

Functions of the Internet Protocols (1/4)

1

Networks provide different services:

- **Connectionless services:**

- Communication takes place without connection setup, packets are simply sent into the network
→ Example: datagram transport with IPv4

- **Connection-oriented services:**

- Communication takes place after a connection has been set up. In result, all data packets are sent and received in the correct order
→ Example: connection setup with TCP

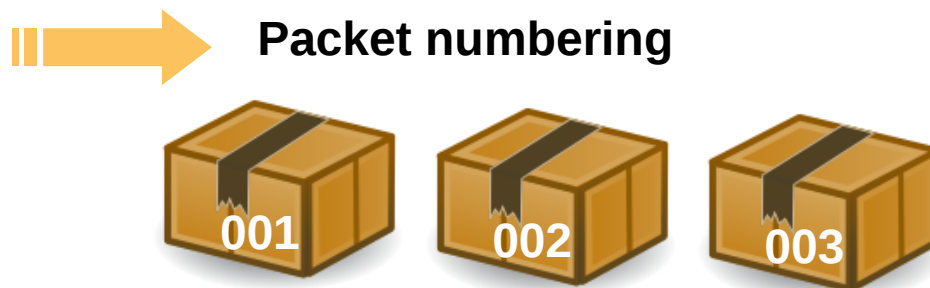
Functions of the Internet Protocols (2/4)

2

Internet protocols IPv4 and IPv6 implement a **connectionless service**

What problems have to be solved in this case?

- Transformation of network protocols offering a connection-oriented service into protocols that use a connectionless service
- Order/sequence of the data packets cannot be guaranteed in connectionless services



Functions of the Internet Protocols (3/4)

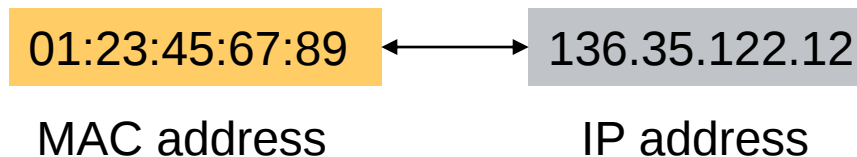
3

Internet protocols offer a uniform, network-wide **addressing scheme** and provide address translation at network interfaces.

Needed are

- Directory services that allow the assignment of different address types
- Protocol (→ ARP) at the interfaces of Internet layer and network access layer to translate addresses

Example:



Functions of the Internet Protocols (4/4)

4

Correct forwarding of data packets over various networks with different technical operating parameters

Problem: E.g. maximum packet size

- If a data packet encounters a network whose **MTU** (Maximum Transfer Unit, maximum data packet size allowed) is smaller than that of the data packet to be forwarded, the data packet must be broken down – „fragmented“ – accordingly
- At the same time, additional information must be added so that
 - the single data packets can be sent solely through the Internet and that
 - they can be put back together again – “defragmented” – correctly

TCP/IP Protocol Stack

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Development of TCP/IP protocol family began in the 1970s. Concept of Internetworking was developed by the designers of TCP/IP

- The ISO/OSI Reference Model is older than the concept of Internetworking – for this reason the Internet protocol layer is missing in the OSI protocol stack ...

