Reliable Data Transfer

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Outline

- Finite-state machines
- Using FSMs to specify protocols
- Principles of reliable data transfer
- Reliability over noisy channels
- ACKs/NACKs

Finite-State Machines

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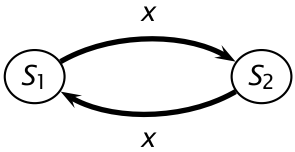
- Ubiquitous in computer science
  - theory of formal languages
  - compiler design
  - theory of computation
  - text processing
  - behavior specification
  - ...

Finite-State Machines



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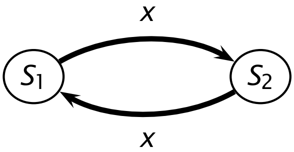
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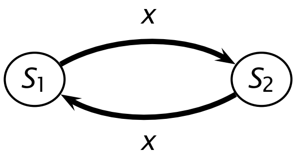
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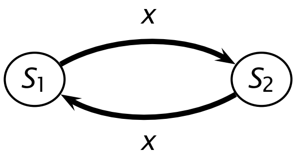
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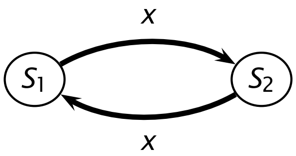

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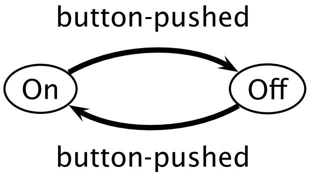

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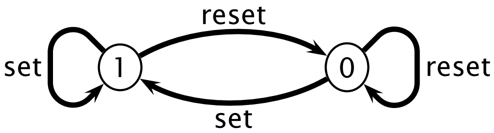

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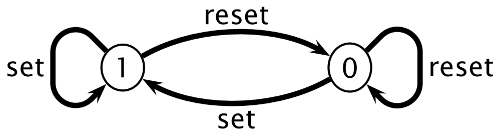

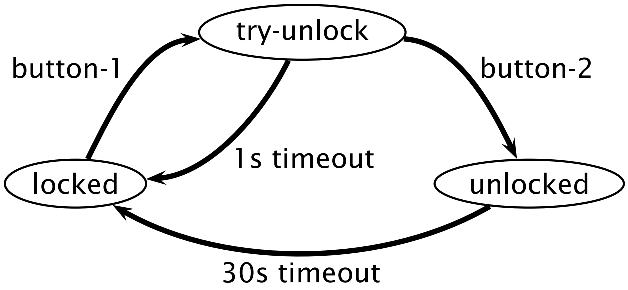

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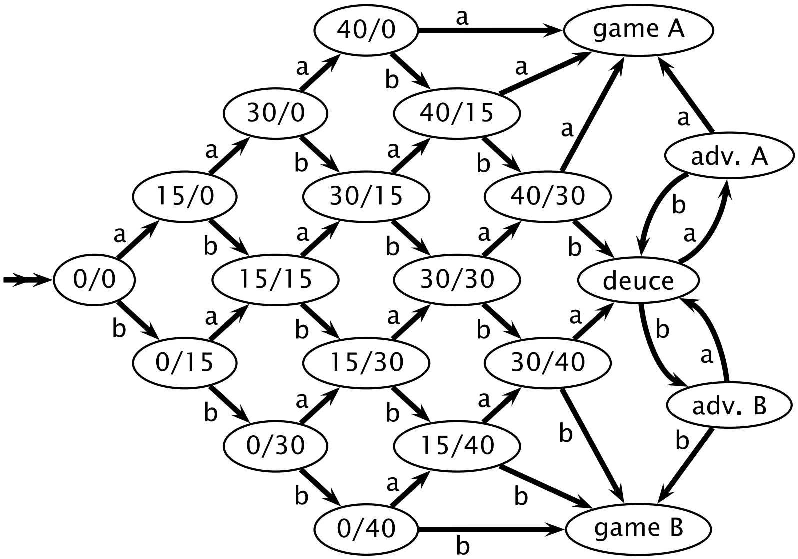

