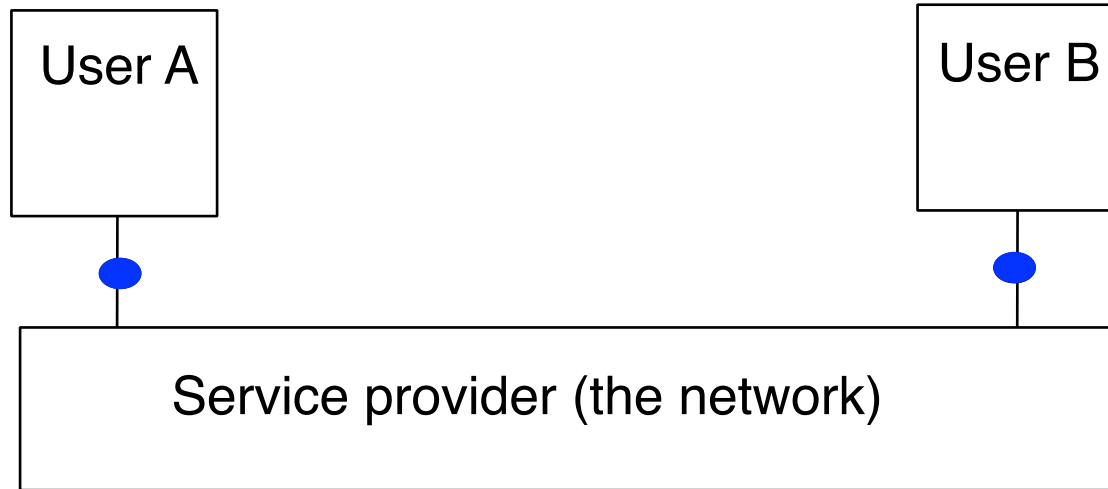
Primitive

Abstract representation of the interaction between one user and its network provider

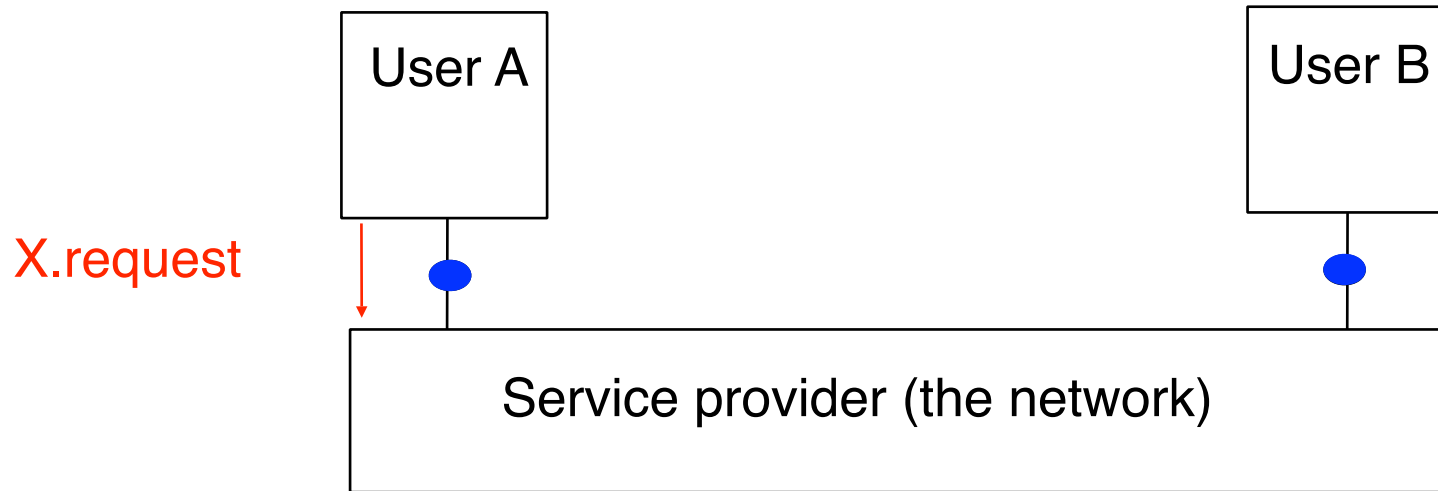
Can contain parameters such as :

- source
- destination
- message (SDU or Service Data Unit)

Types of primitives (2)

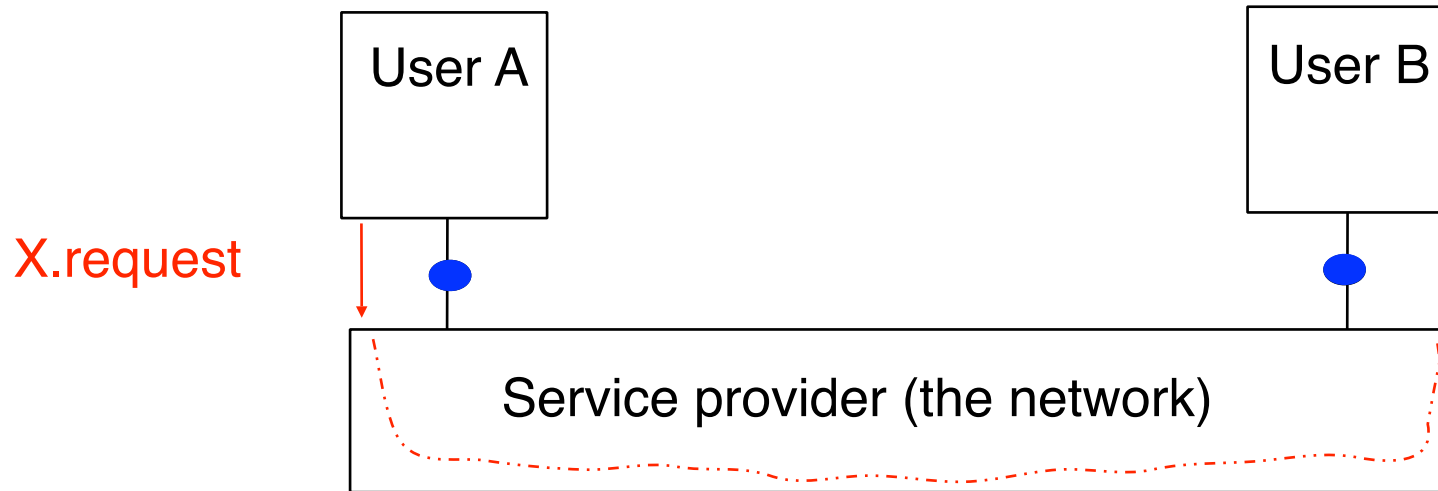


Types of primitives (2)



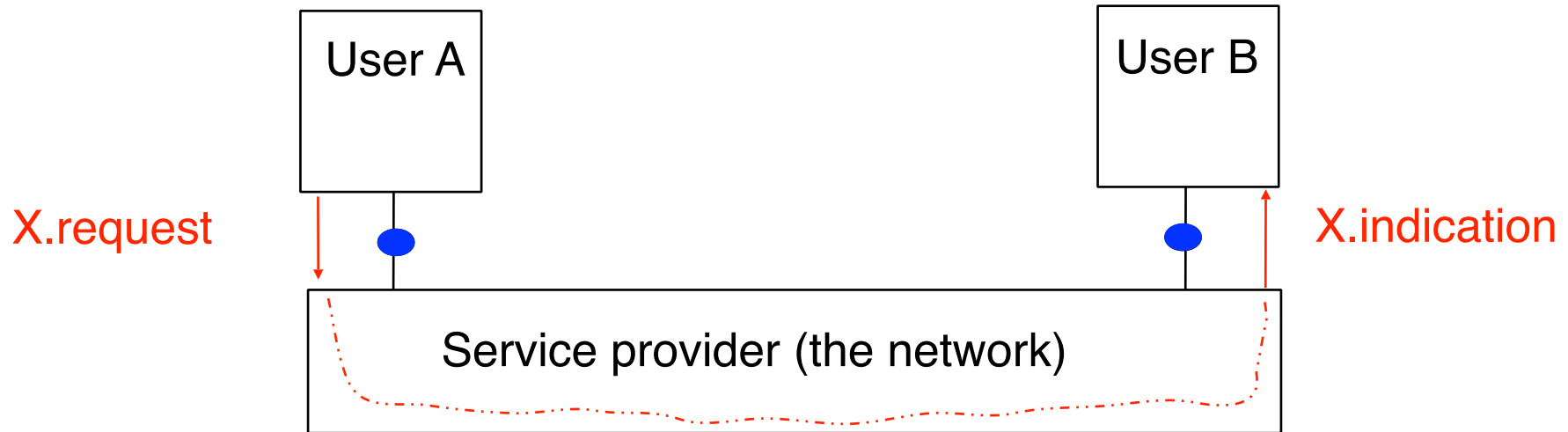
- X.request
 - request from a user to a service provider

Types of primitives (2)



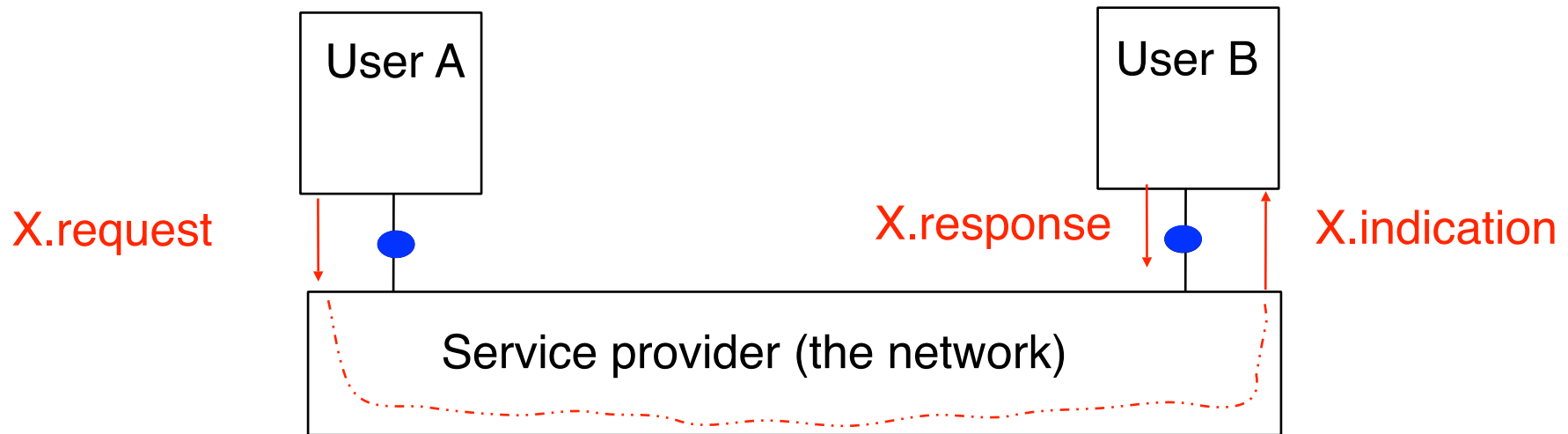
- X.request
 - request from a user to a service provider

Types of primitives (2)



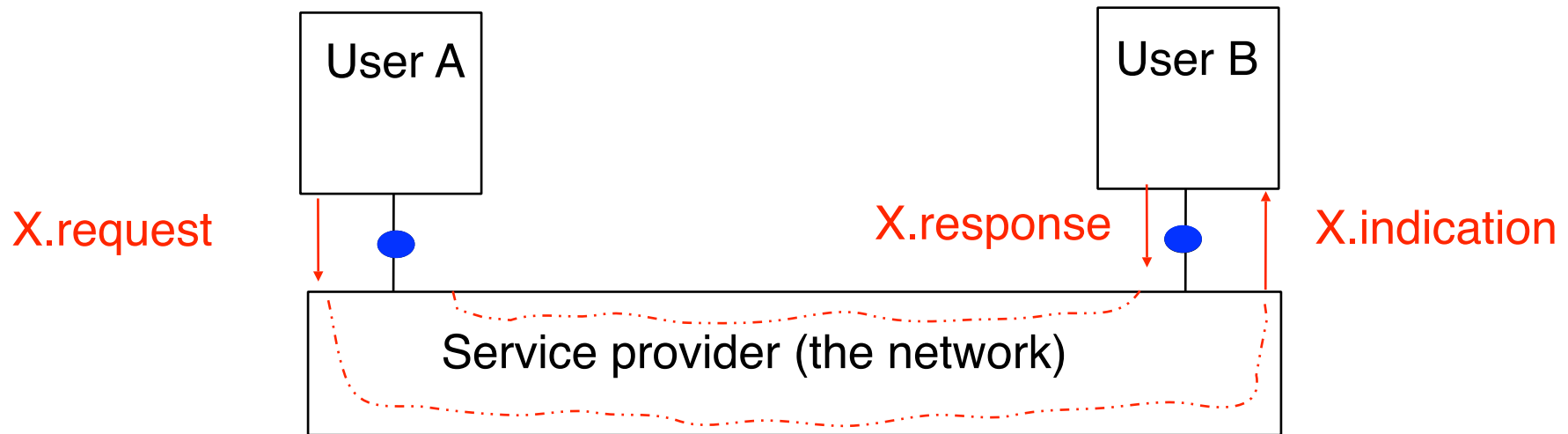
- **X.request**
 - request from a user to a service provider
- **X.indication**
 - primitive generated by the network provider to a user (often related to an earlier and remote X.request primitive)

Types of primitives (2)



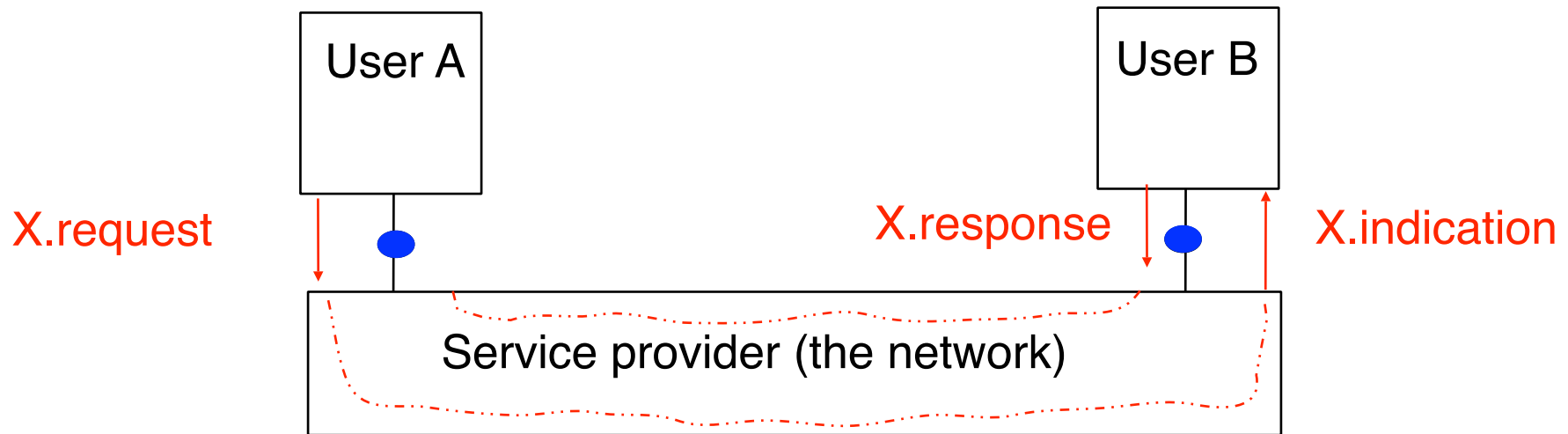
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- **X.response**
 - primitive used to answer to an earlier X.indication primitive

Types of primitives (2)



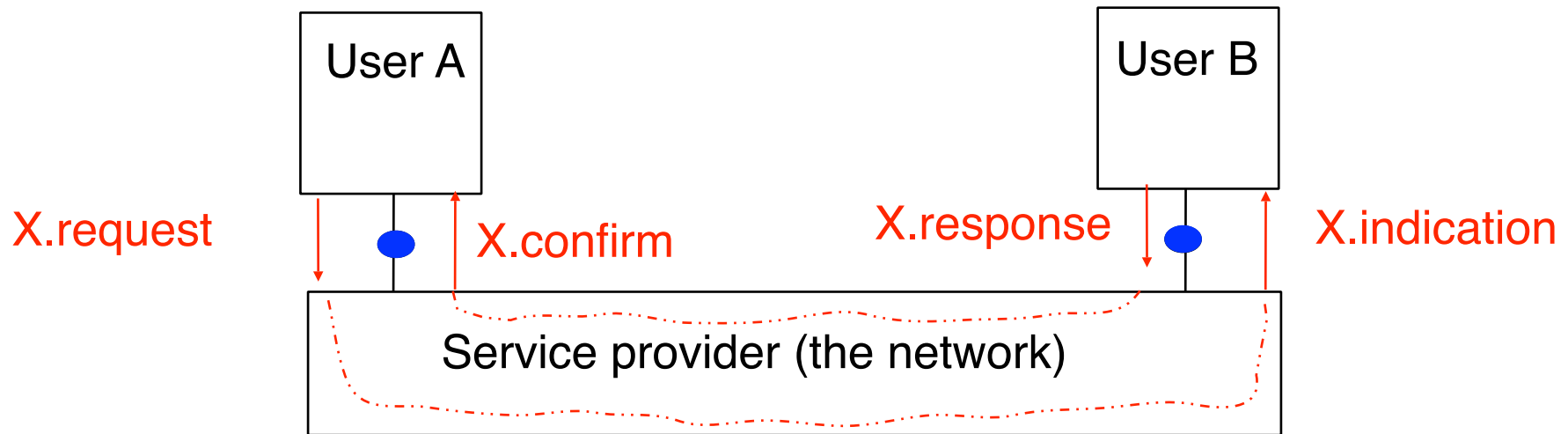
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- **X.response**
 - primitive used to answer to an earlier X.indication primitive
- **X.confirm**
 - primitive generated by the network provider to a user (related to a remote X.response primitive)

Types of primitives (2)



- **X.request**
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- **X.response**
 - primitive used to answer to an earlier X.indication primitive
- **X.confirm**
 - primitive generated by the network provider to a user (related to a remote X.response primitive)

The connectionless service

Goal

Allow a sender to quickly send a message to one receiver

Principle

The sender places the message to be transmitted in a DATA.req primitive and gives it to the network provider
The network provider carries the message and delivers it to the receiver by using a DATA.ind primitive

