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6.033 Computer System Engineering  
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# Best effort network

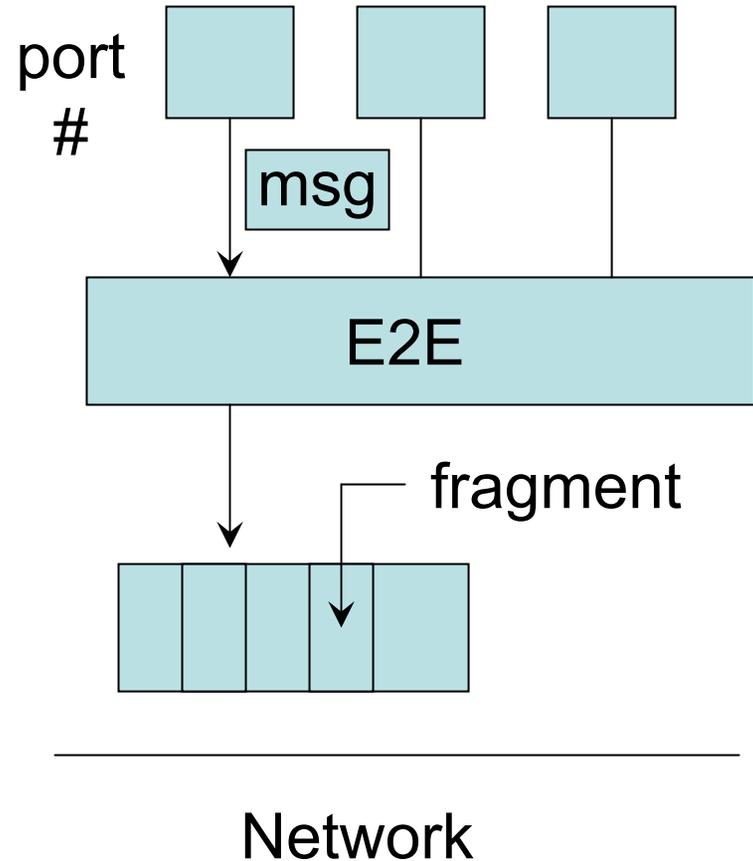
- Losses ←
- Reordering
- Delays / Congestion

## E2E Layer

- Multiplexing
- Fragmentation
- Delays / Congestion

Stream →

loss-free, in-order



## Loss

“At least once” delivery

“At most once”



“exactly once”

At least once

Acknowledgement (ACK) → Nonce

# Setting Timers

Q: how long to wait?

$$\text{timeout} = \underline{\text{RTT}} + \text{slop}$$

# EWMA

Samples of RTTs  $S_1, \dots, S_{new}$

$$rtt \leftarrow (1 - \alpha) S_{new} + \alpha \cdot rtt$$

$$slop = \beta \cdot var \quad 0 \leq \alpha \leq 1$$

└→ diff between predicted and actual RTT

At most once

Suppress duplicates

Tombstones

Exactly once

“Lock step”

$$t_{\text{put}} = \frac{512 \text{ bytes}}{100 \text{ ms}} \approx 50 \text{ kbits/sec}$$

Performance prob. Multiple overlapping xmissions

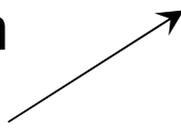
# Flow Control

Receiver driven

Fixed windows

Sliding windows

how much data the receiver  
can accept at one time



## Pick window size

small windows → underutilization

how big is window?

$$\text{window size} \geq \underline{\text{rate}} \times \underline{\text{rtt}}$$