TCP/IP Protocol Stack

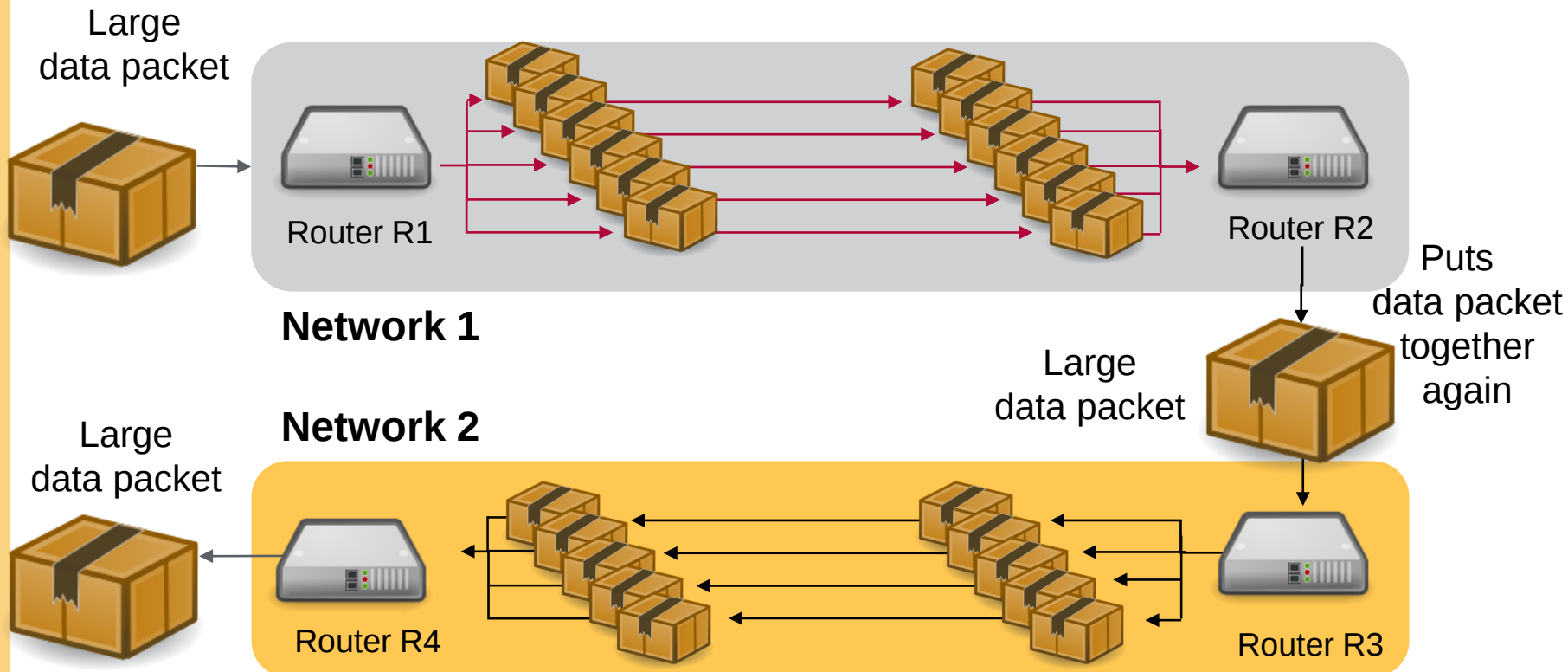


4	OSI: Session, Presentation, Application TCP/IP: Application Layer
3	OSI: Transport TCP/IP: Transport Layer
2	OSI: Network TCP/IP: Internet Layer
1	OSI: Physical and Data Link TCP/IP: Network Access Layer
0	(TCP/IP: Hardware Layer)

Fragmentation (1/5)