Utilisation

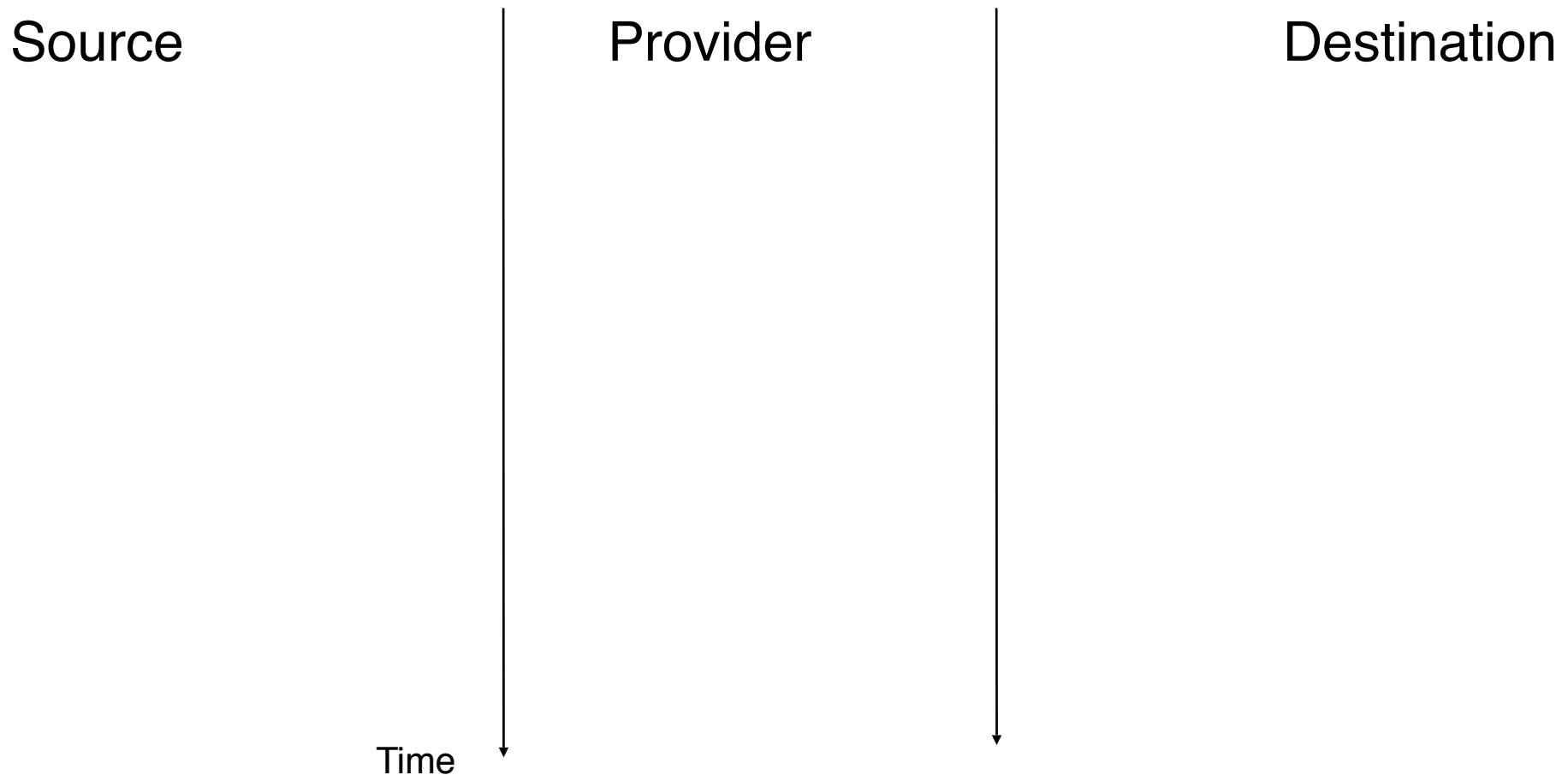
useful to send short-length messages
example : post office

Connectionless service

Primitives

DATA.request(source, destination, SDU)

DATA.indication(source, destination, SDU)

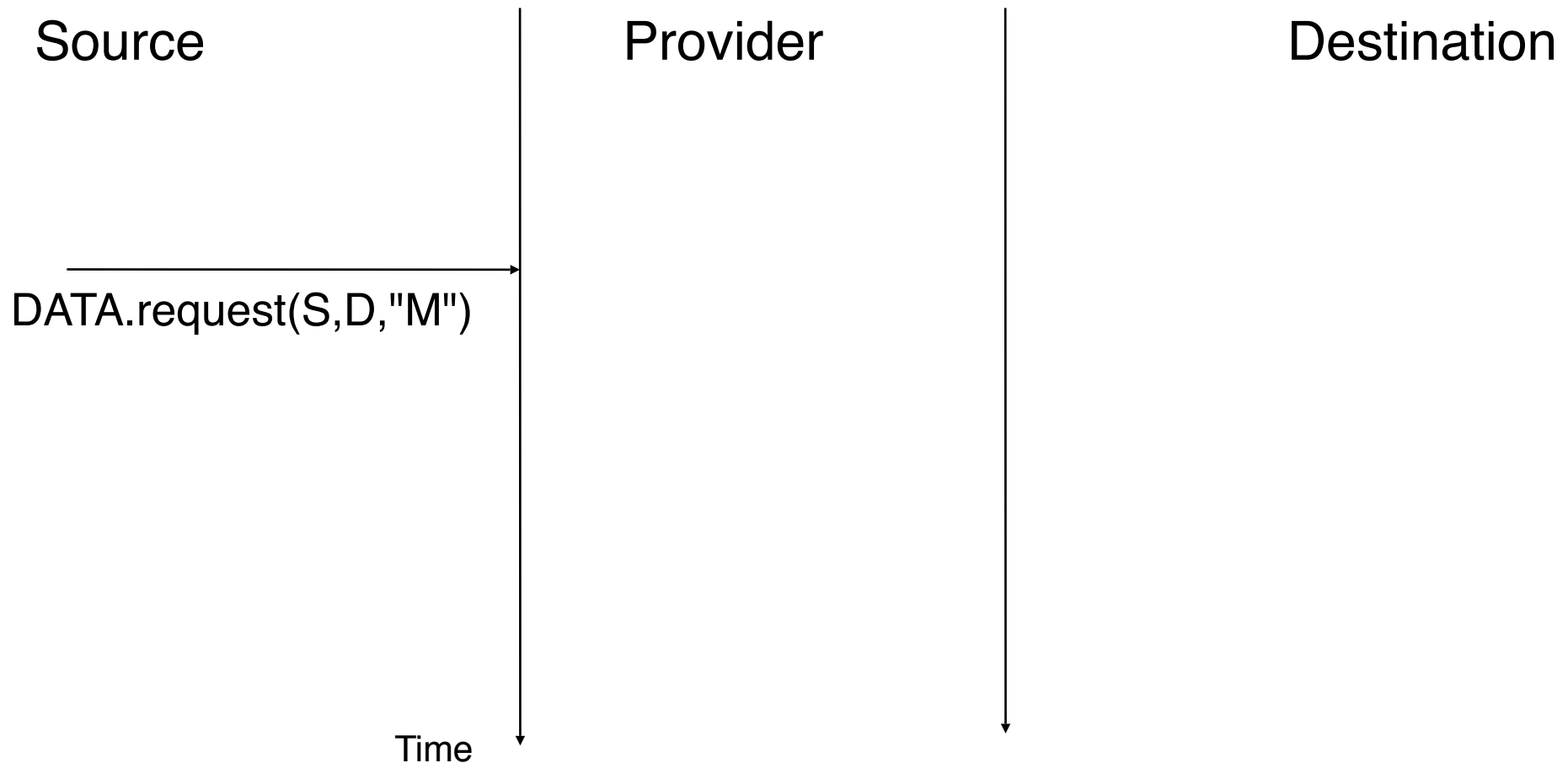


Connectionless service

Primitives

DATA.request(source, destination, SDU)

DATA.indication(source, destination, SDU)

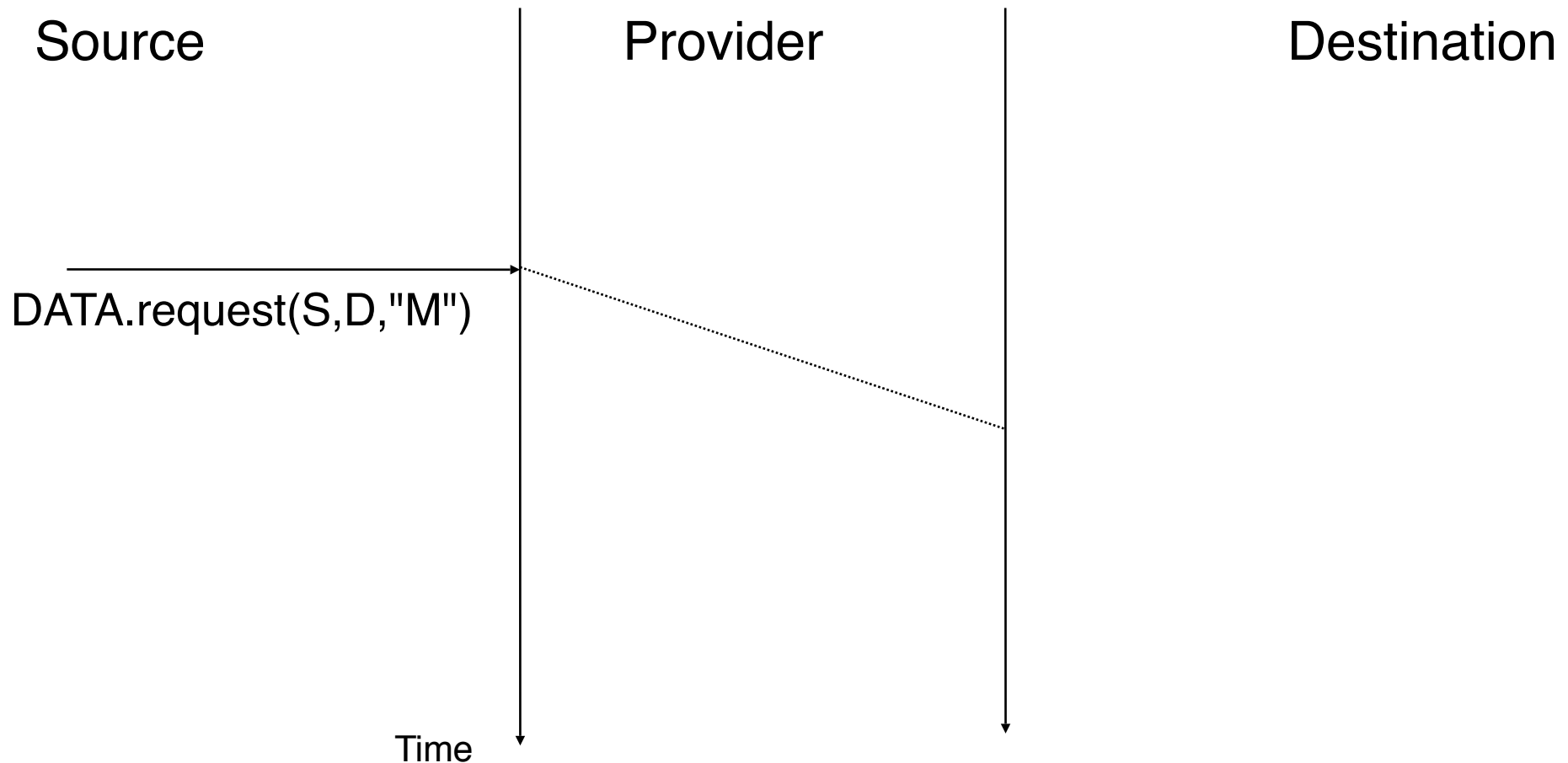


Connectionless service

Primitives

DATA.request(source, destination, SDU)

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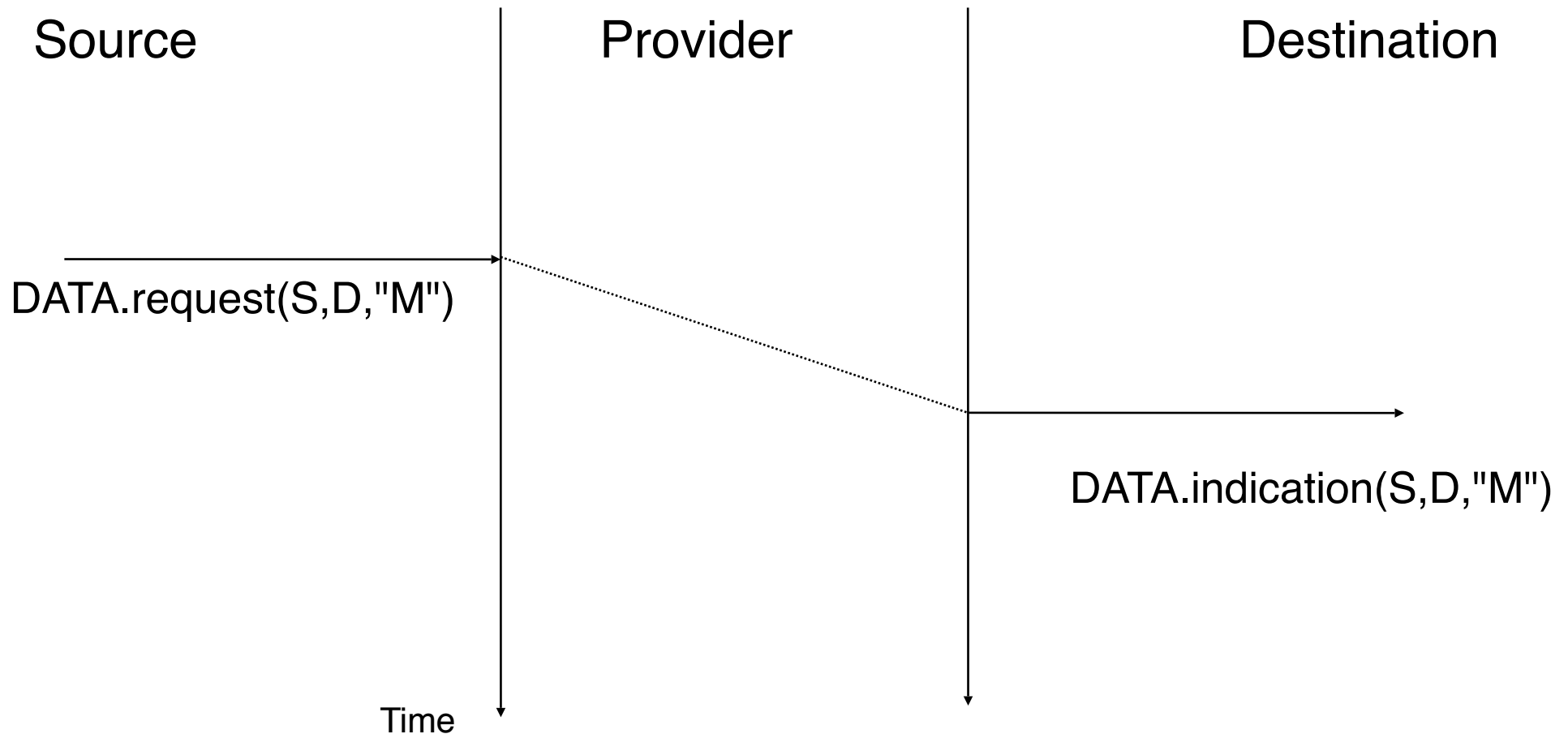


Connectionless service

Primitives

DATA.request(source, destination, SDU)

DATA.indication(source, destination, SDU)



Connectionless service (2)

Variants of connectionless service

confirmation

primitive DATA.confirm delivered by provider to sender to confirm that some message has been delivered to destination

reliability

reliable connectionless service (no errors)

unreliable connectionless service (errors are possible)

