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Network Layer

Why layering needed?

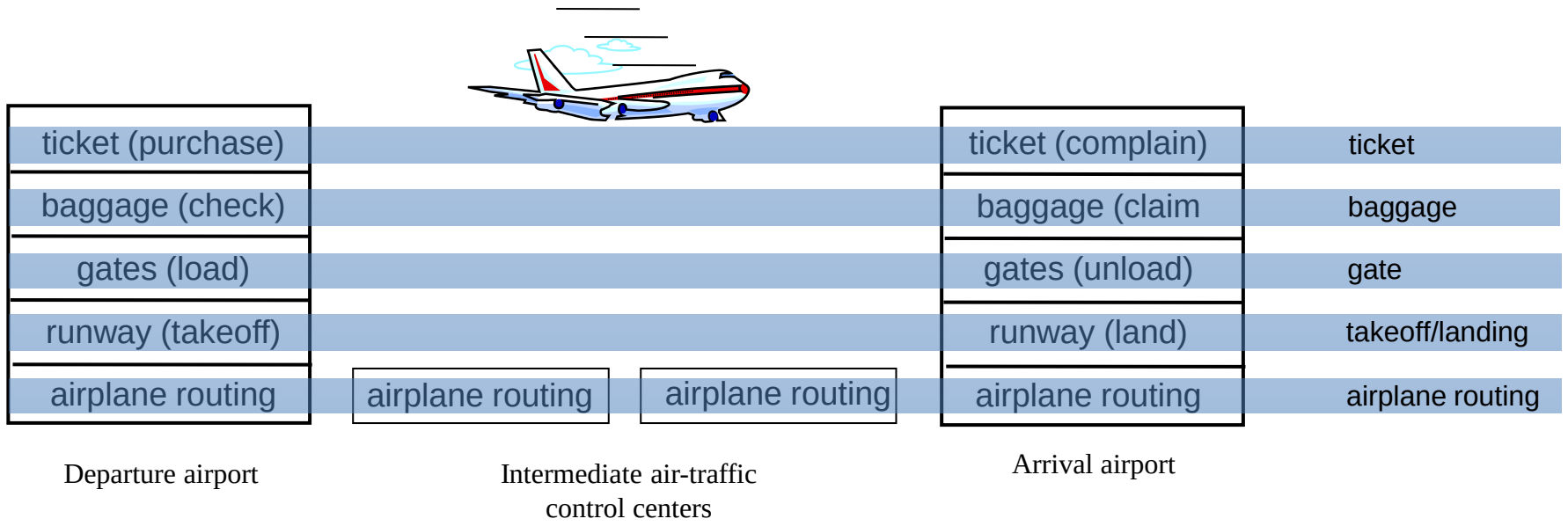

Fig 1. Layering Example

Services

- **Packetizing**
- **Routing and Forwarding**

Other expected services

- **Error Control**
- **Flow Control**
- **Congestion Control**
- **Quality of Service**
- **Security**

Delay Types

- **Transmission Delay**

  $Delay_{tr}$ = *(packet length)/(transmission rate)*

- **Propagation Delay**

  $Delay_{pg}$ = *(distance)/(propagation speed)*

- **Processing Delay**

  $Delay_{pr}$ = *time required to process a packet in router*

- **Queueing Delay**

  $Delay_{qu}$ = *time a packet waits in input/output queues*

Total Delay?