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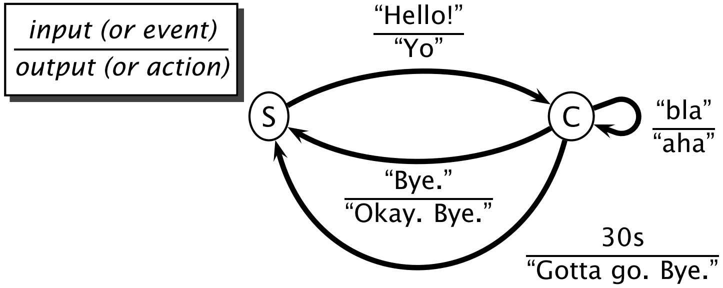
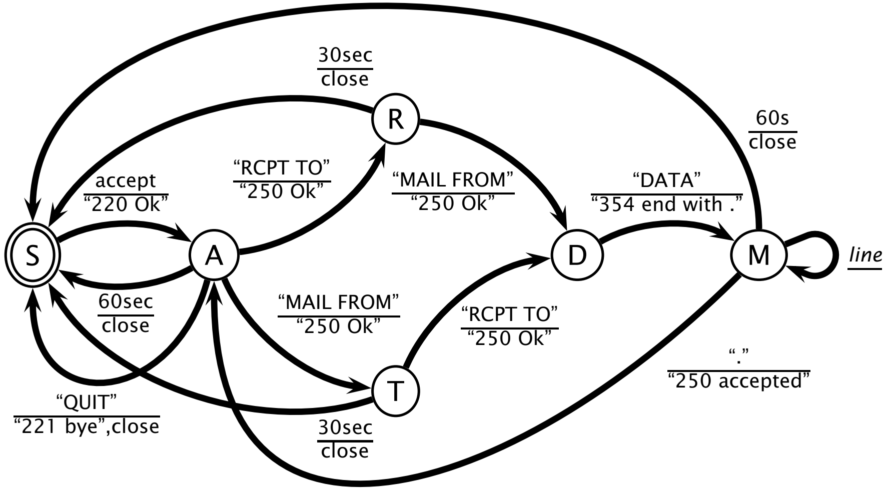
- E.g., here’s a specification of a “simple conversation protocol”



Example

E.g., a subset of a server-side, SMTP-like protocol



Back to Reliable Data Transfer

application
Web browser
Web server

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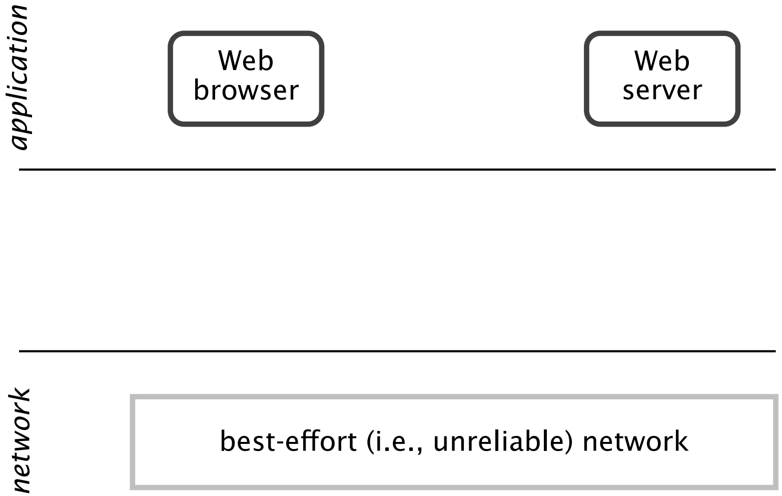

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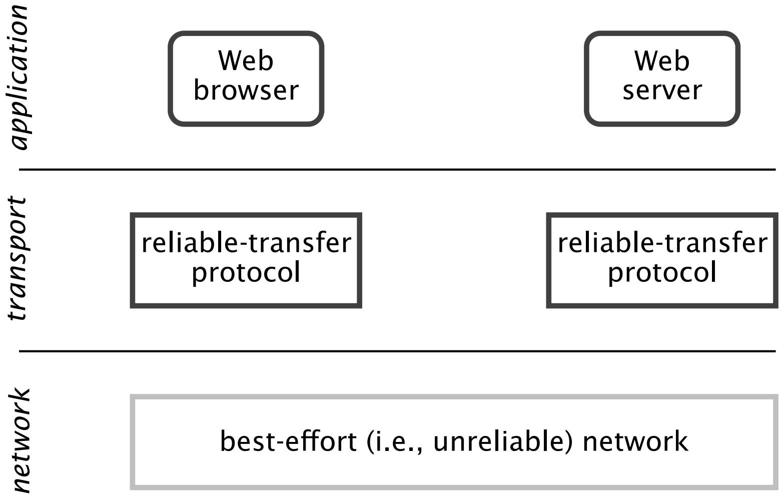