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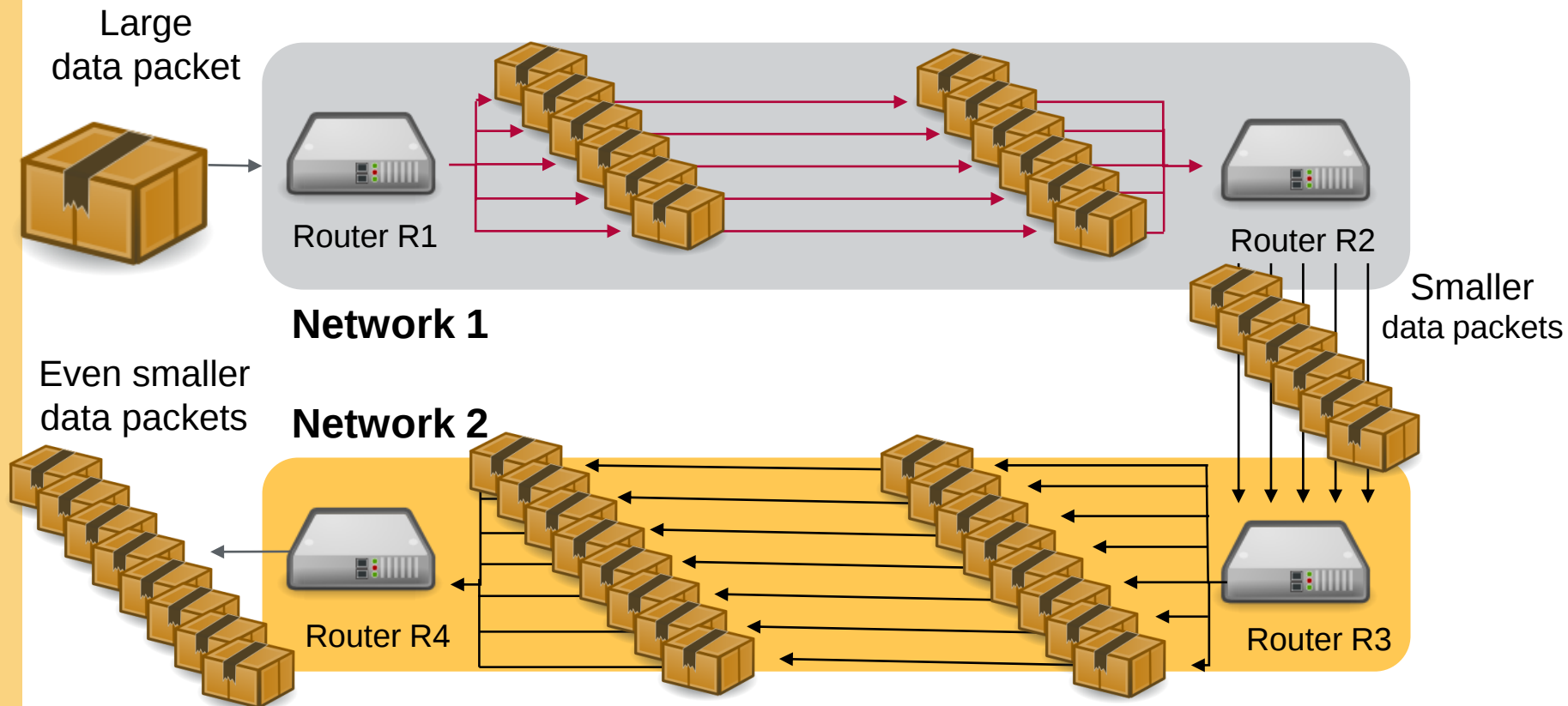
Transparent Fragmentation



Fragmentation (1/5)

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Non-Transparent Fragmentation

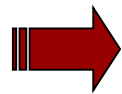


Fragmentation (3/5)

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Problems:

- Receiver must be able to **correctly reassemble** individual data packets
- Data packets can reach their goal on different paths
 - **different fragmentation** history with different fragmentation sizes can occur
 - **transmission errors** may require **retransmission** of a fragment, which is implemented along another path and there again leads to another fragmentation



How can correct assembly be ensured?

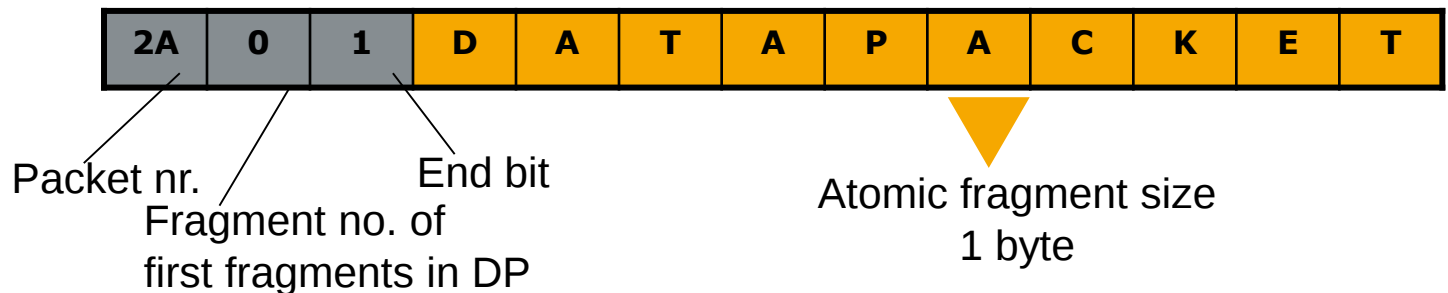
Fragmentation (4/5)