protection against transmission errors

service may or may not detect/correct errors

protection against losses

the service may or cannot lose messages

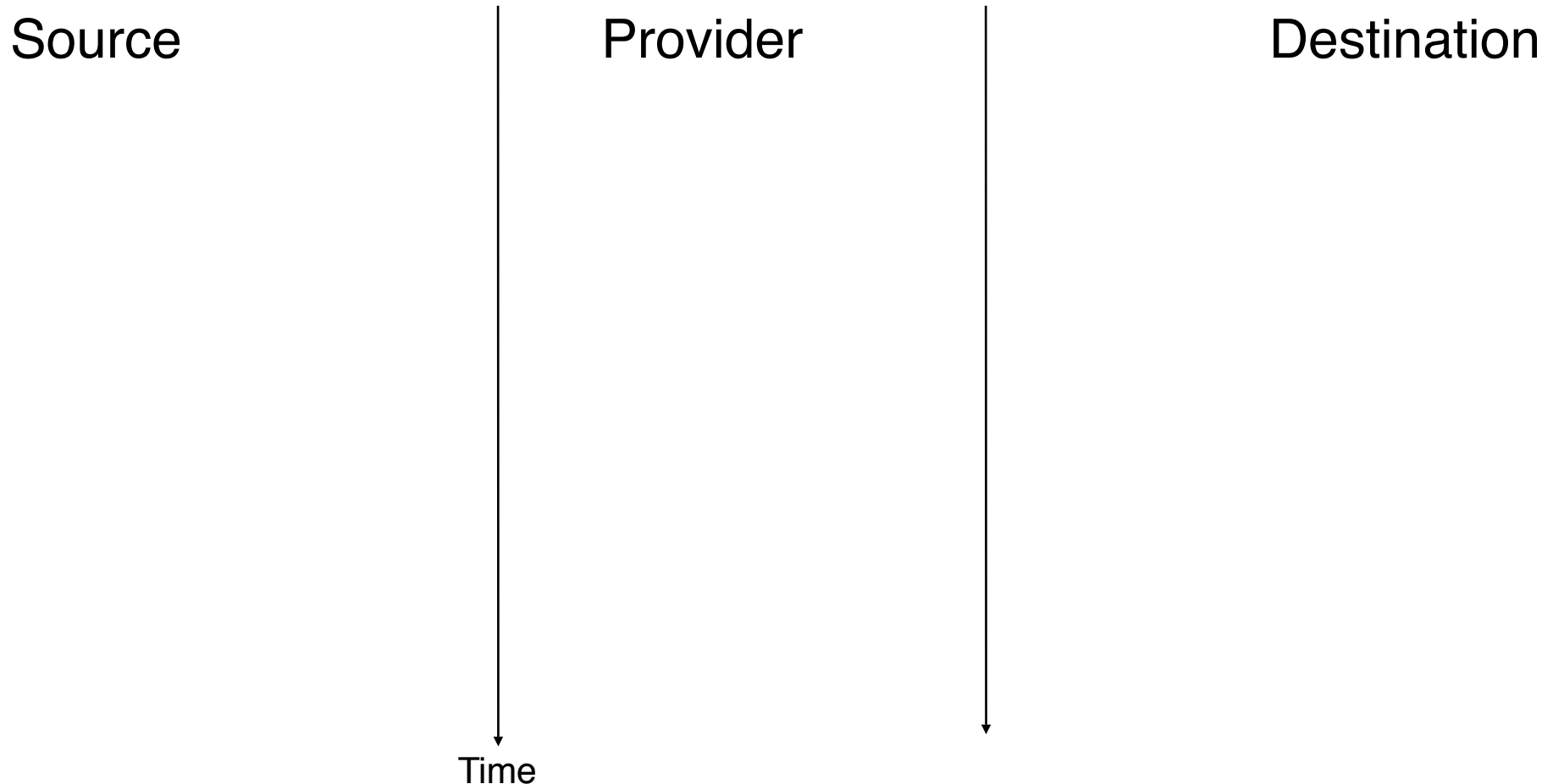
in sequence delivery

not guaranteed

in-sequence delivery for all messages sent by one source

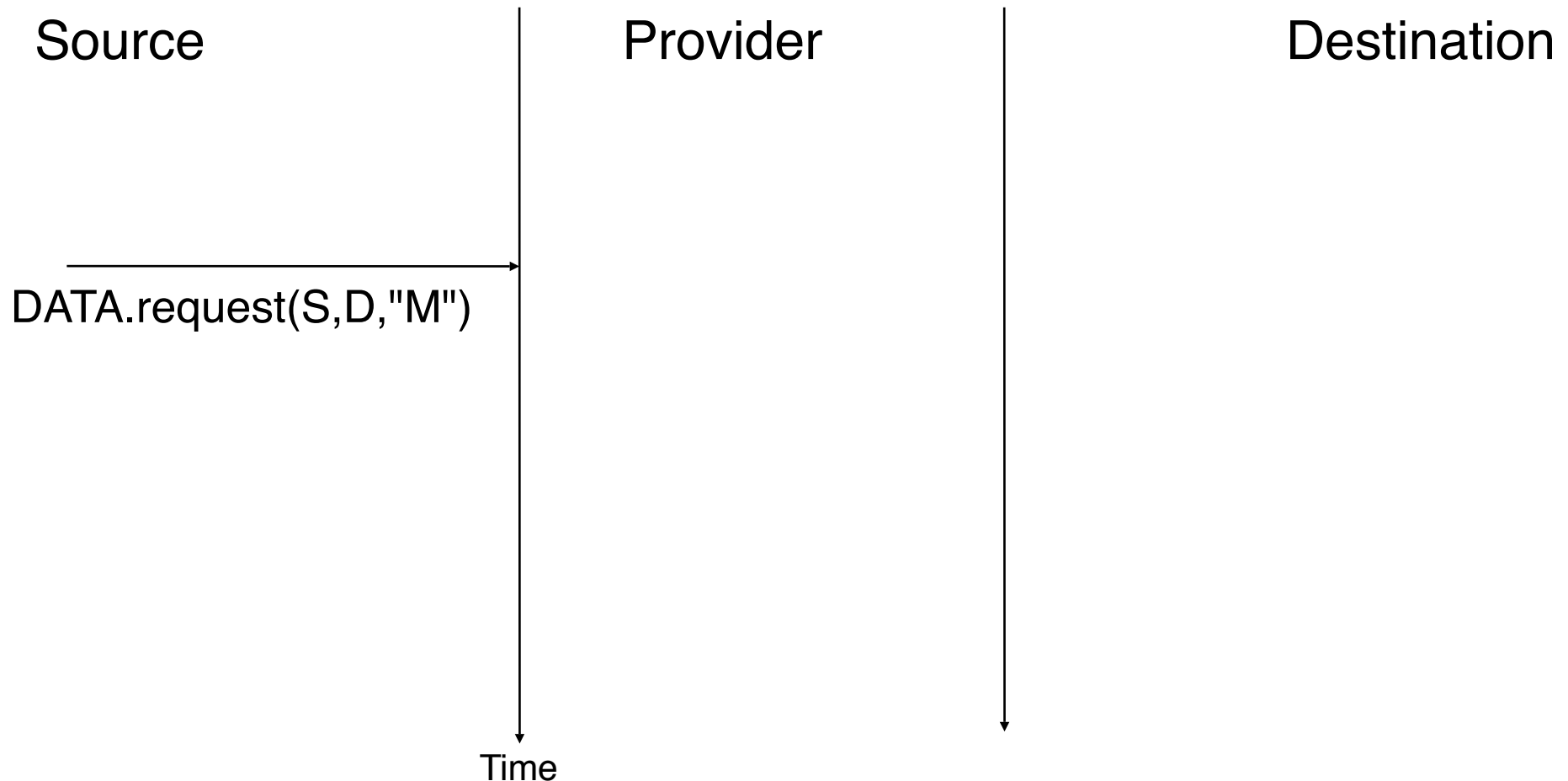
Connectionless service (3)

Example of acknowledged service



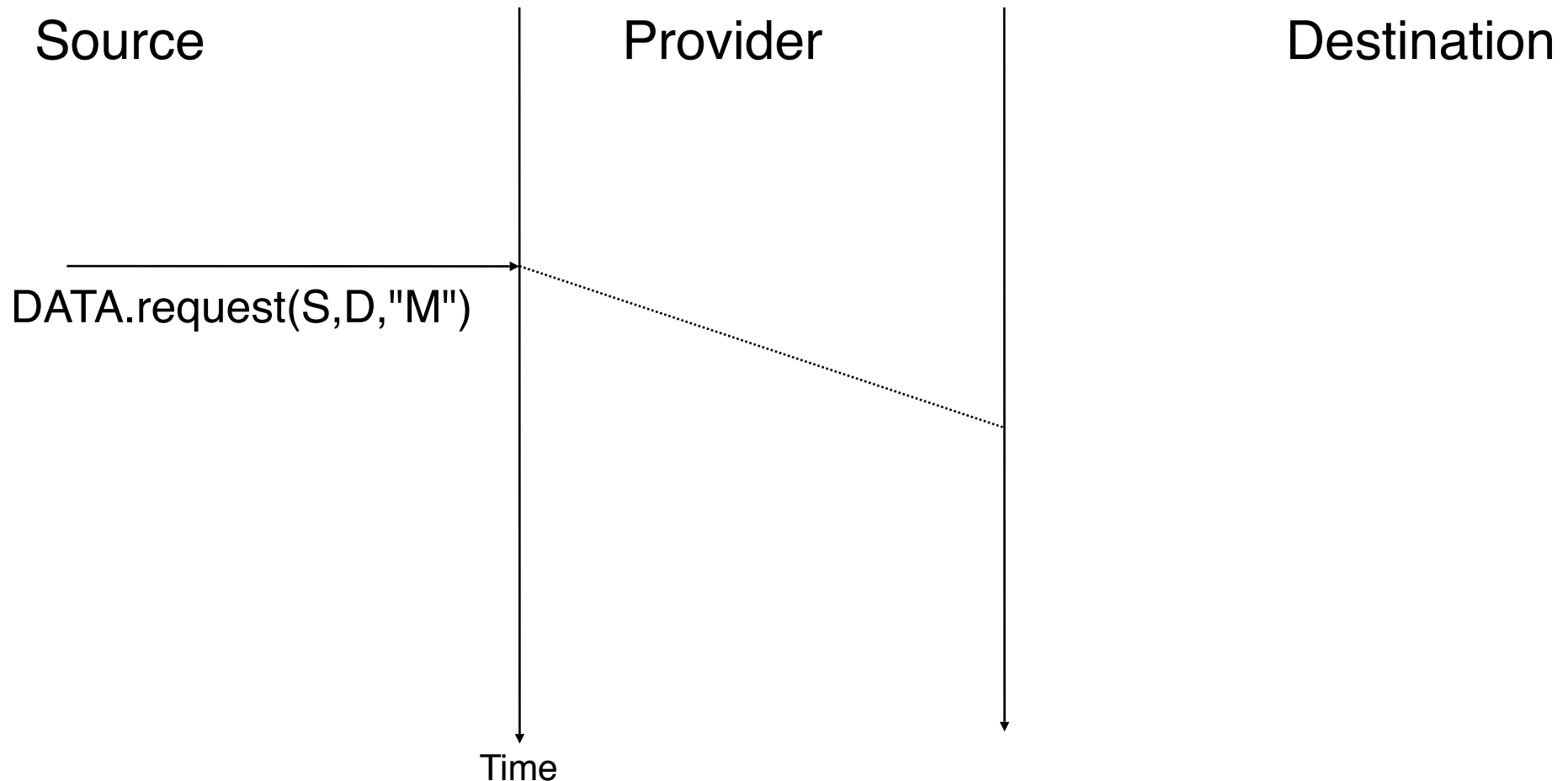
Connectionless service (3)

Example of acknowledged service



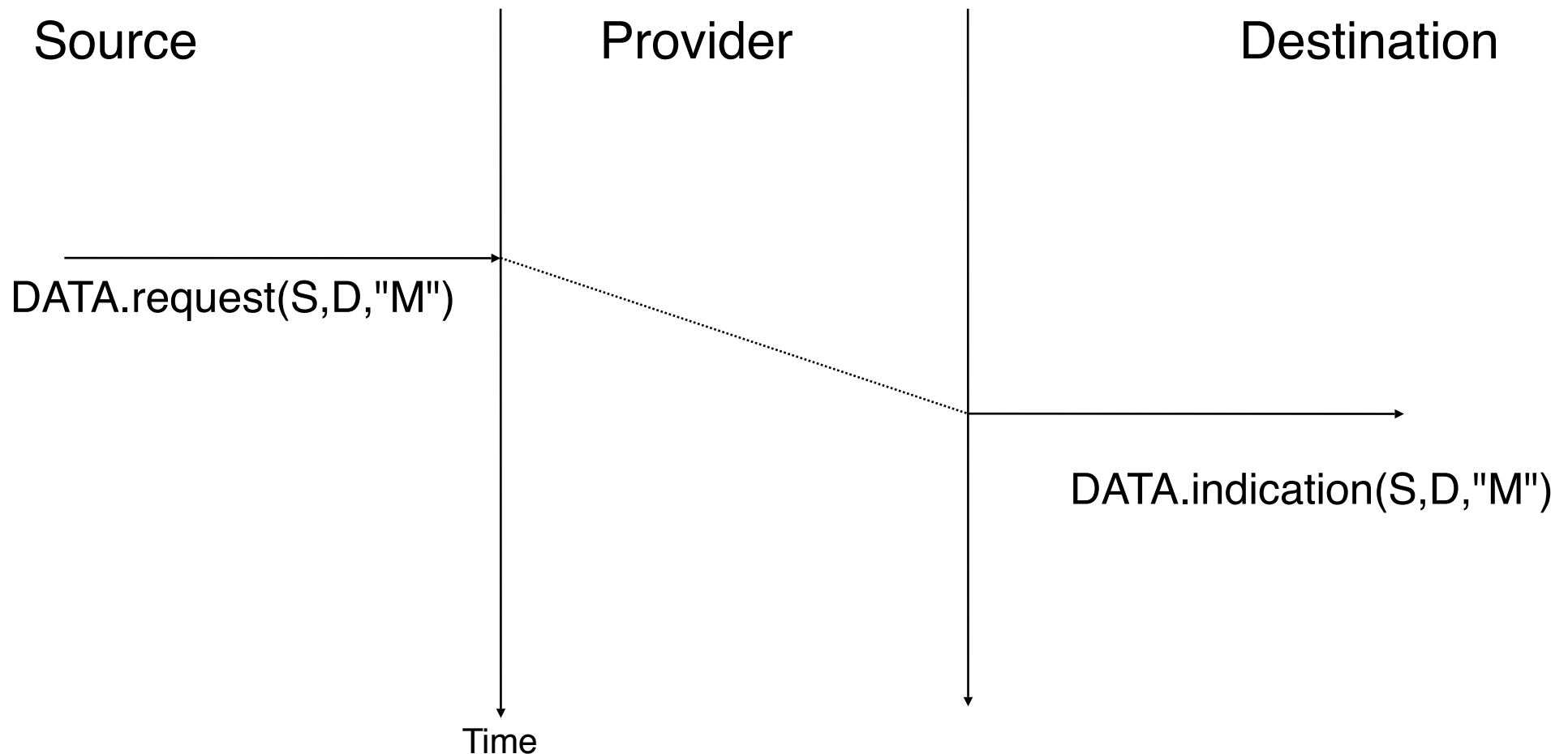
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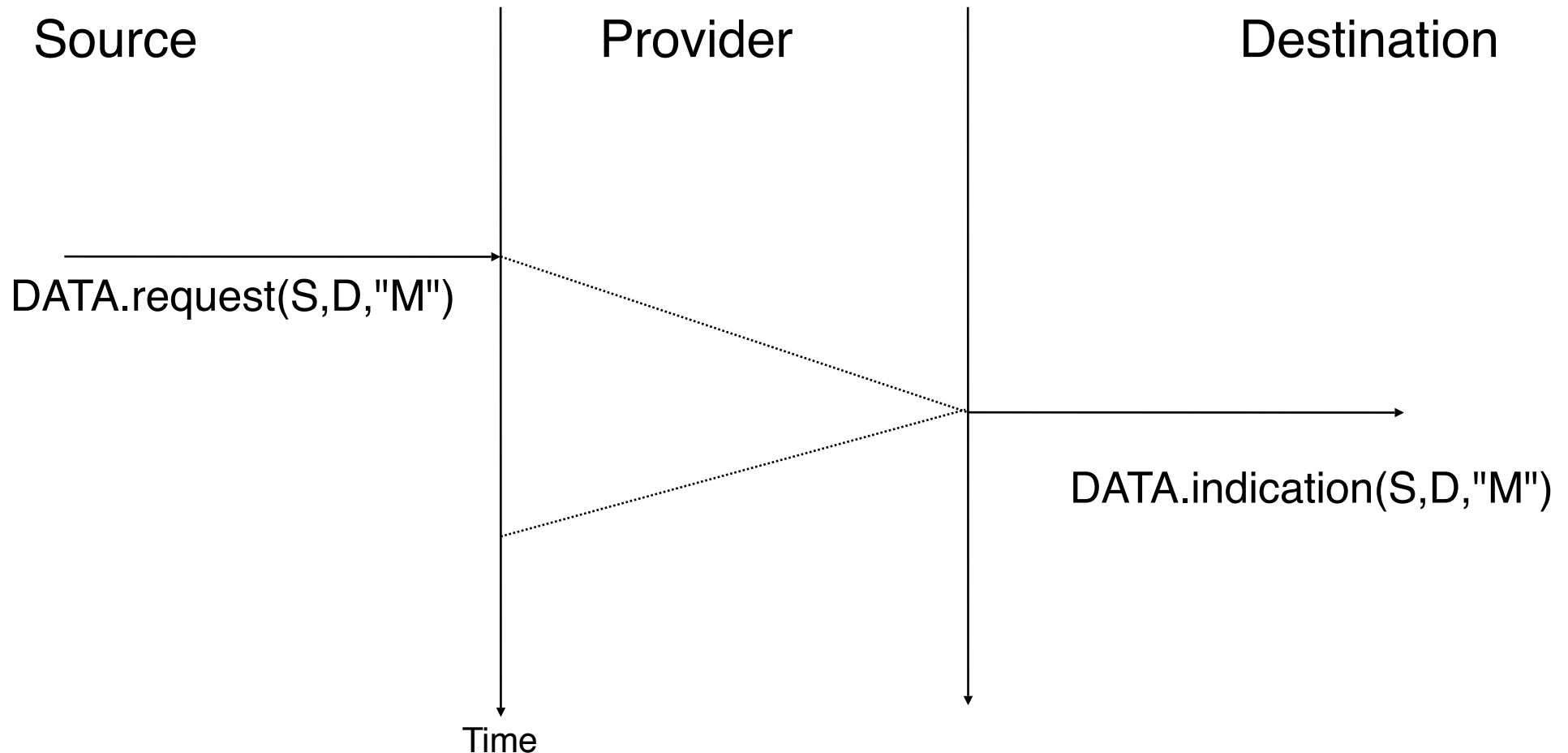
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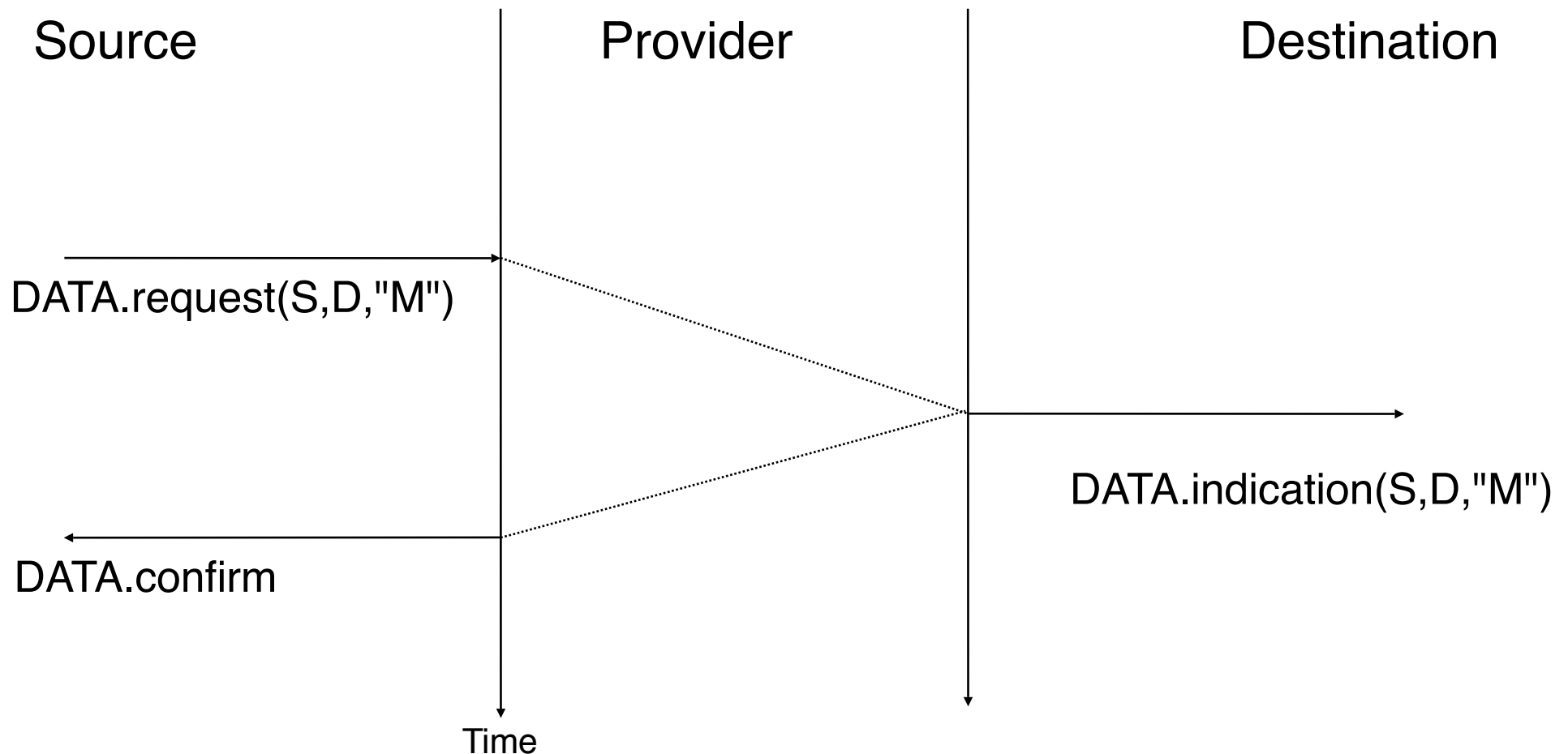
Connectionless service (3)

Example of acknowledged service



Connectionless service (3)

Example of acknowledged service



Connection-oriented service

Goal

Create a logical binding (connection) between two users to allow them to efficiently exchange messages

Main phases of service

- Connection establishment
- Data transfer
 - both users can send and receive messages over connection
- Connection release
- Utilisation
 - useful when the two users either
 - must exchange a large number of messages
 - need a structured exchange
 - example : telephone