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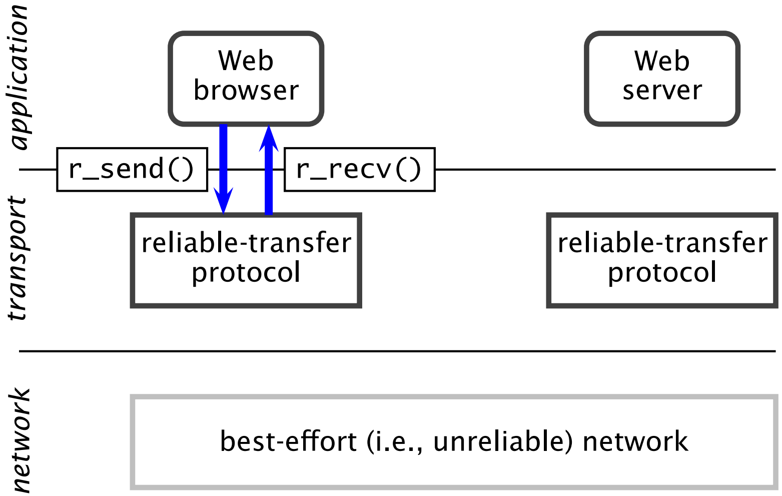
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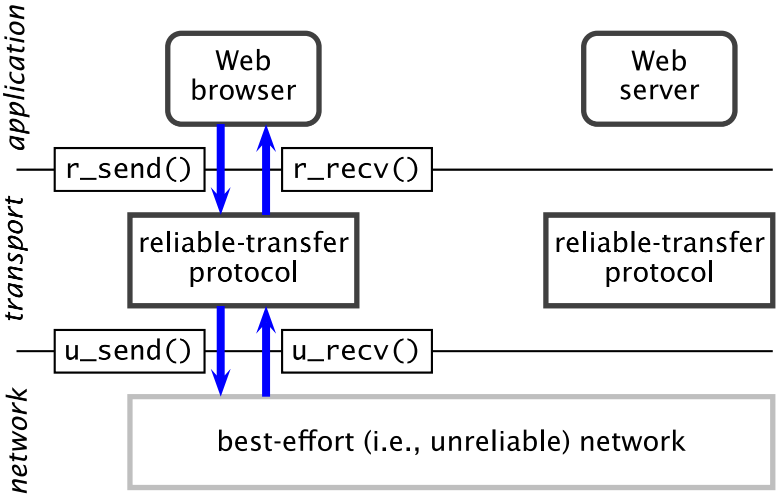
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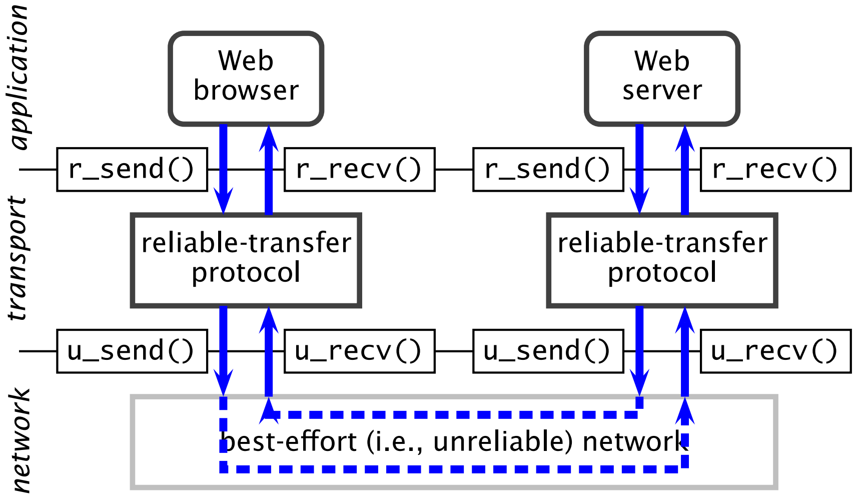

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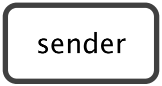

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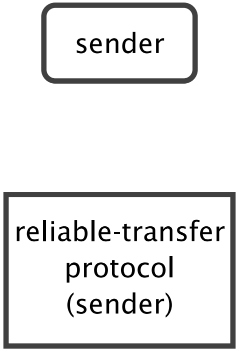