Throughput

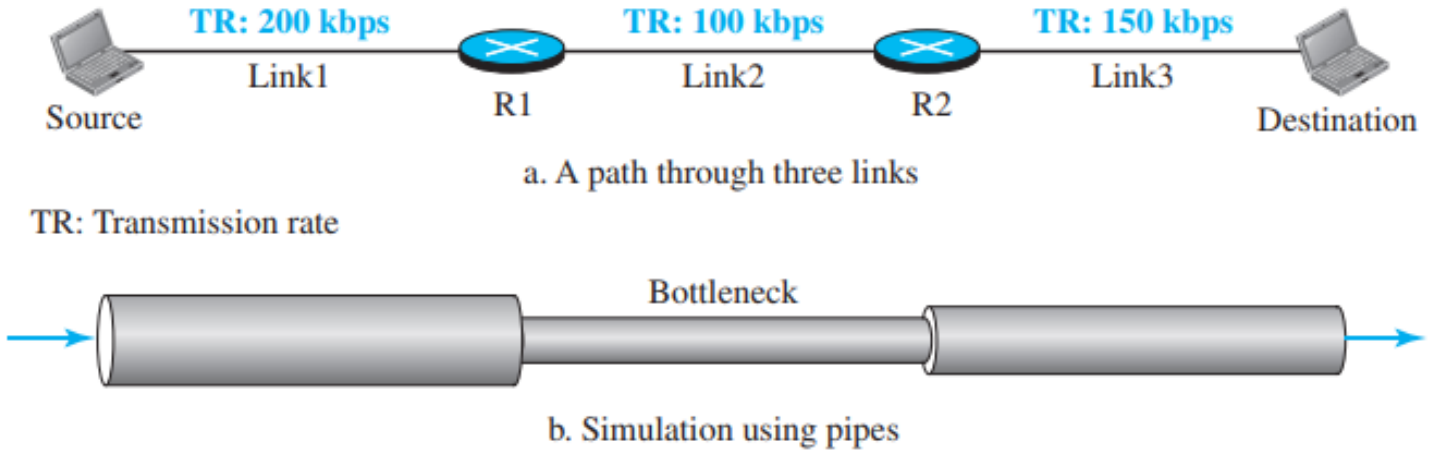

Fig 2. Throughput Example

$$Throughput = min(TR_1, TR_2, \ldots, TR_n)$$

Bandwidth Vs Throughput

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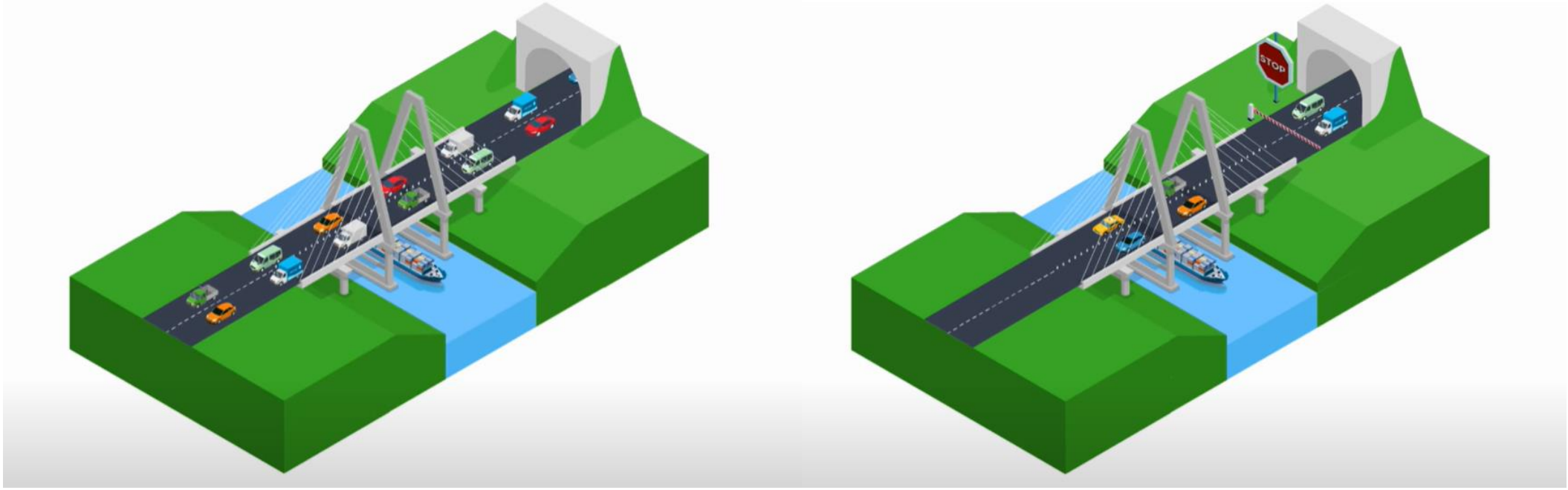

Fig 3(a). Bandwidth

Fig 3(b). Throughput

IPv4 Addresses

- **IP Address**
  - 32-bit address
  - Address of the connection (interface), not the host/router

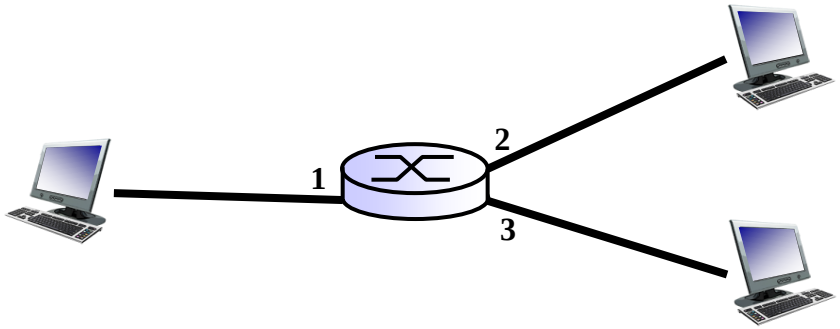

Fig 4(a). Router with connections

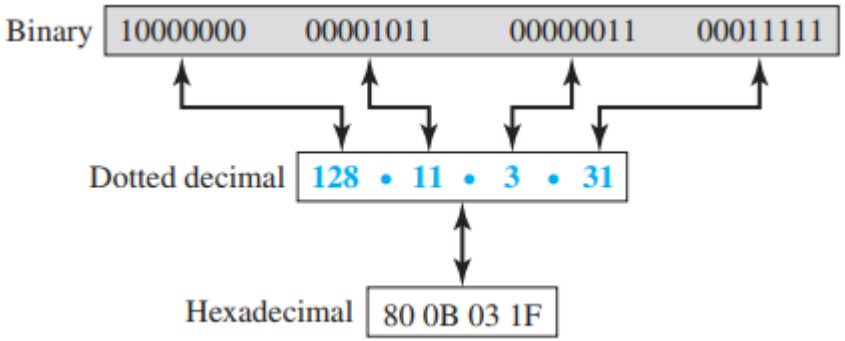

Fig 4(b). Types of notation

- **Address space**
  - Total number of possible addresses = 2^{32}
  - Binary notation (base2), dotted-decimal notation (base256), hexadecimal notation (base16)