Connection oriented service

Connection establishment

Primitives

CONNECT.request
CONNECT.indication
CONNECT.response
CONNECT.confirm

Source

Network provider

Destination

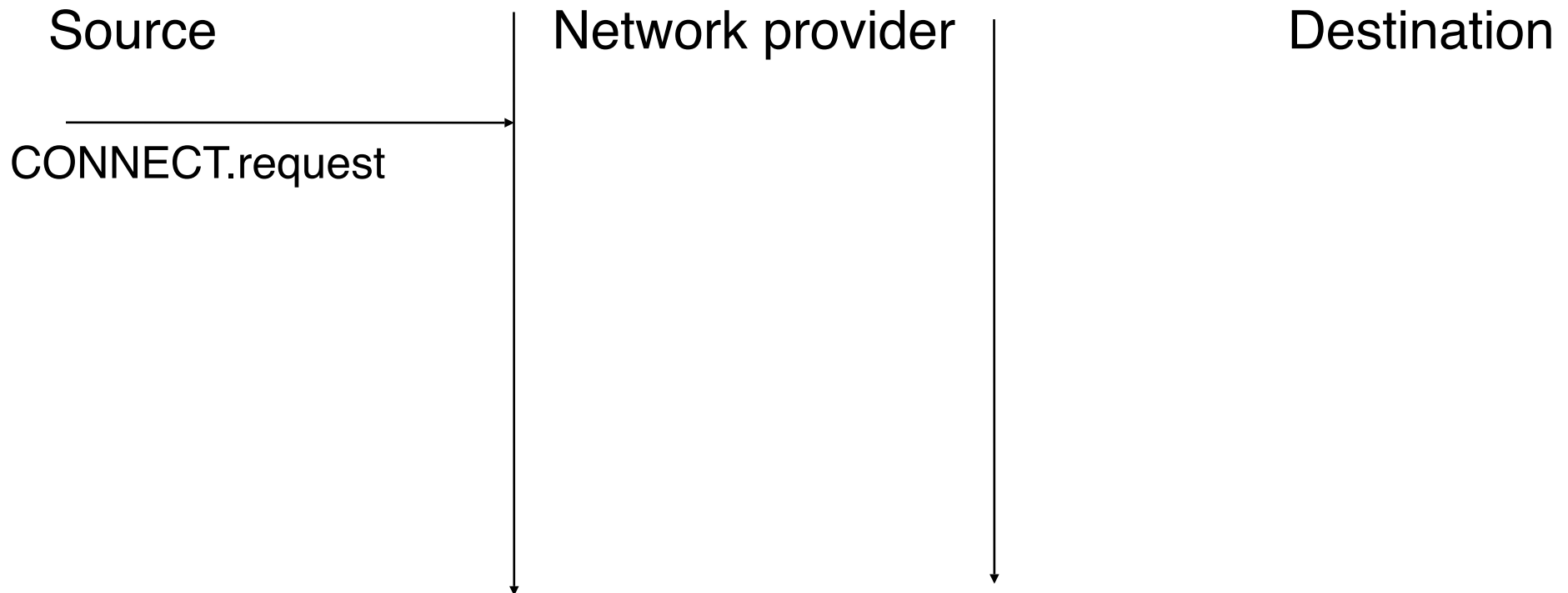


Connection oriented service

Connection establishment

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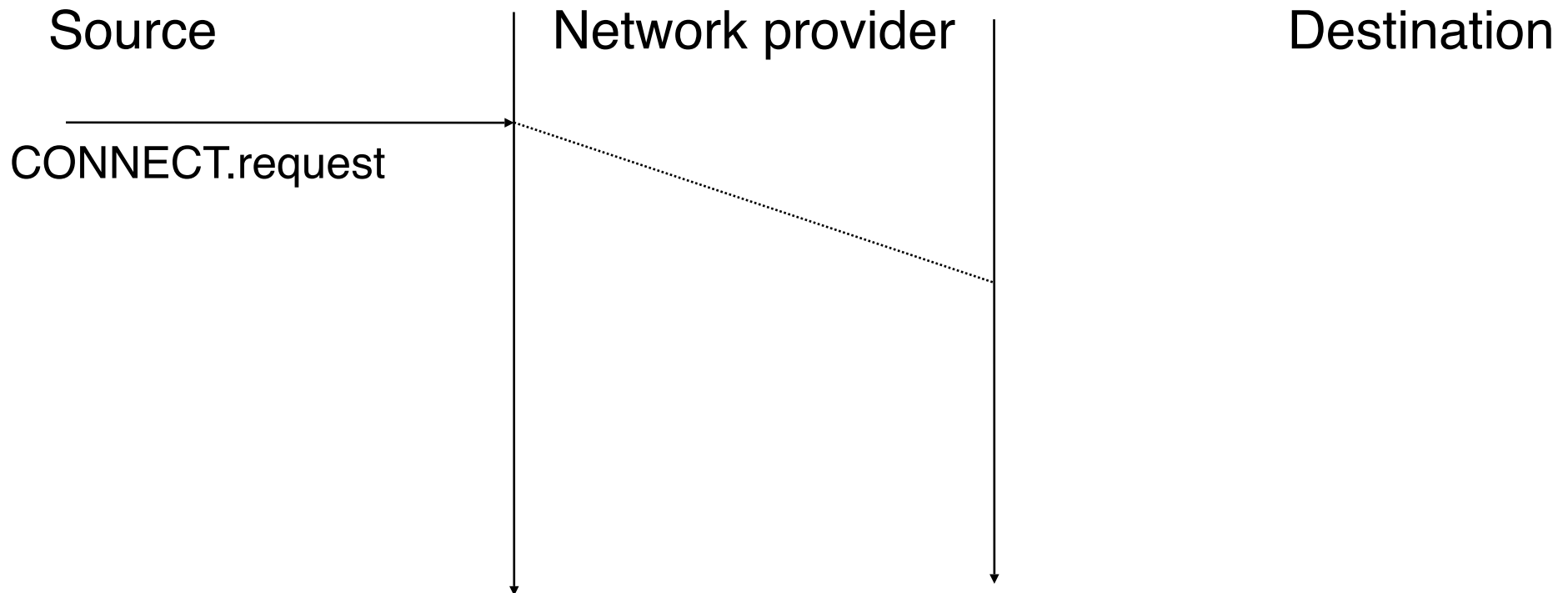


Connection oriented service

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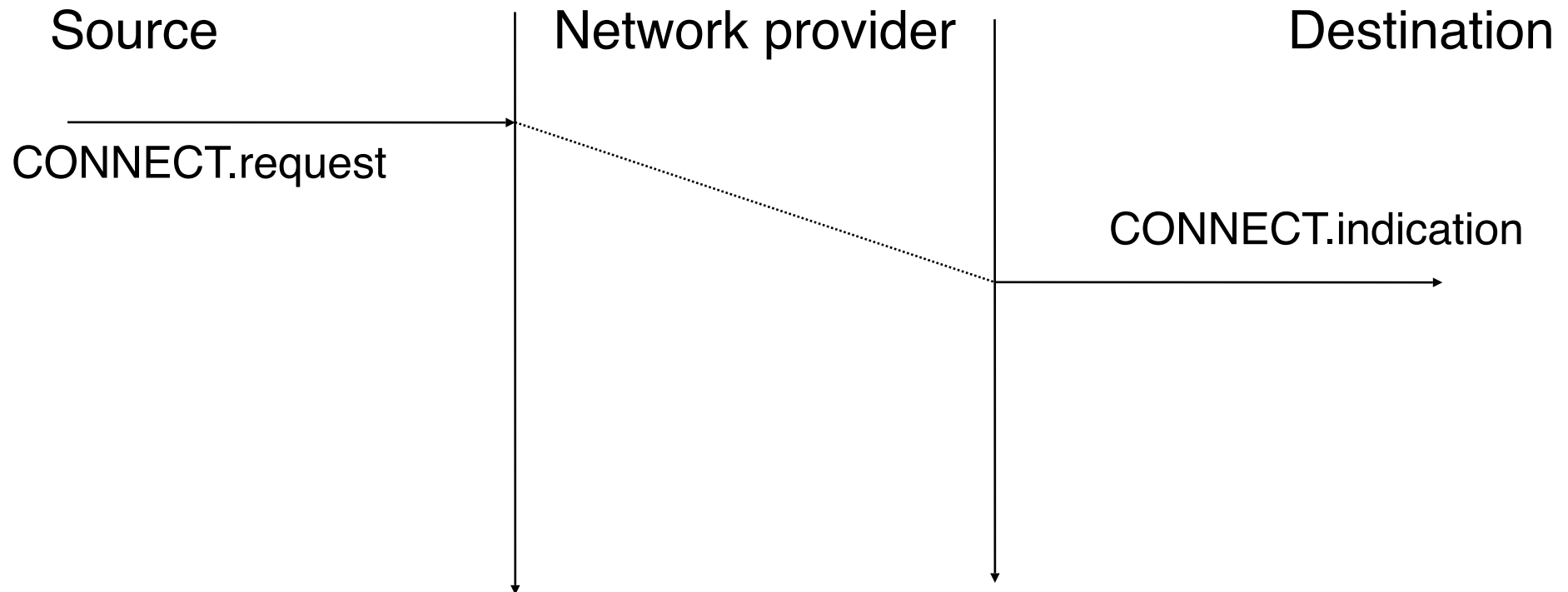


Connection oriented service

Connection establishment

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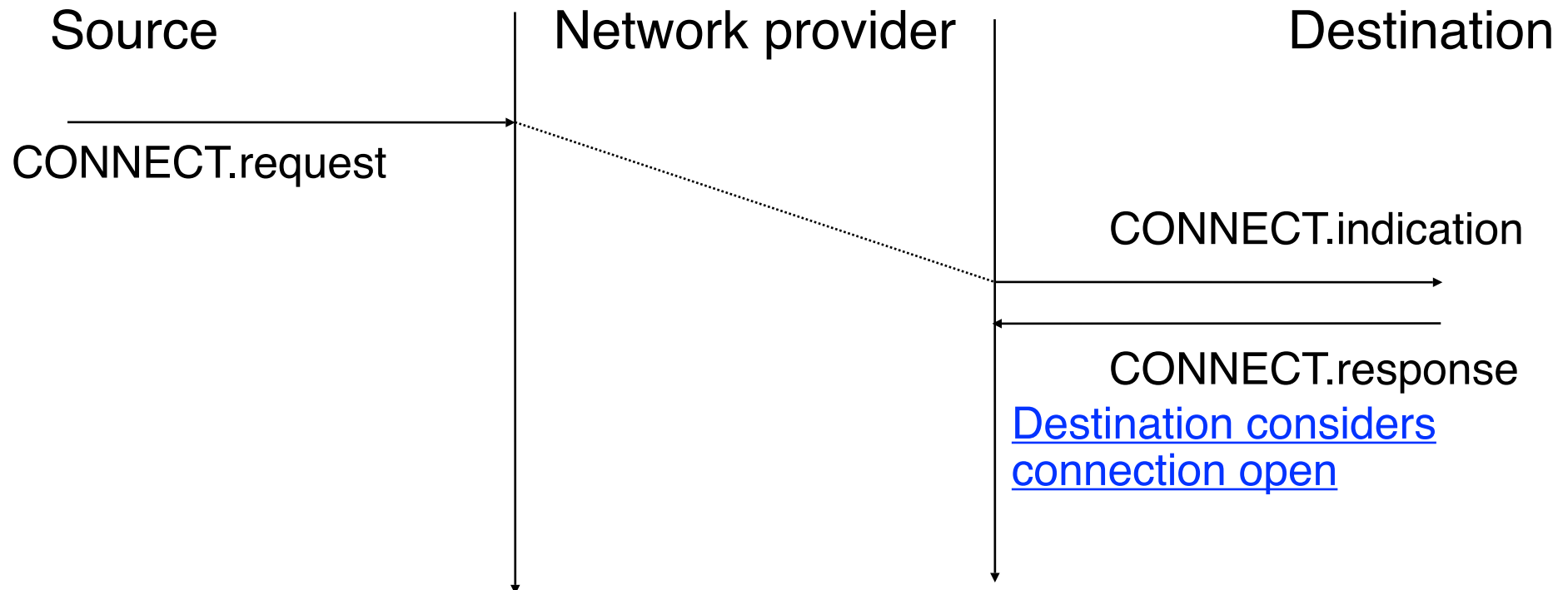


Connection oriented service

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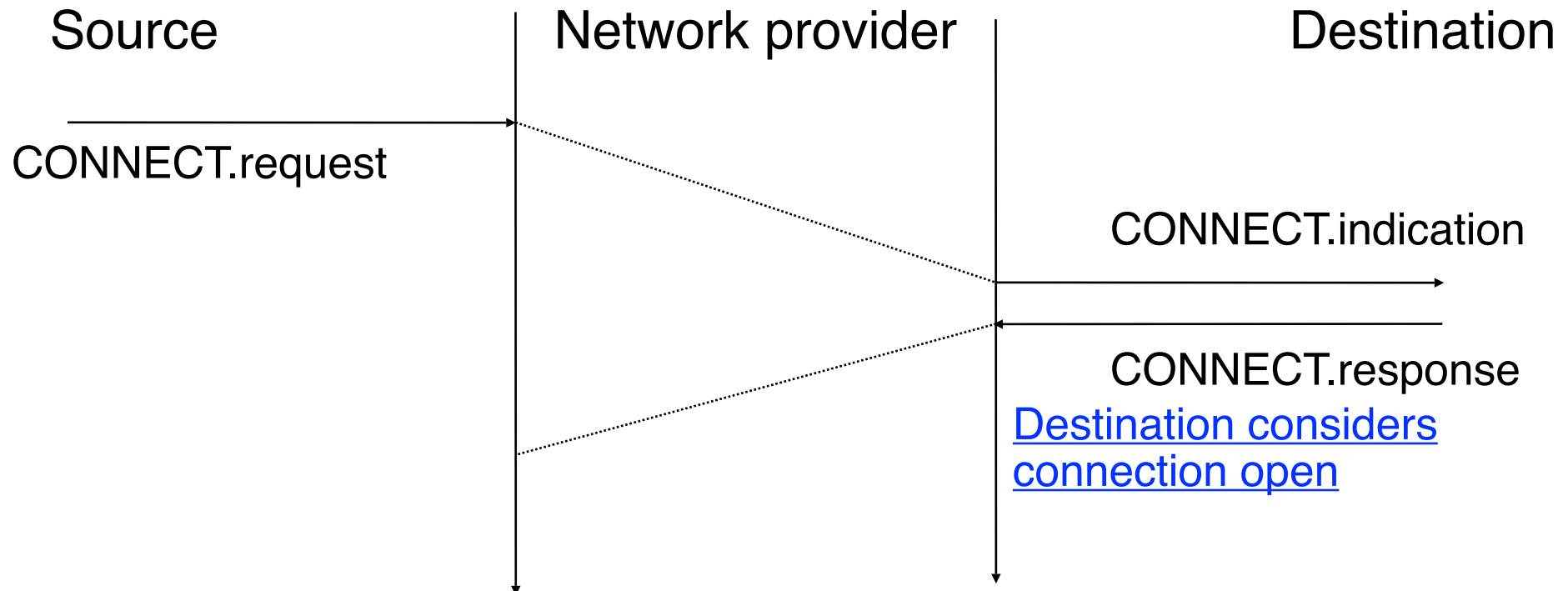


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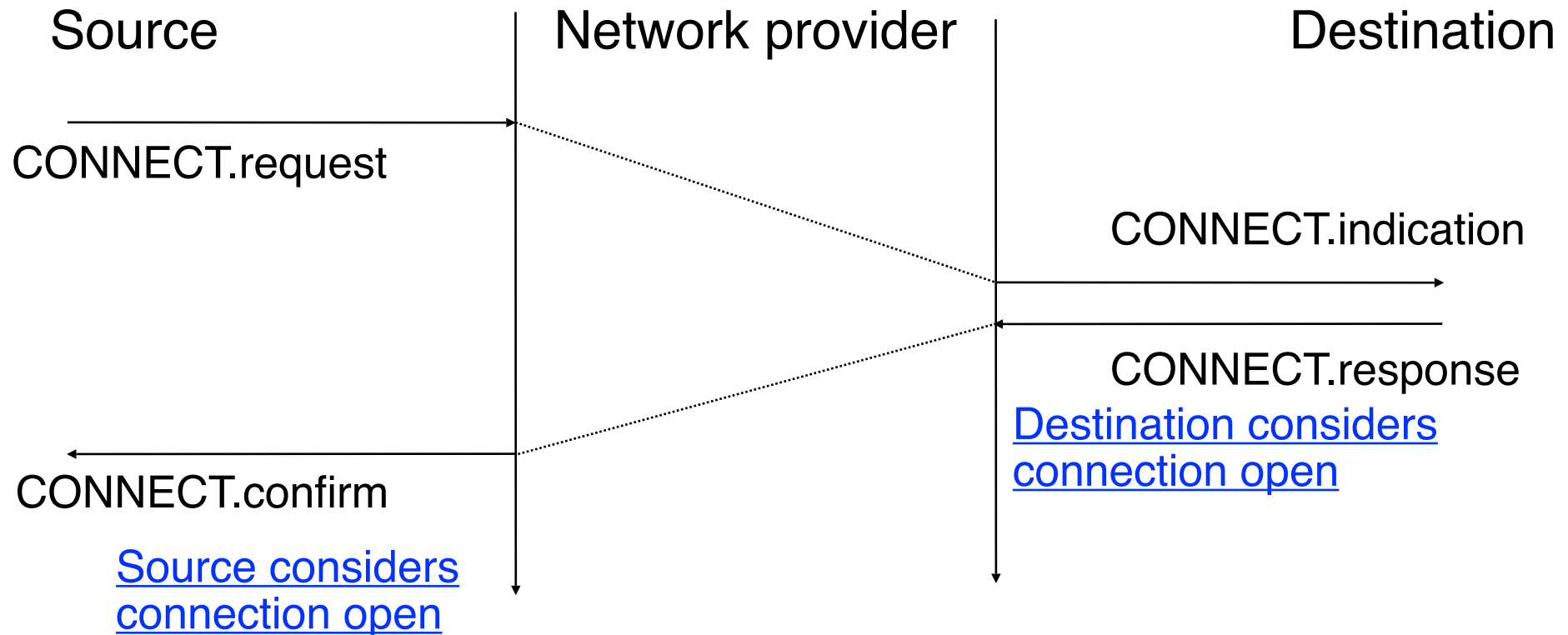


Connection oriented service

Connection establishment

Primitives

CONNECT.request
CONNECT.indication
CONNECT.response
CONNECT.confirm



Connection oriented service (2)