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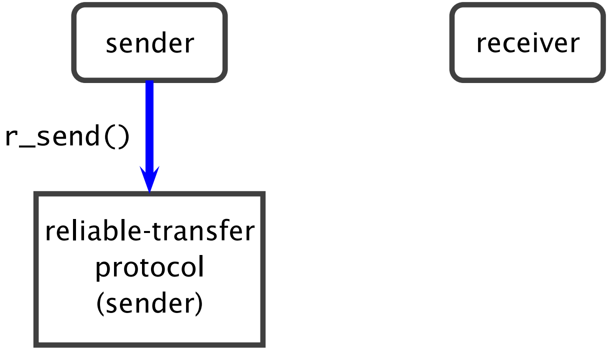

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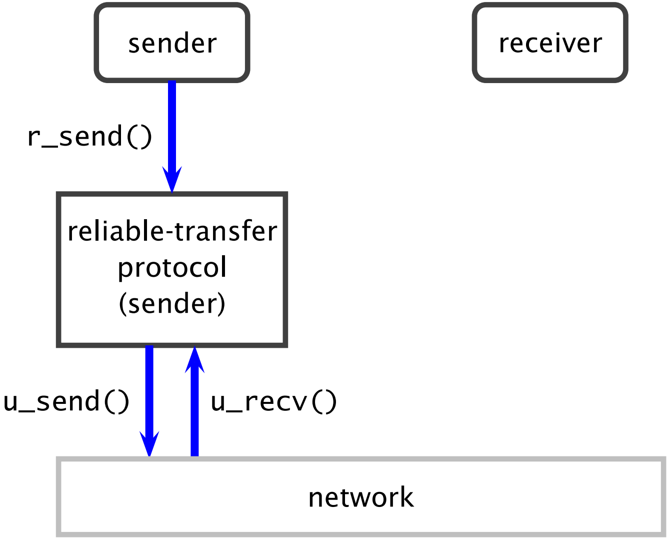

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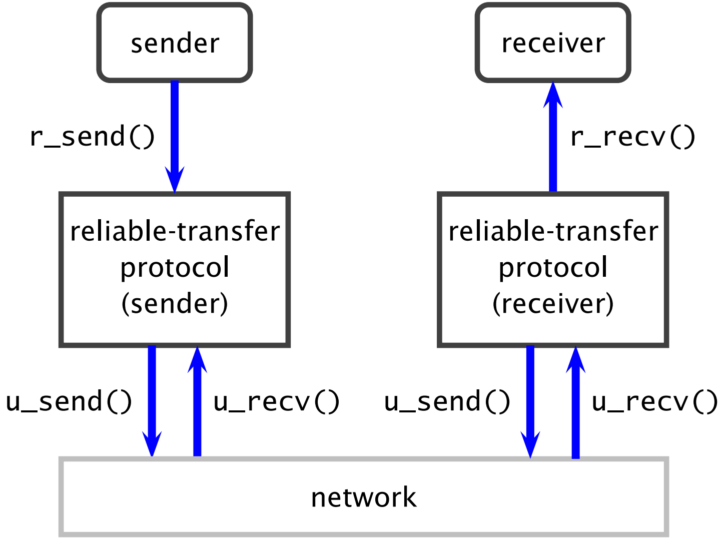
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Baseline Protocol

- Reliable transport protocol that uses a reliable network (obviously a contrived example)

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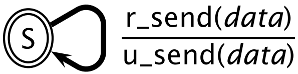

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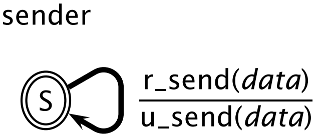

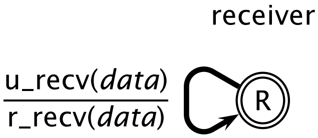

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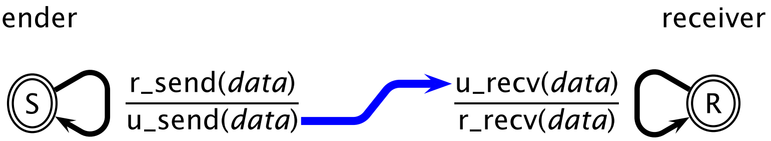

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  - *retransmission:* the sender retransmits corrupted packets