9

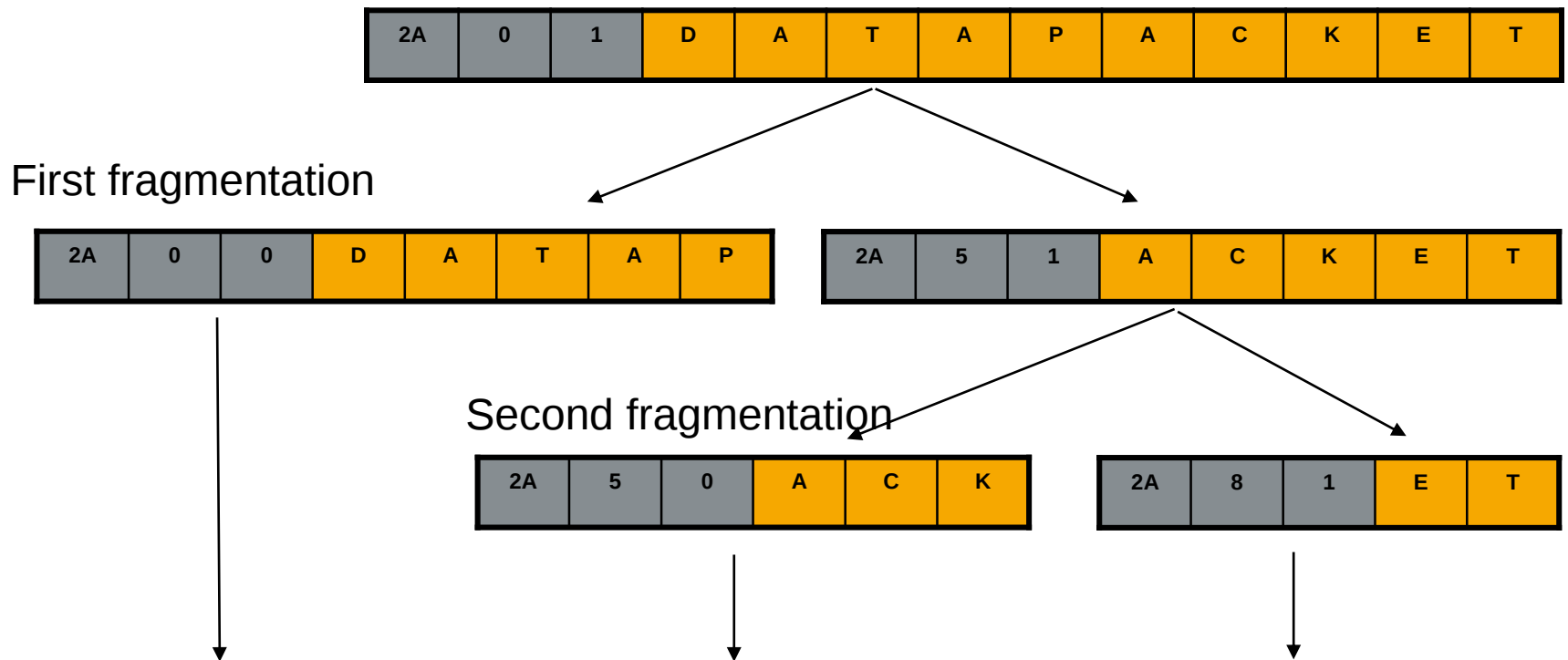
Establishment of an **atomic fragment size**
(the smallest size of fragments allowed)

Additional information in the header of the data packet:

- Packet number
- Number of the first fragment contained in the IP data packet
- Control bit indicating whether this is the last fragment in a data packet (=1) or whether there are more fragments to follow (=0)



Fragmentation (5/5)



Problems in Internetworking: Consistent Error Handling

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Individual networks react differently to transmission errors, e.g.

- discarding the erroneous data packet,
- new request for erroneous or missing data packet, or
- automatic error correction
- ...

Internet protocols implement consistent error handling

- Heterogeneous networks have different **Quality of Service** parameters
- Different reactions of the individual network technologies to **overload** and **congestion** situations at the routers
 - very problematic in the context of different error handling and maximum packet sizes
 - data packet loss can occur at routers

Internet protocols implement a rudimentary **flow control / congestion control**

- Heterogeneous networks implement different **encryption methods** and rules for the handling of confidential data
- Coordination and implementation is labor-intensive and often not completely possible

Internet protocols guarantee rudimentary **security requirements**

Problems in Internetworking: Rudimentary Accounting Systems

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Accounting is done in different networks according to varying criteria, e.g.

- based on **connection duration**
- based on **amount of data** transmitted (can even be calculated differently in each case)

Internet protocols implement rudimentary **accounting systems**