Connection can be rejected

Source

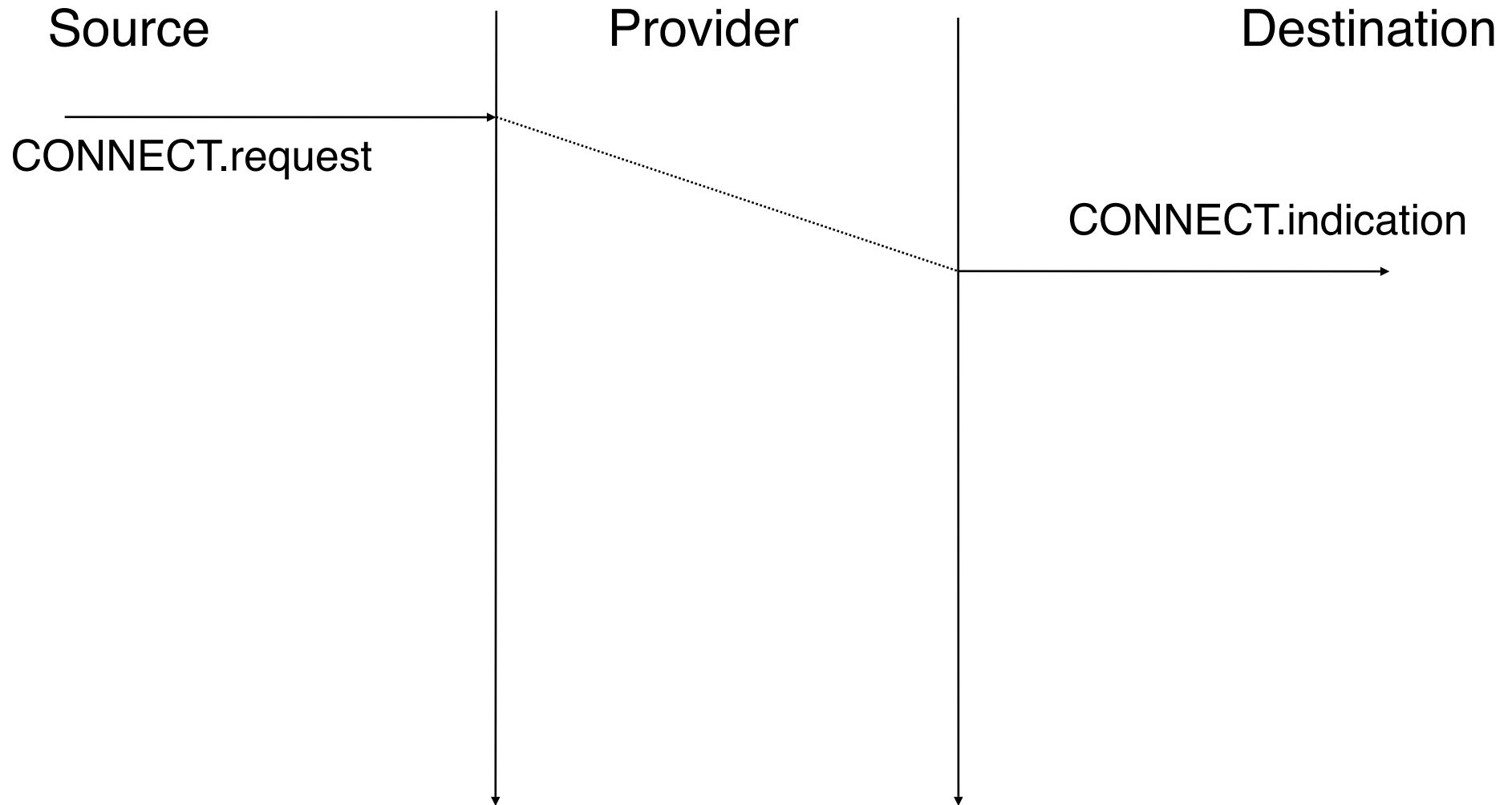
Provider

Destination



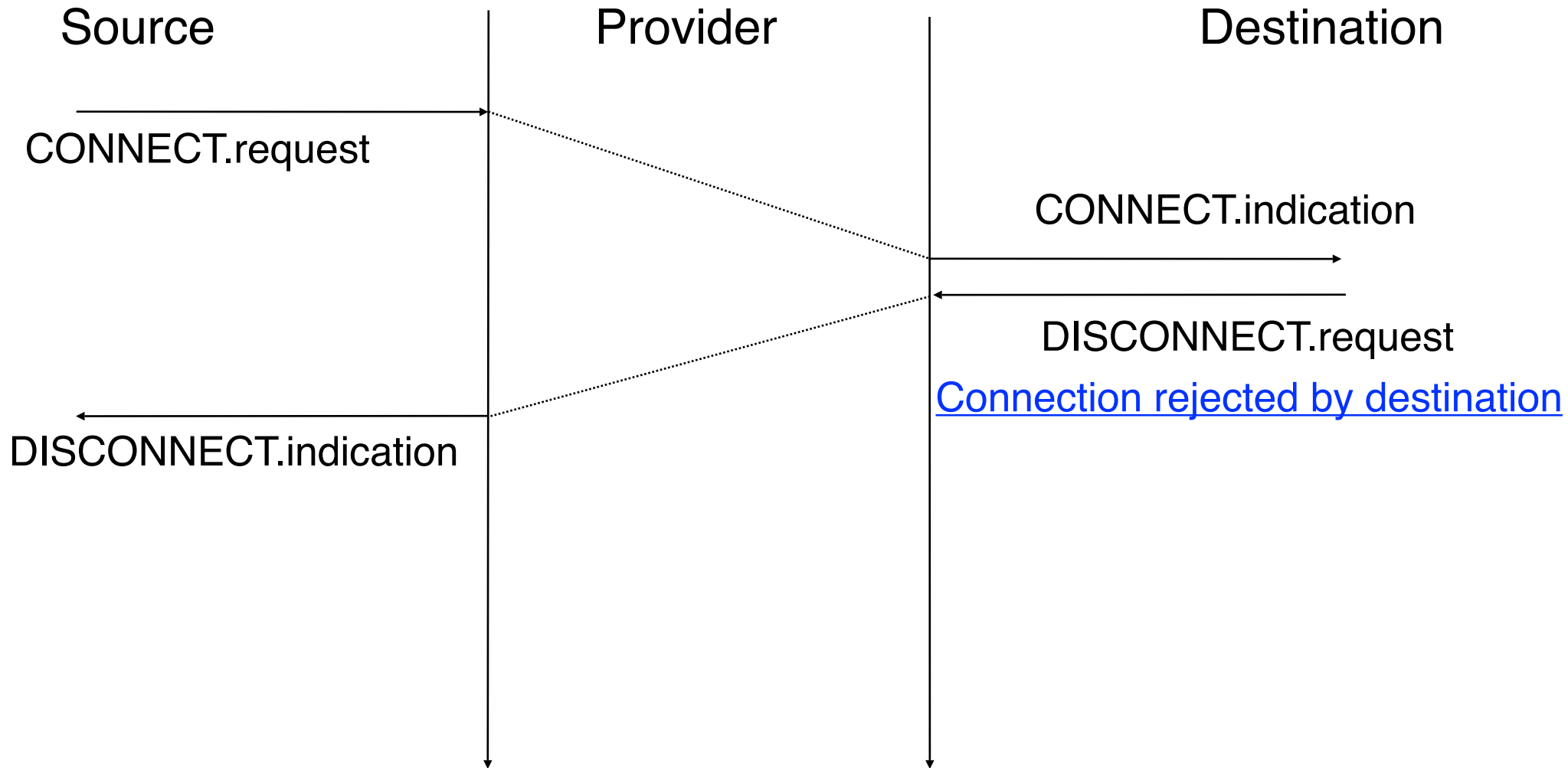
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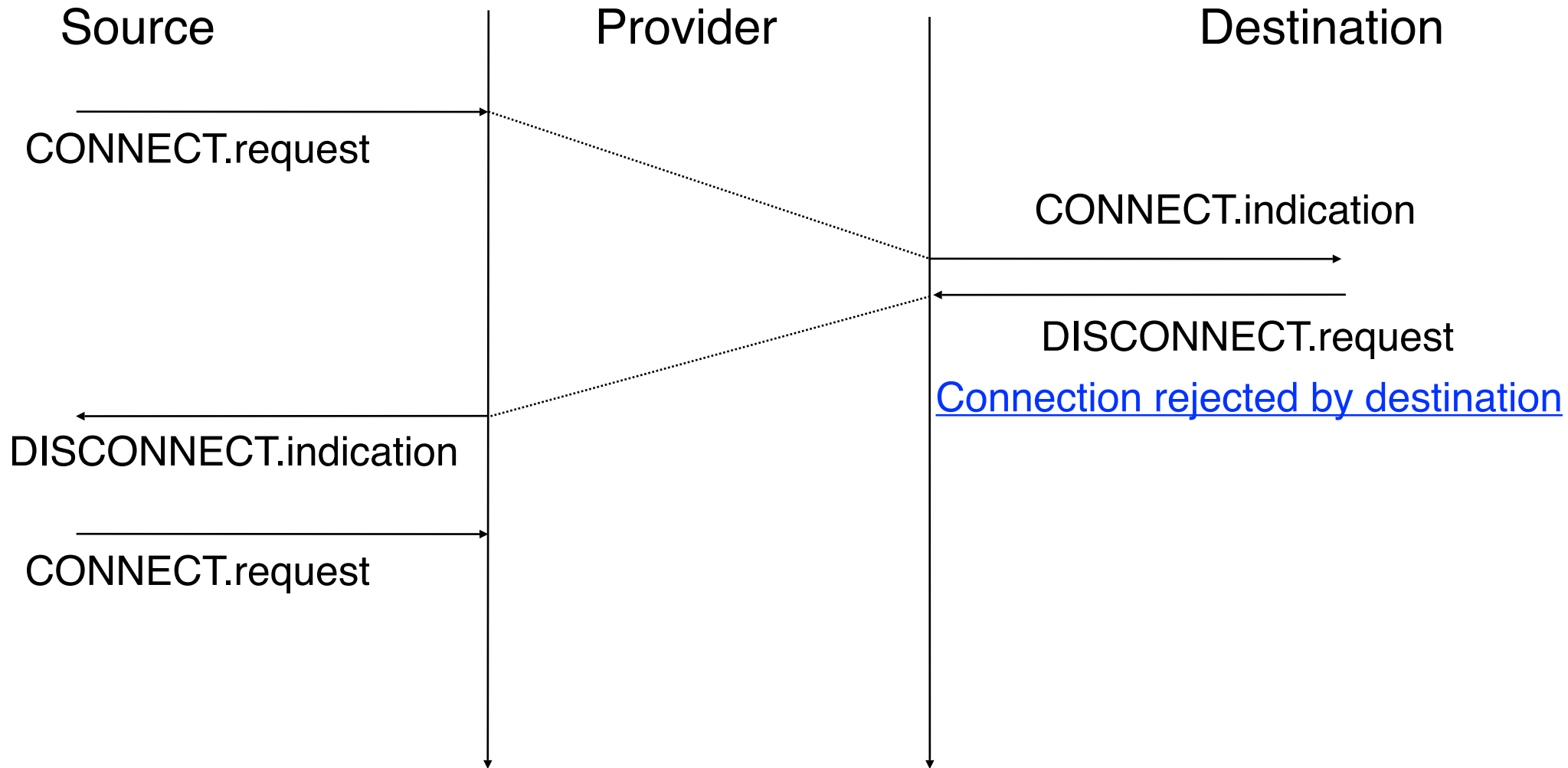
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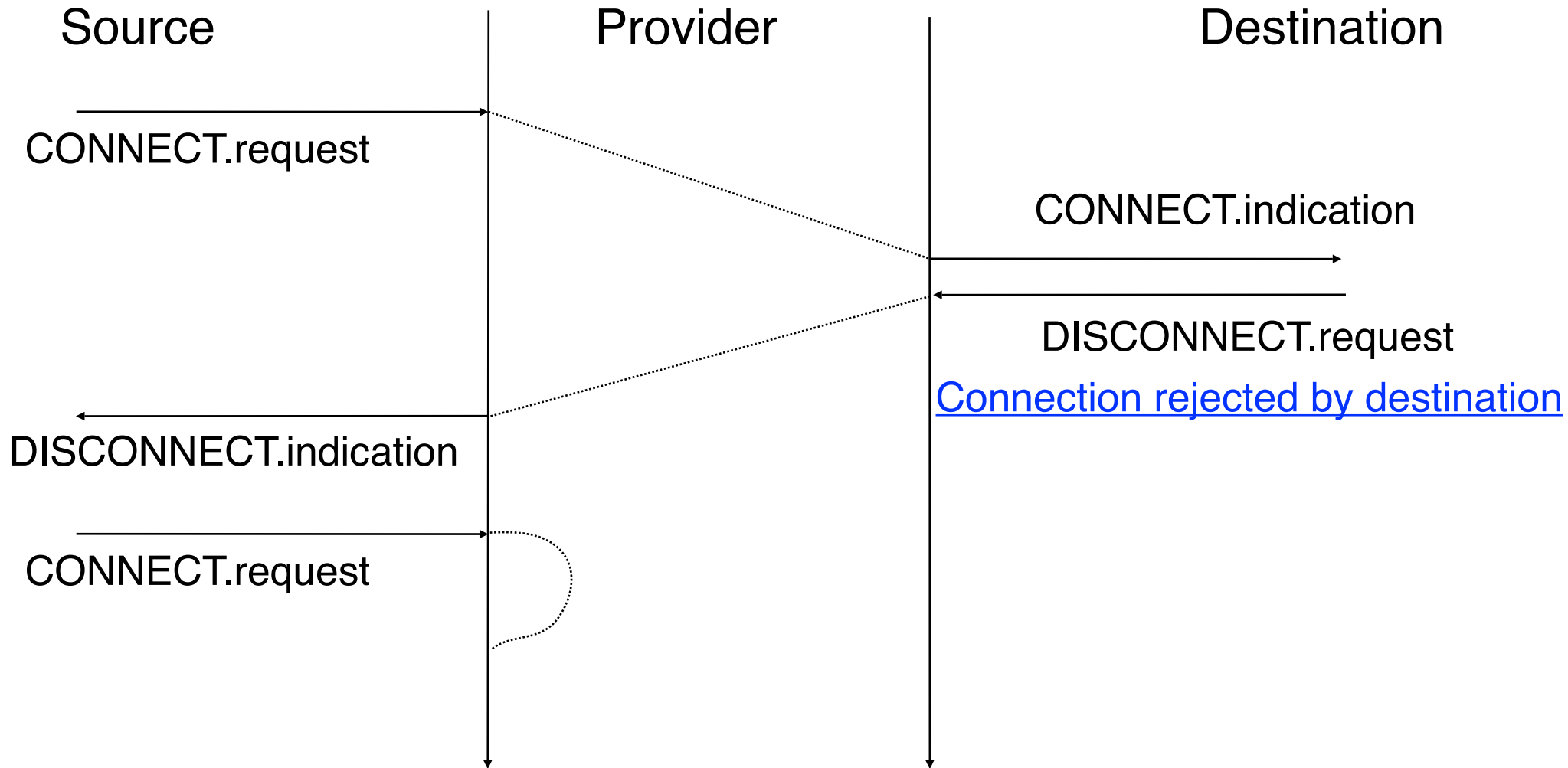
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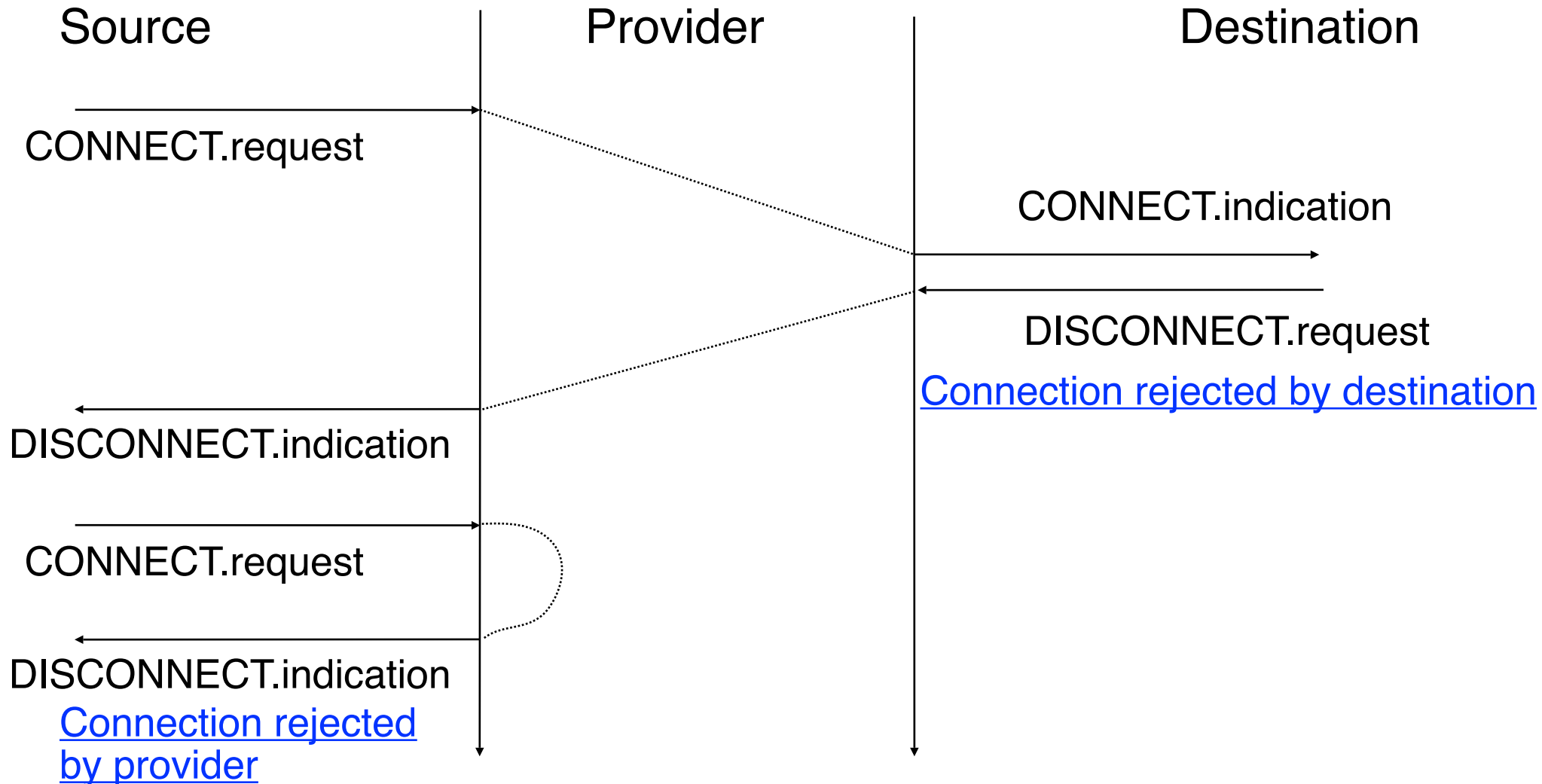
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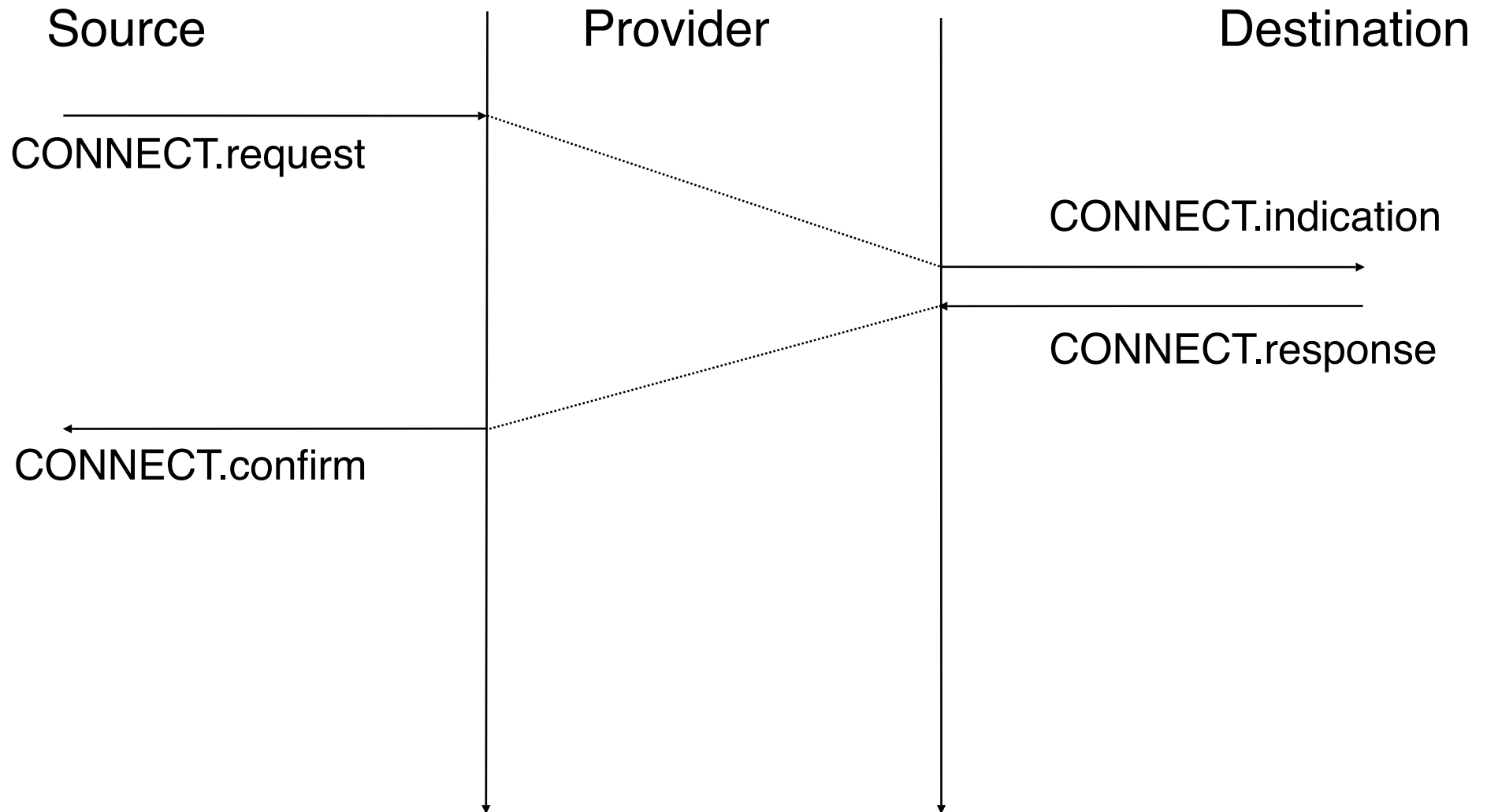