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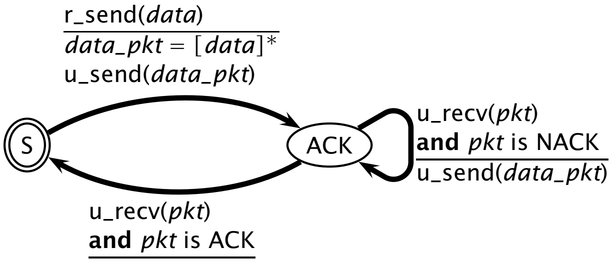

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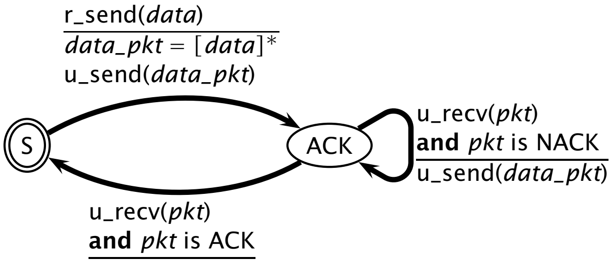

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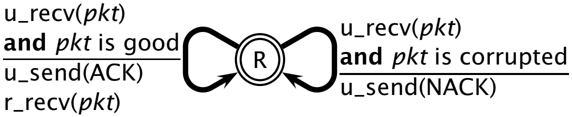
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- What happens if an error occurs within an ACK/NACK packet?

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  - good idea, but it introduces *duplicate packets* (why?)

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  1. sender says: “7: let’s go see Taxi Driver”
  2. receiver hears: “7: let’s go see Taxi Driver”
  3. receiver passes “let’s go see Taxi Driver” to application layer
  4. receiver says: “Got it!” (i.e., ACK)

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Using Sequence Numbers: Sender

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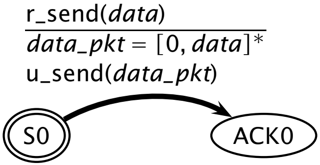

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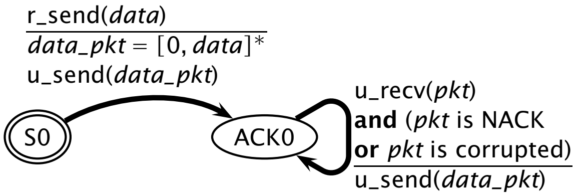

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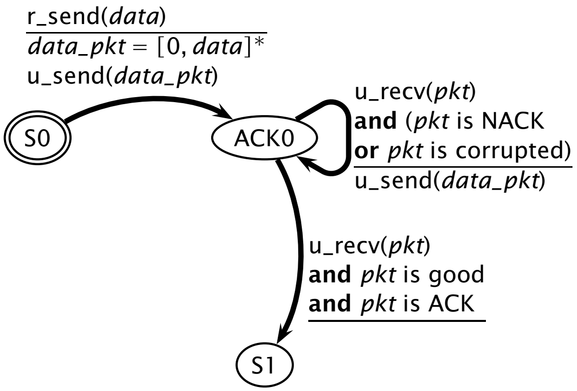

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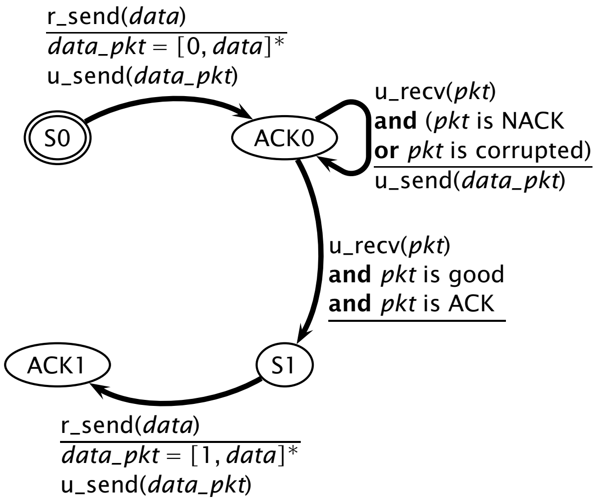