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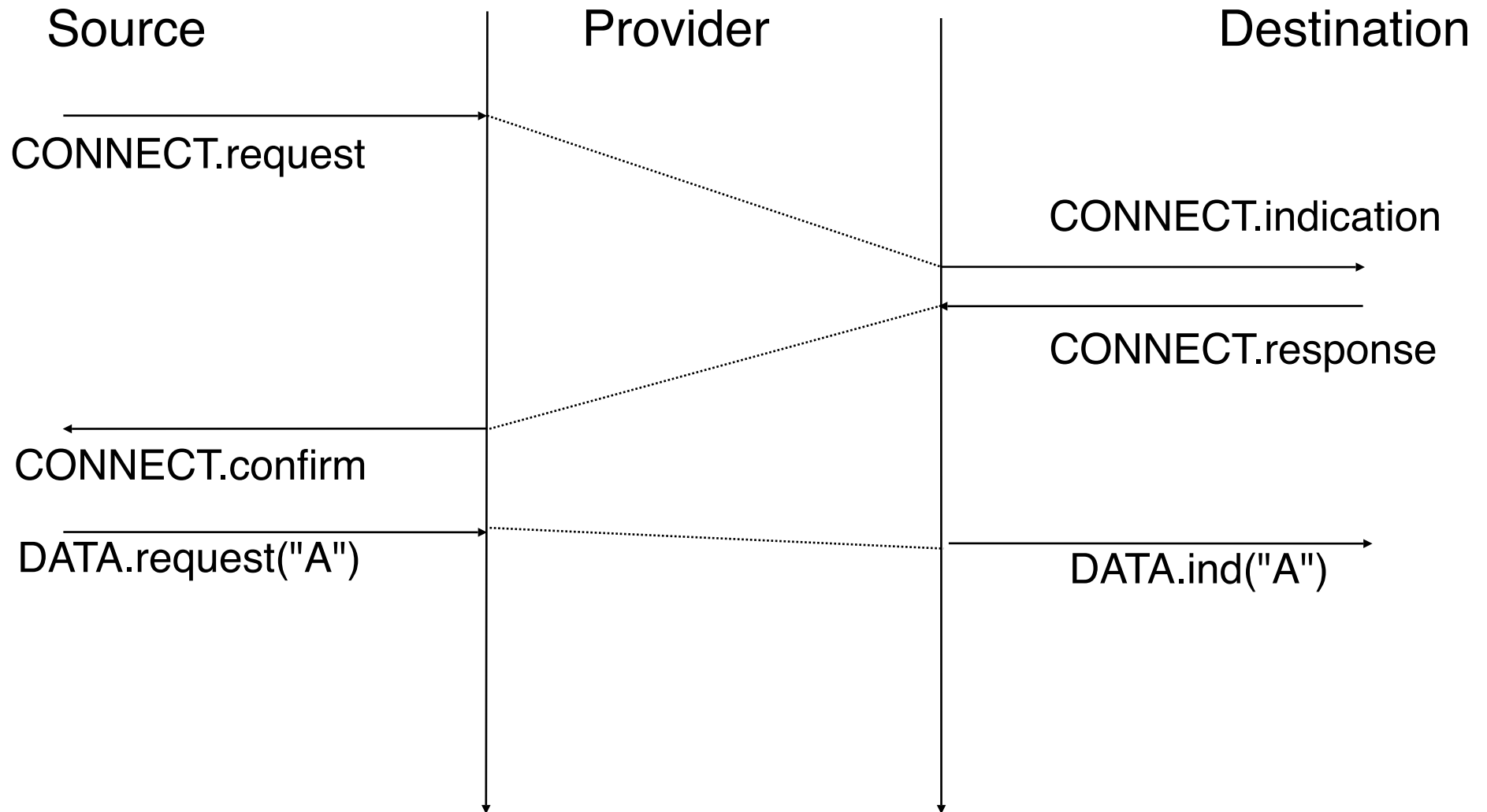
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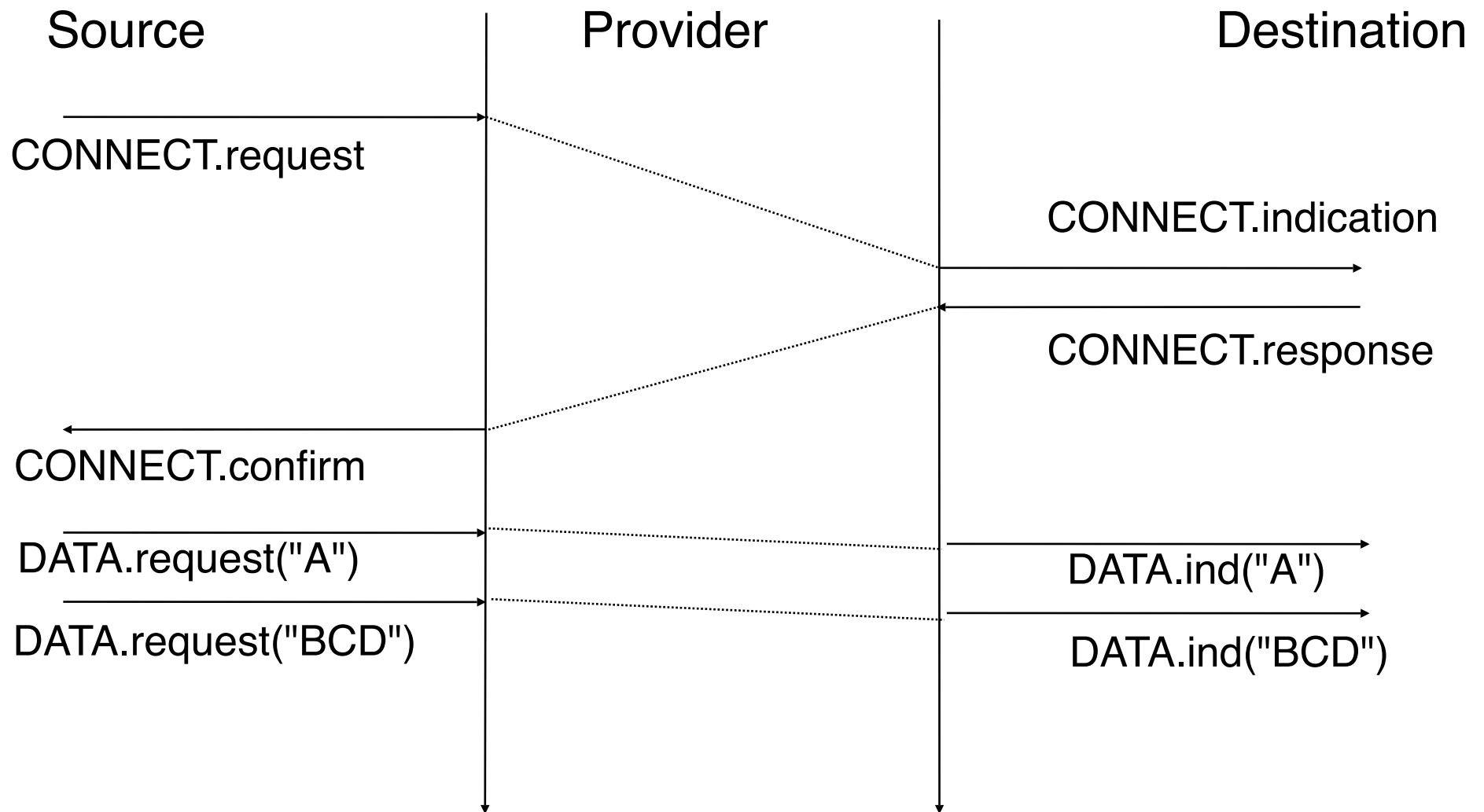
Data transfer : message mode



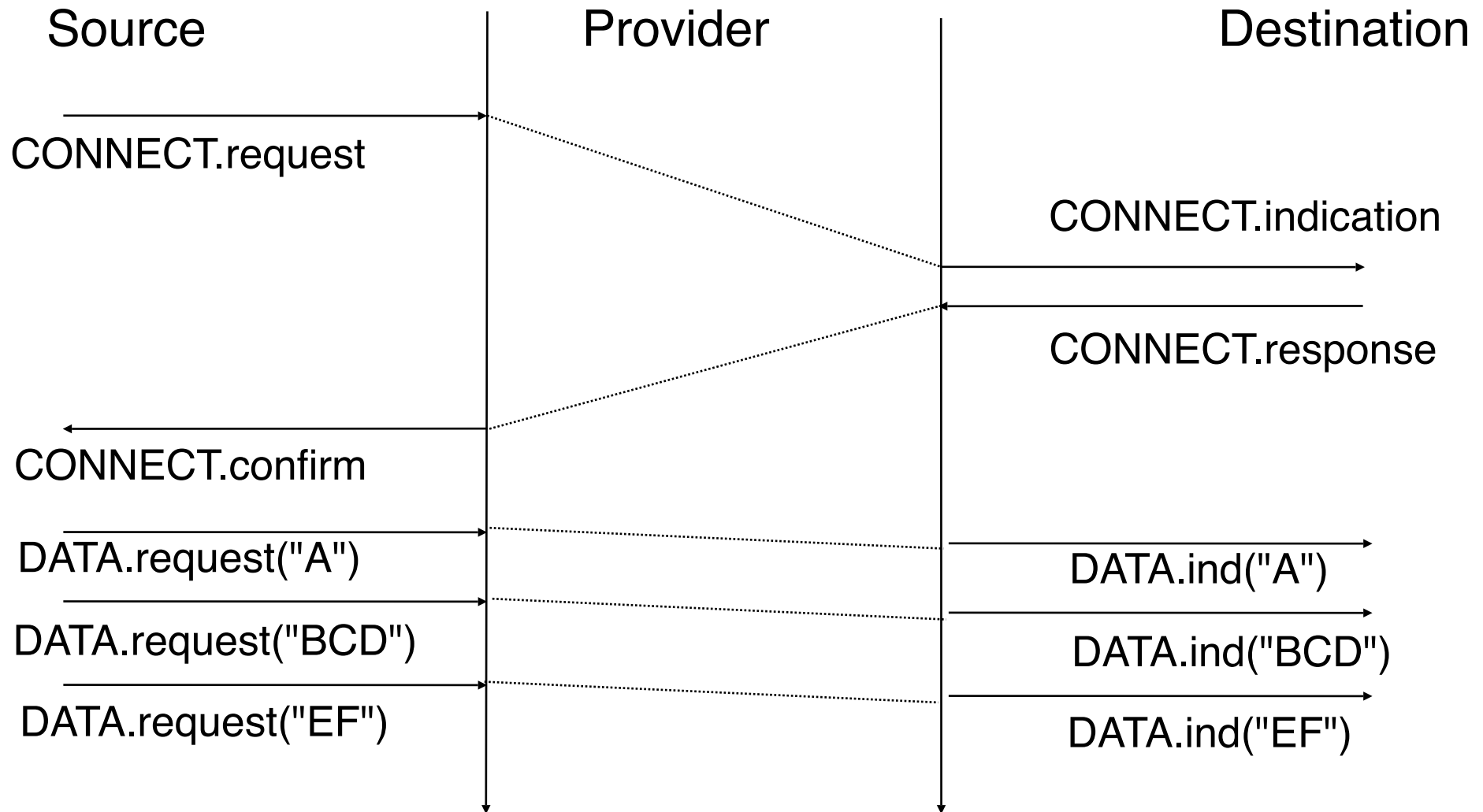
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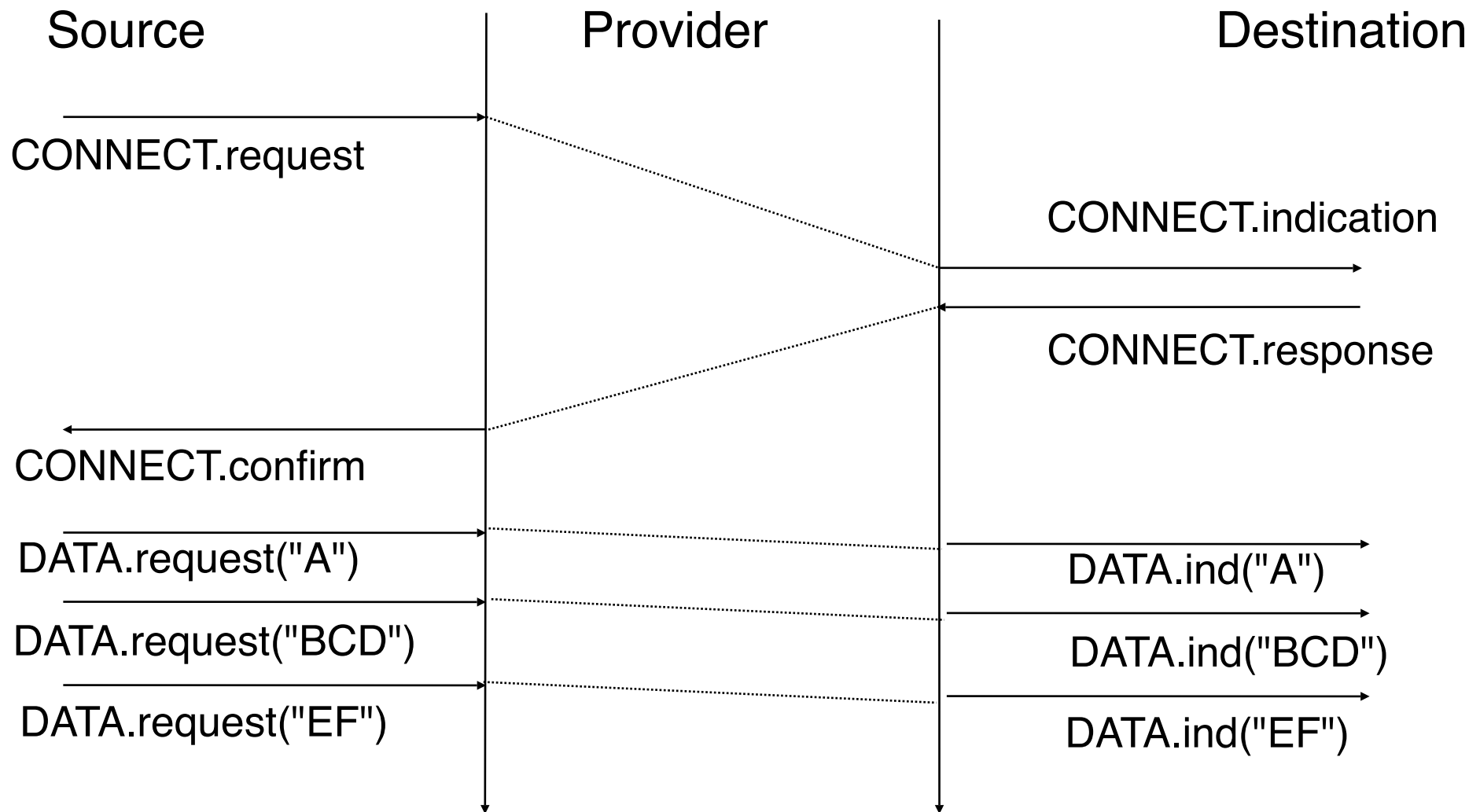
Data transfer : message mode



Data transfer : message mode



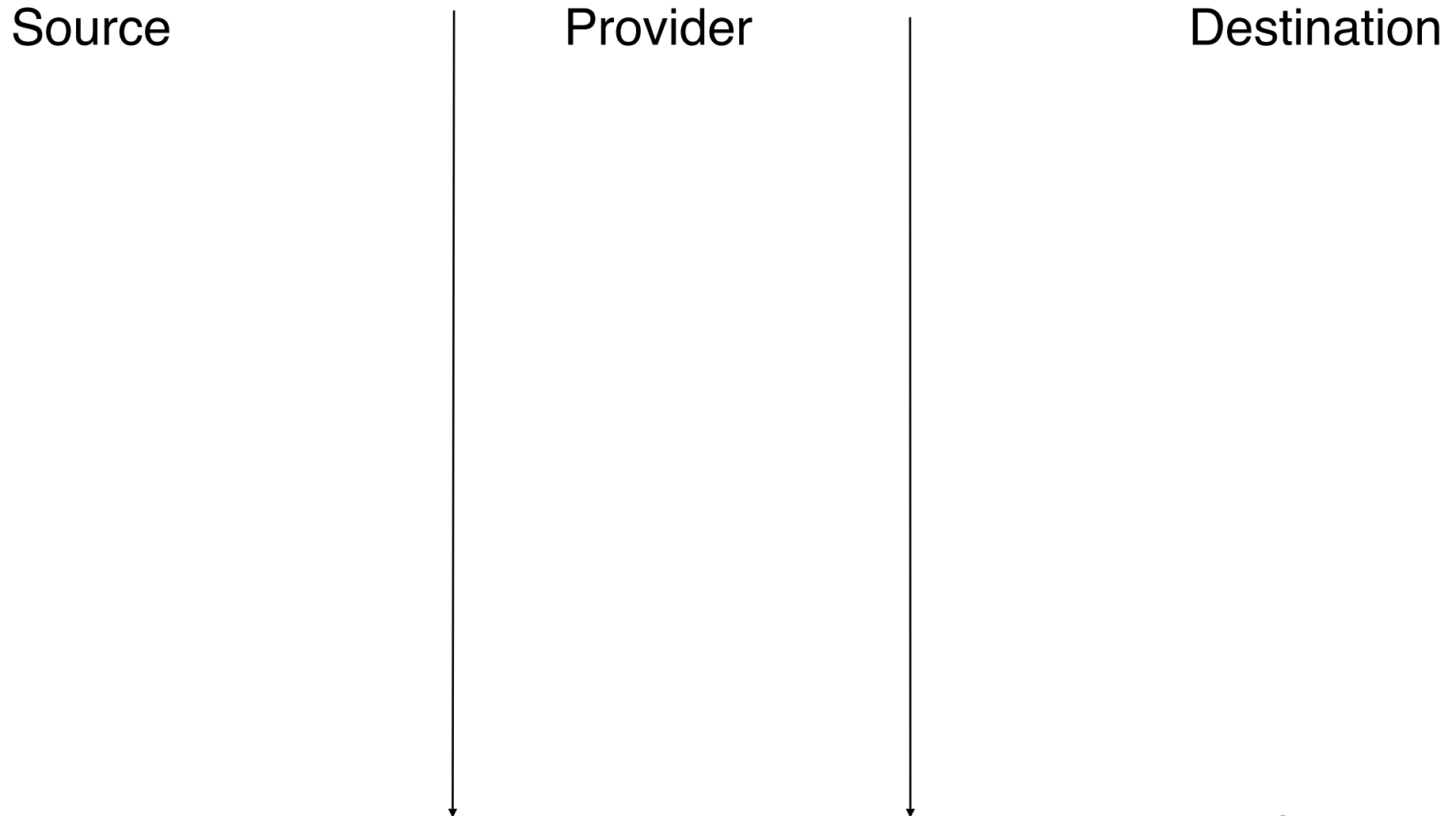
Data transfer : message mode



Provider delivers one Data.ind for each Data.req

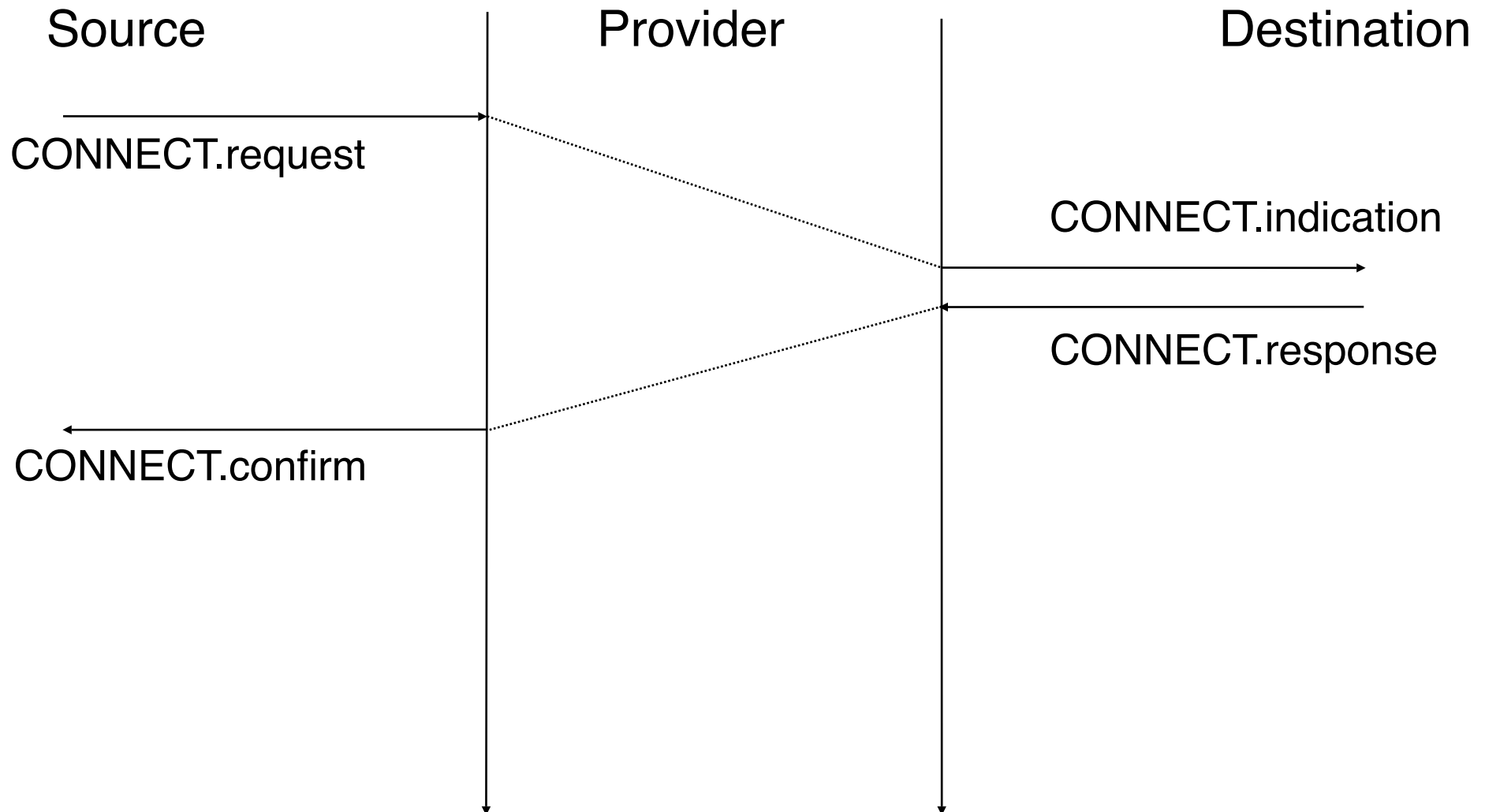
Data transfer : stream mode

The providers delivers a **stream of characters** from source to destination



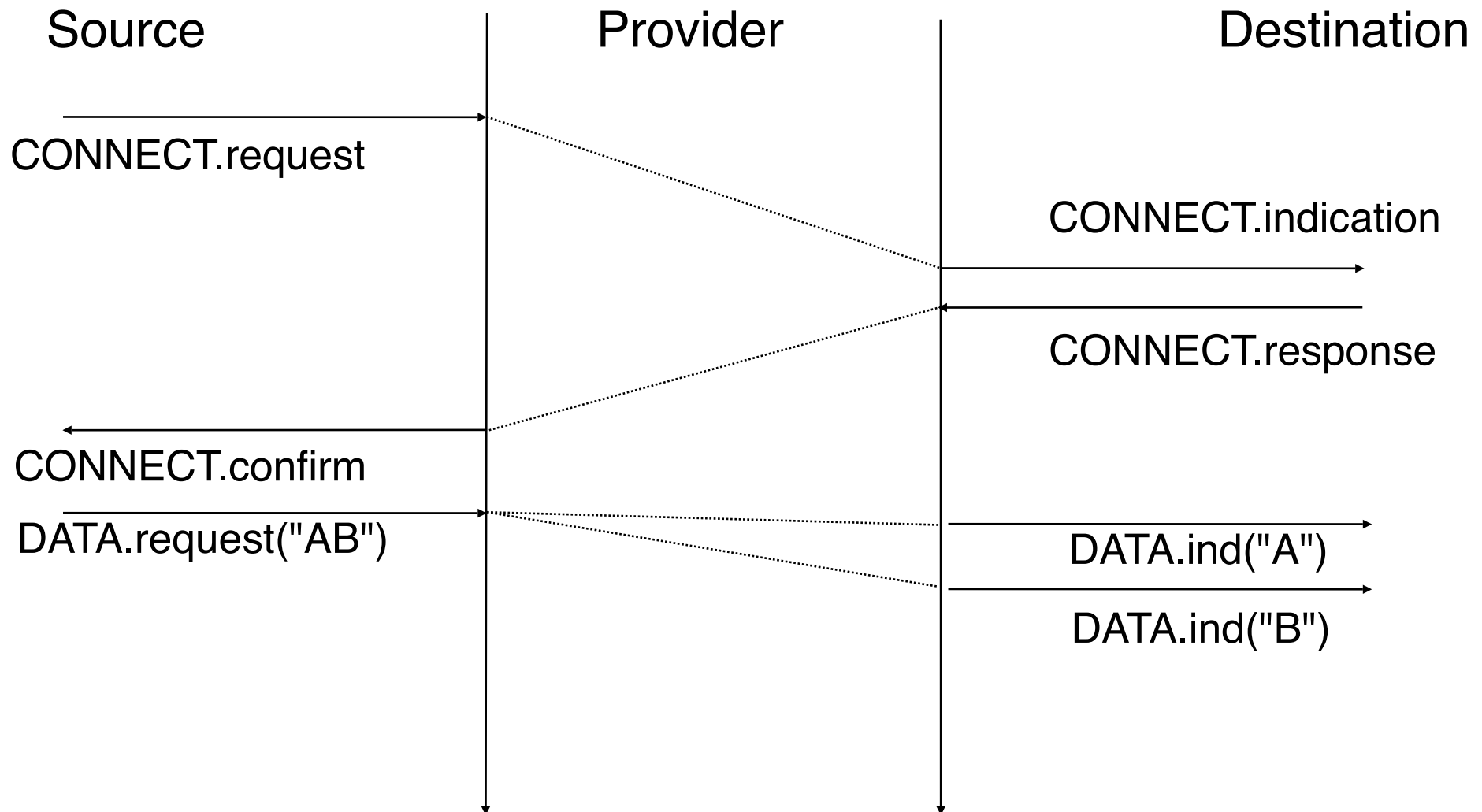
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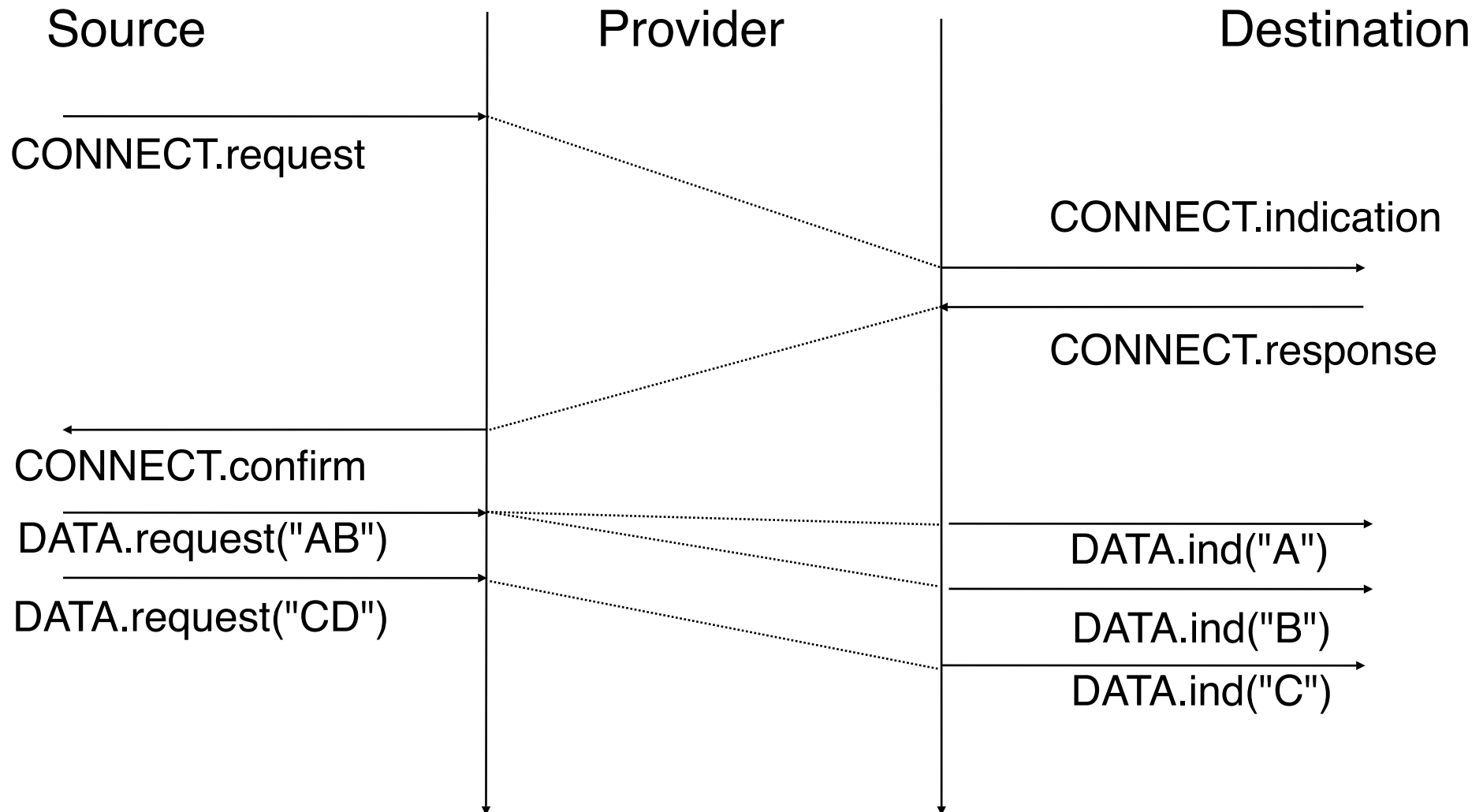
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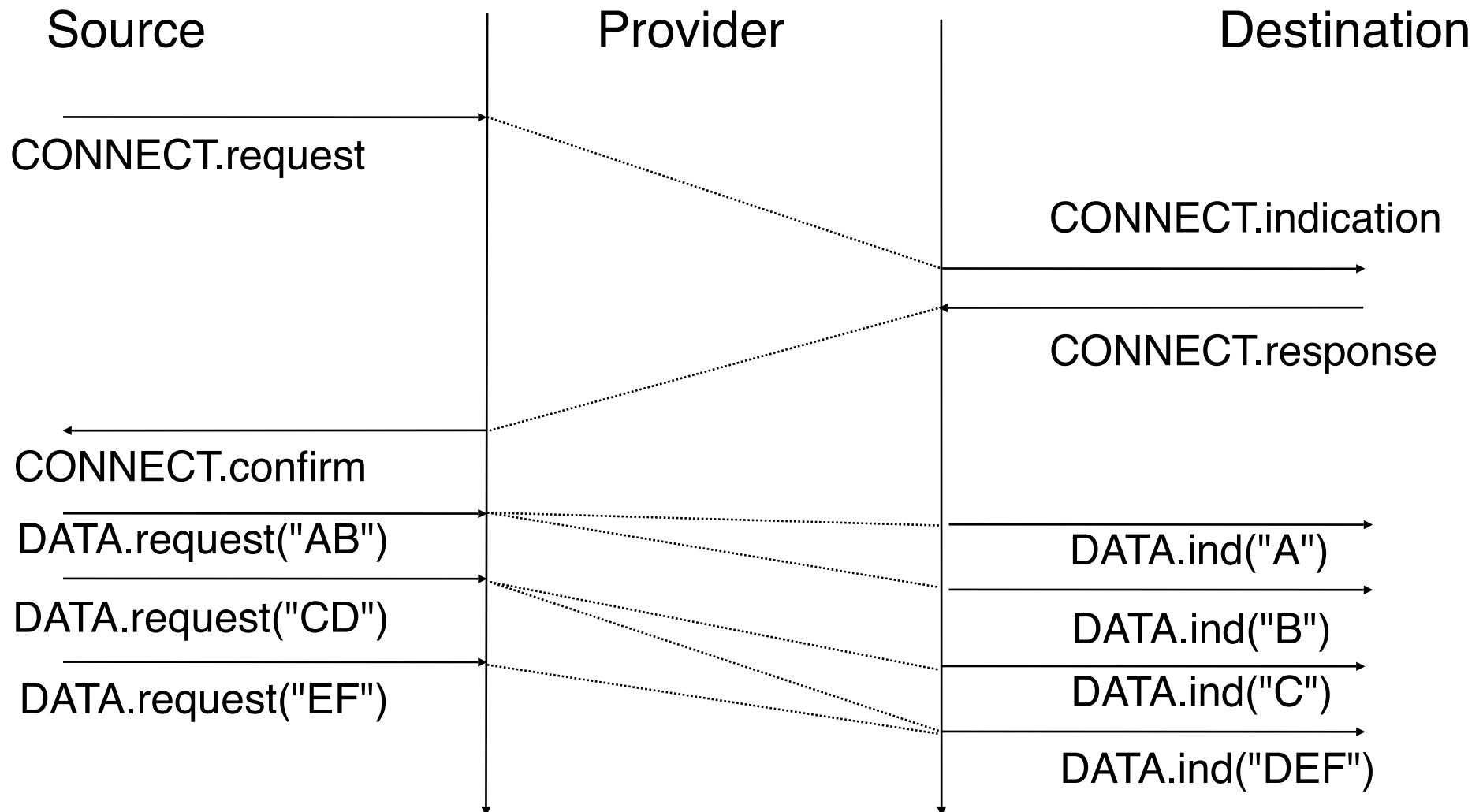
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Data transfer : stream mode

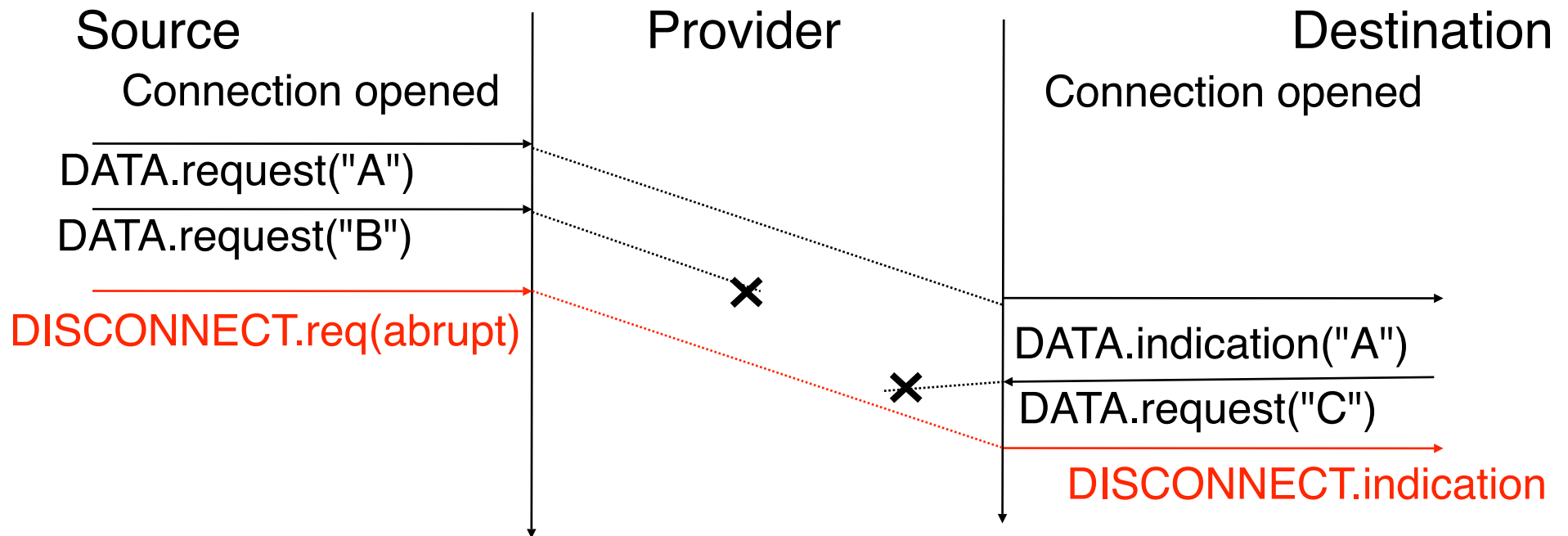
The providers delivers a **stream of characters** from source to destination