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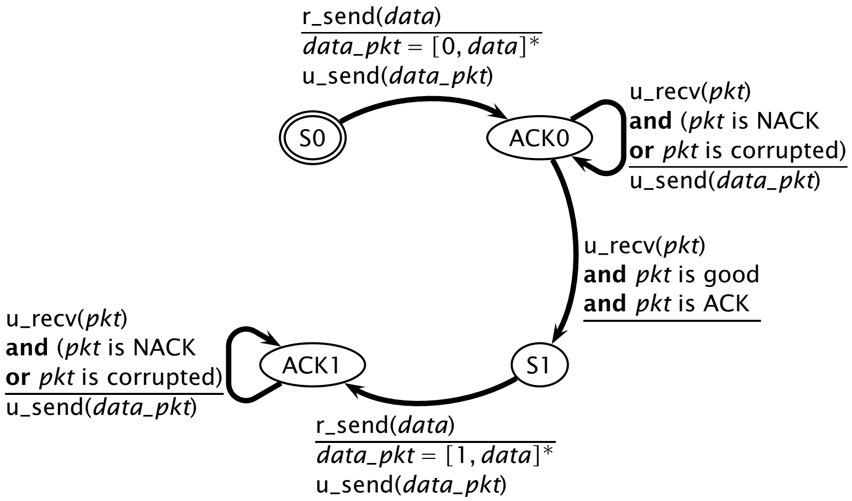

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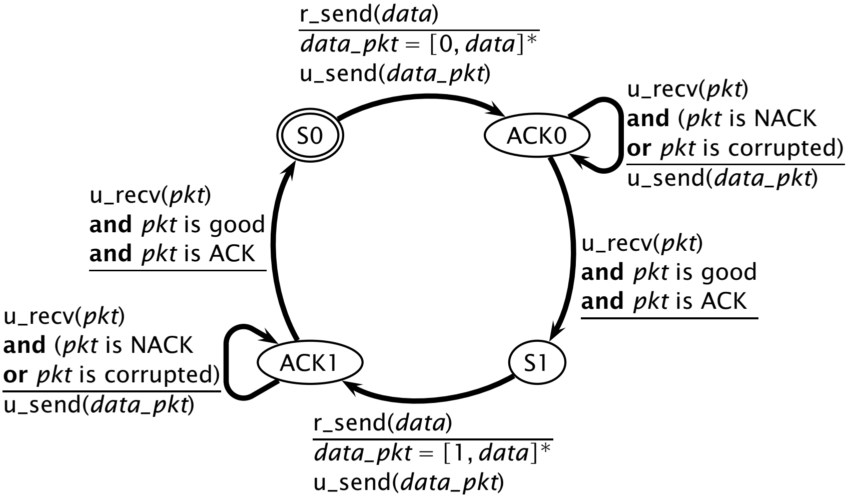

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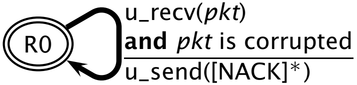

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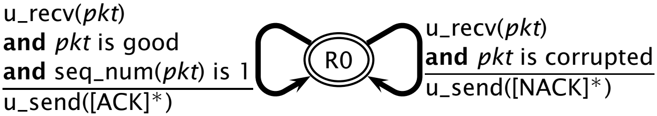

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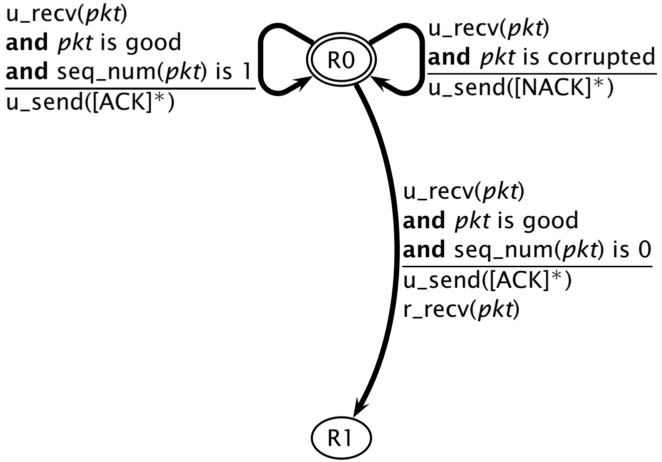

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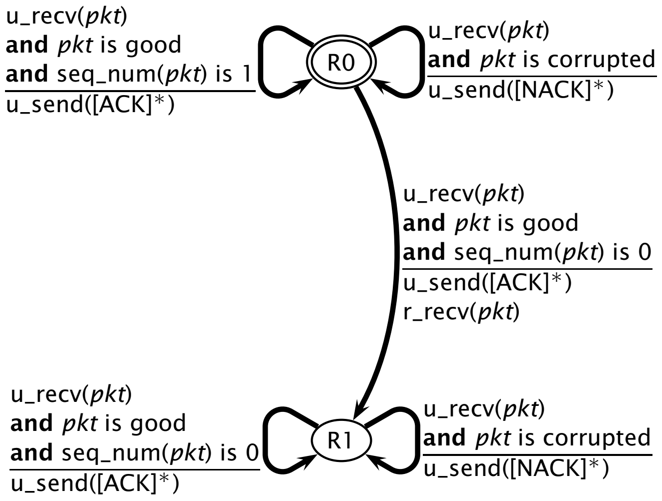

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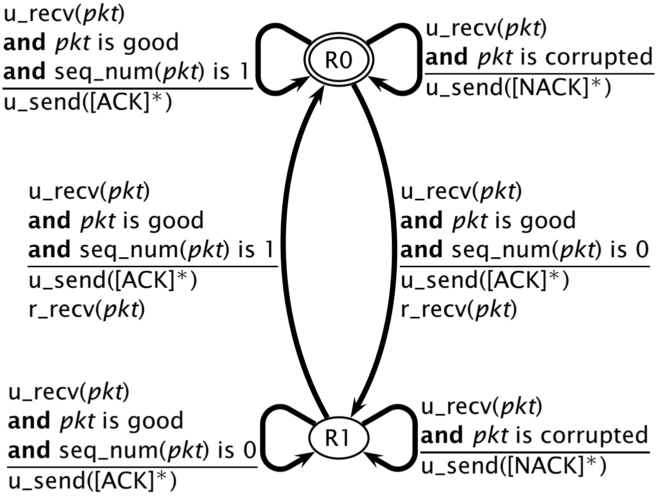
R0
R1
u_recv(*pkt*) **and** *pkt* is good **and** seq_num(*pkt*) is 1 / u_send([ACK]*)
u_recv(*pkt*) **and** *pkt* is corrupted / u_send([NACK]*)
u_recv(*pkt*) **and** *pkt* is good **and** seq_num(*pkt*) is 1 / u_send([ACK]*) r_recv(*pkt*)
u_recv(*pkt*) **and** *pkt* is good **and** seq_num(*pkt*) is 0 / u_send([ACK]*) r_recv(*pkt*)
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  9. sender knows that the current message is 8, and therefore repeats: “8: let’s meet at 8:00PM”

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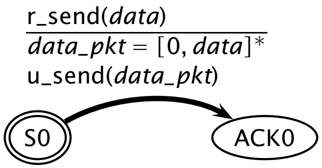

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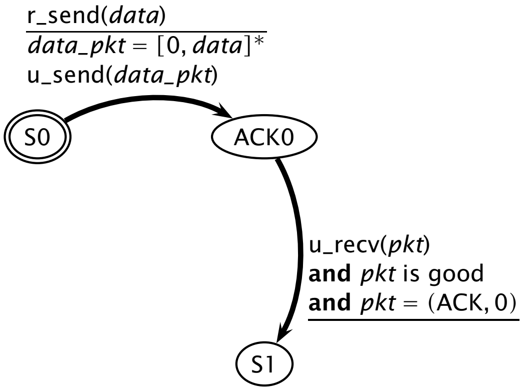

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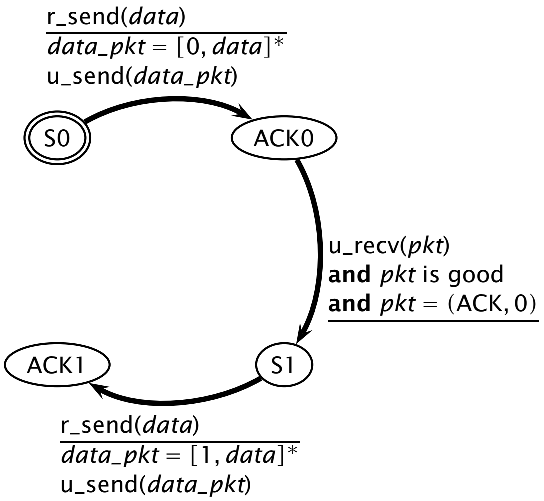