Connection release

Abrupt release

SDUs can be lost during connection release



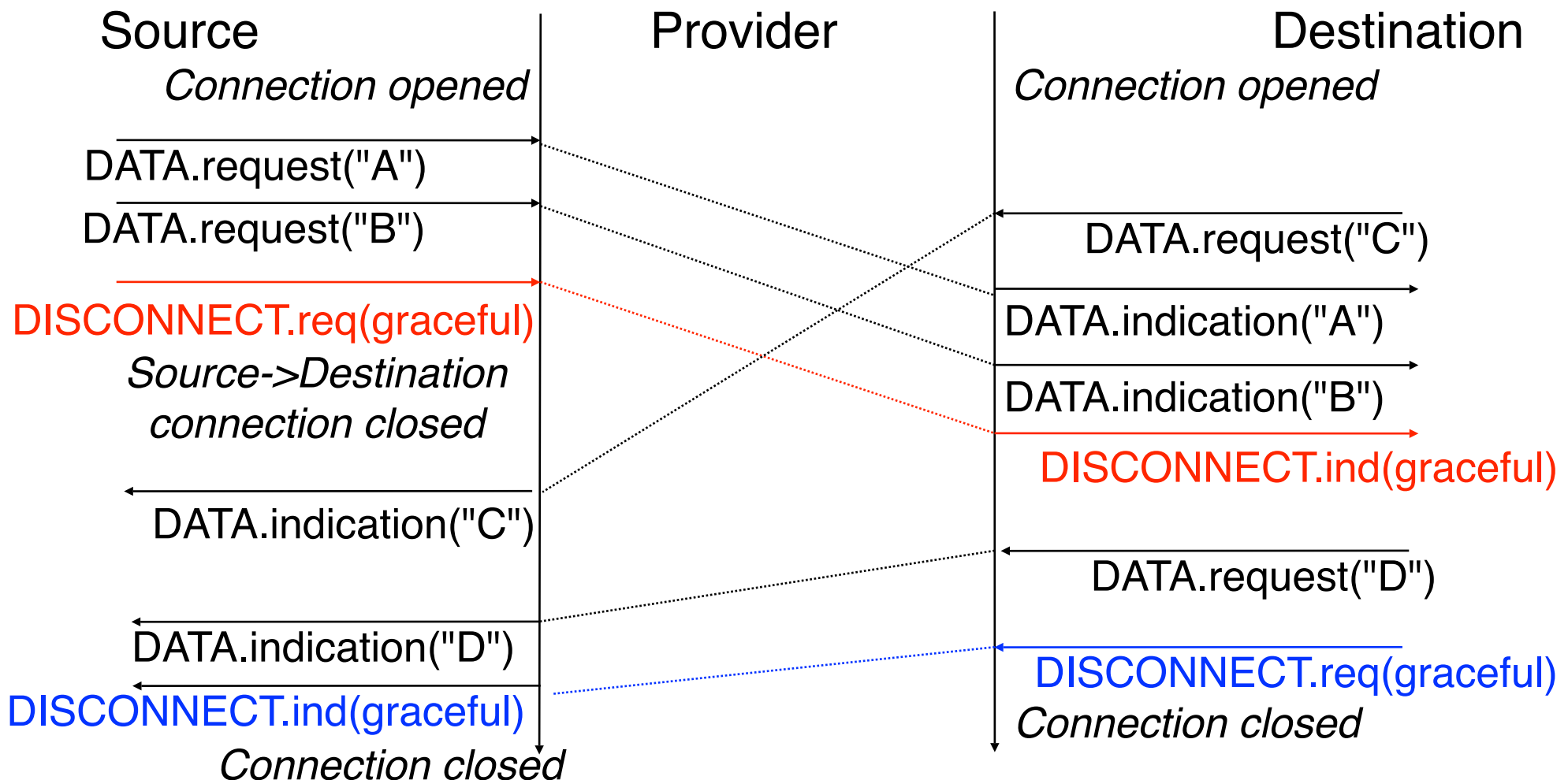
Such an abrupt connection release can be caused by the network provider or by the users

Connection release (2)

Ordered/graceful connection release

A single direction is closed at a time

no SDUs can be lost



Characteristics of the connection-oriented service

Possible characteristics

- bidirectional transmission

 - both users can send and received SDUs

- reliable delivery

 - All SDUs are delivered in sequence

 - No SDU can be lost

 - No SDU can be corrupted

- message mode or stream mode

- Connection release

 - Usually abrupt when the provider is forced to release a connection

 - Abrupt or graceful when the users request the end of a connection

Module 1 : Basics

- Contents
 - Introduction
 - Services in computer networks
 - Connectionless service
 - Connection oriented service
 - • Layered reference models

Layered reference models

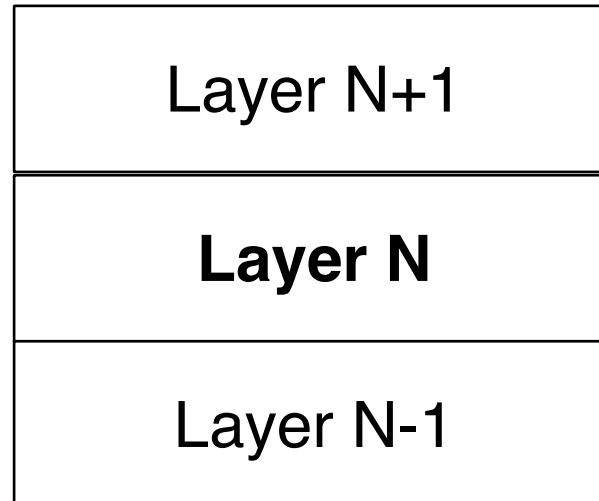
Problem

How is it possible to reason about complex systems such as computer networks or the Internet ?

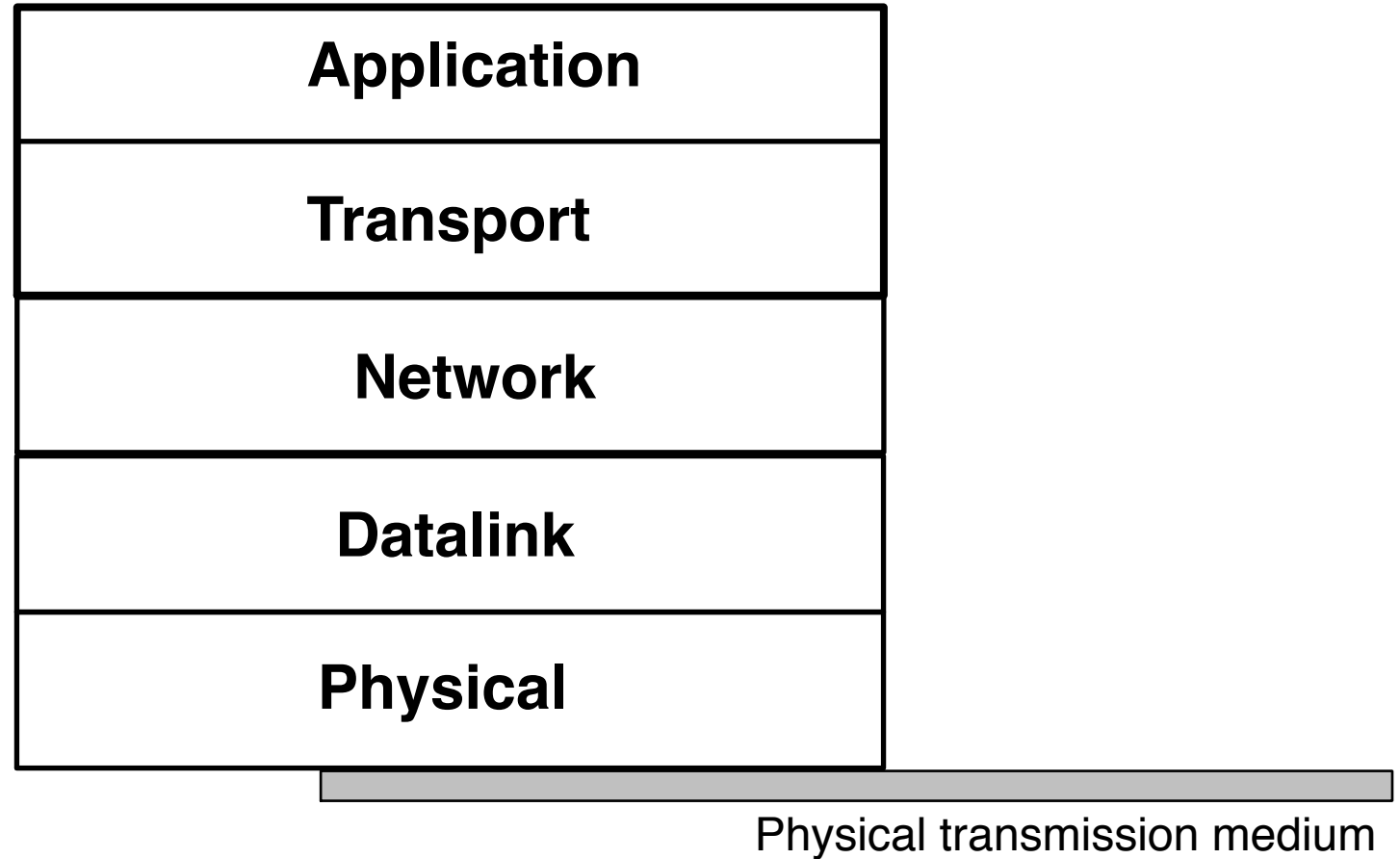
Solution

Divide the network in layers

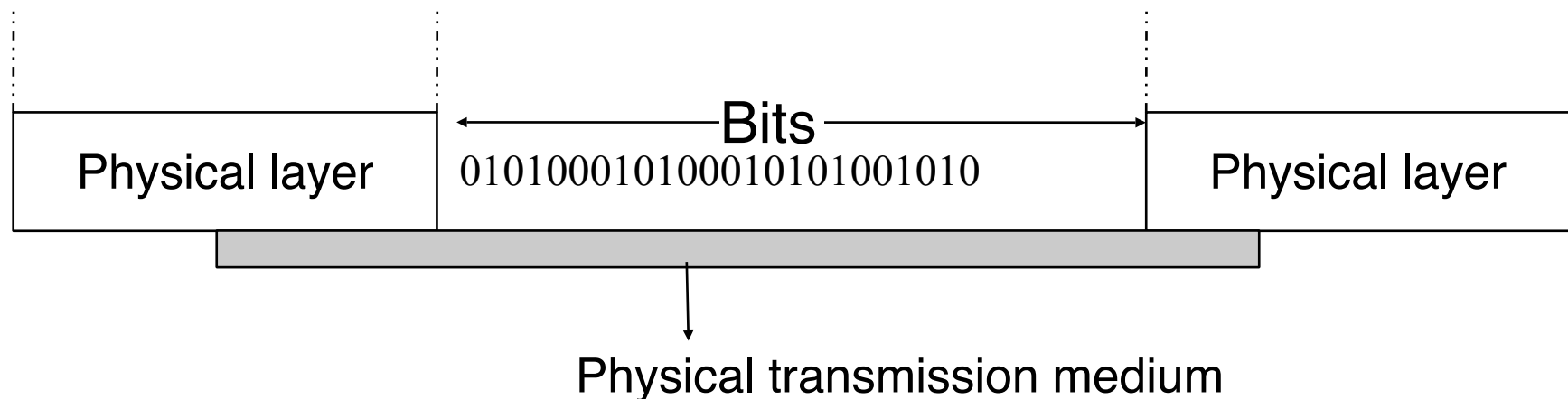
Layer N provides a well defined service to layer N+1 by using the service provided by layer N-1



Layered reference model



The physical layer



Goal

Transmit bits between two physically connected devices

Service provided by physical layer

bit transmission and reception

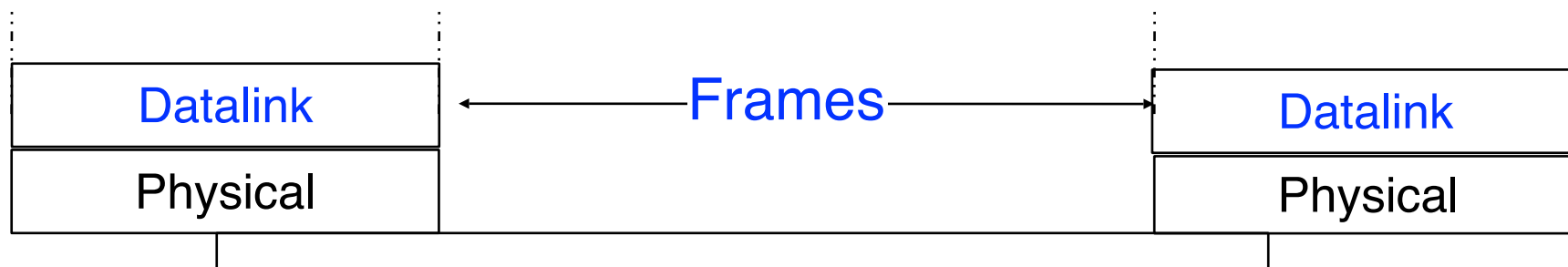
unreliable service

The receiver may decode a 1 while the sender sent 0

Some transmitted bits may be lost

The receiver may decode more bits than the bits that were sent by the sender

The datalink layer



Goals

Provide a service that allows the exchange of frames

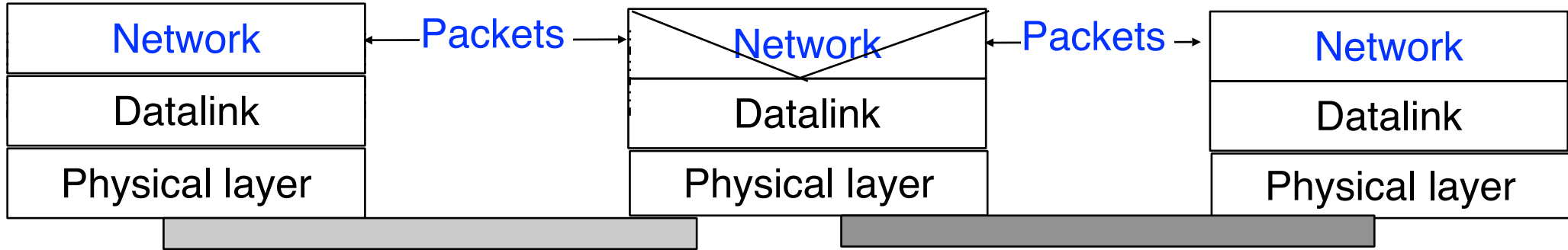
Frame : structured group of bits

Support local area networks

Services

- Reliable connection-oriented service
- Unreliable connectionless service

The Network Layer



Goals

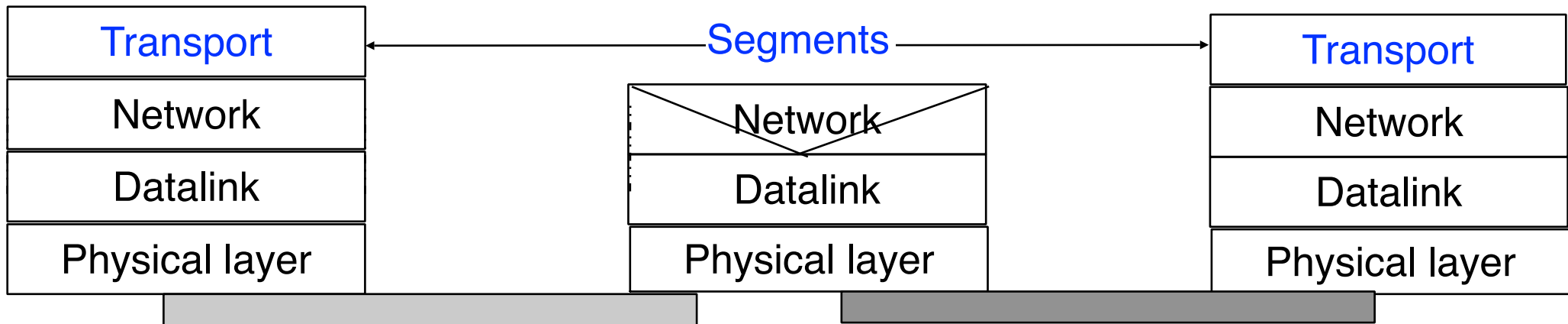
Allow information to be exchanged between hosts that are not attached to the same physical medium by using relays

The unit of information in the network layer is called a packet

Services

unreliable connectionless (Internet)
reliable connection-oriented

The Transport Layer



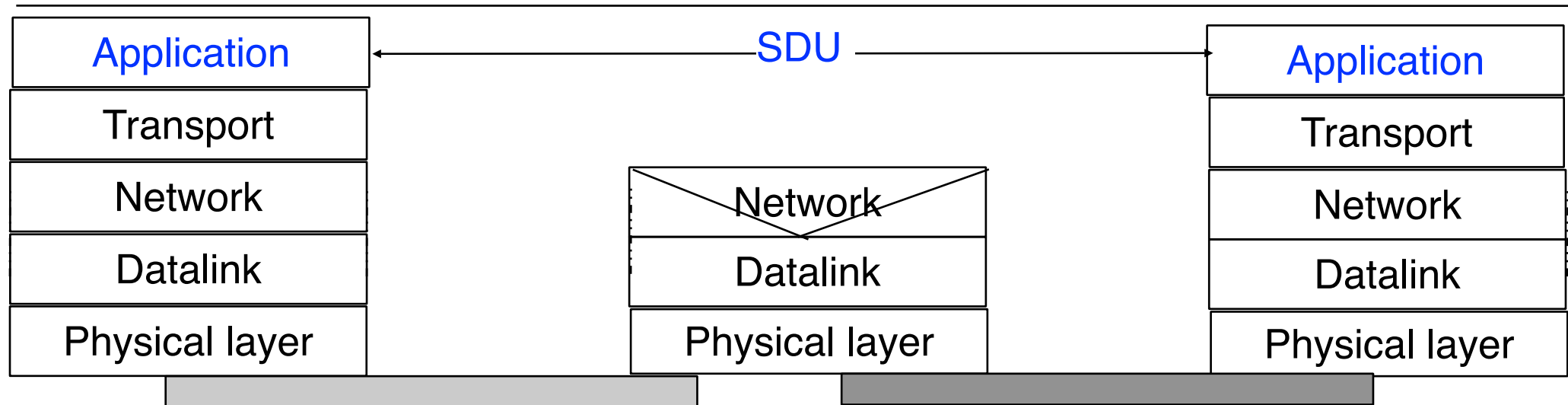
Goals

Ensure a reliable exchange of data between endsystems even if the network layer does not provide a reliable service

Services

Unreliable connectionless service
Reliable connection-oriented service

The application layer



Goals

Exchange useful information between applications by relying on the transport layer that hides the complexity of the network

Unit of information

Service Data Unit, SDU