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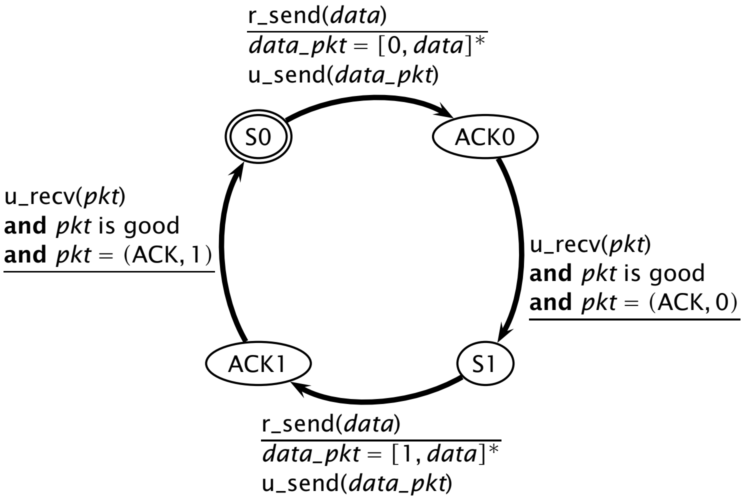

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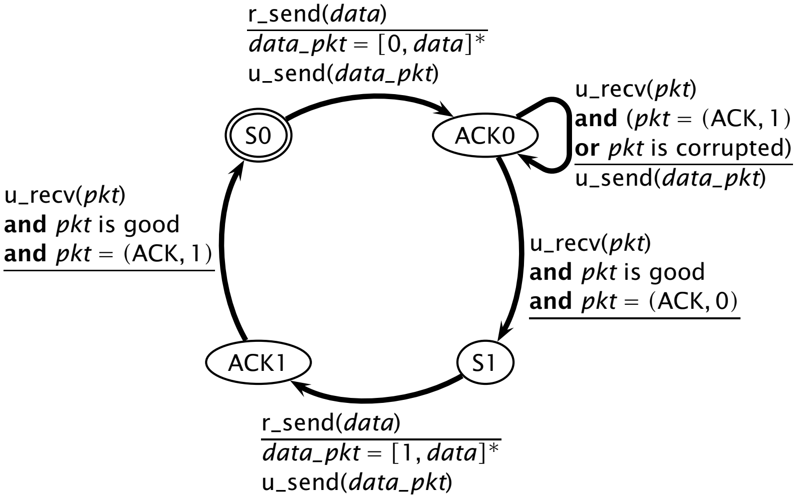

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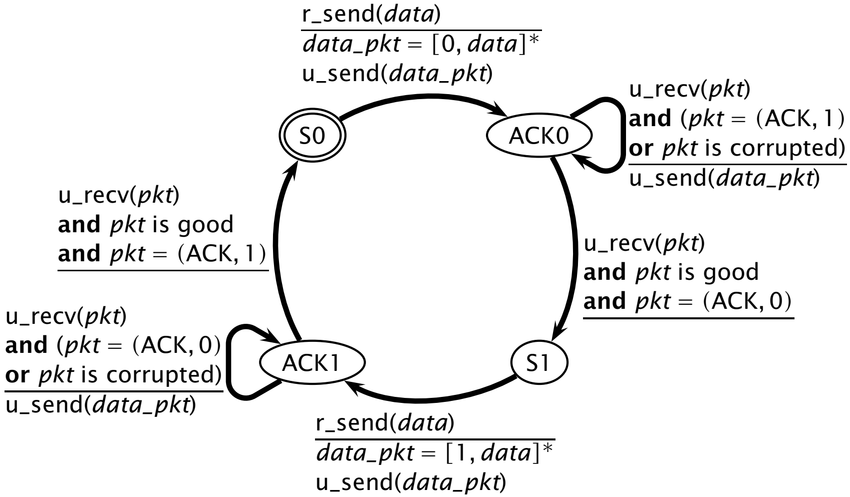

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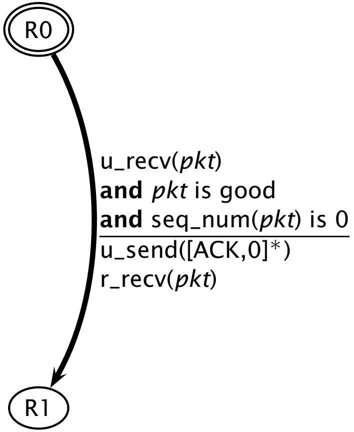

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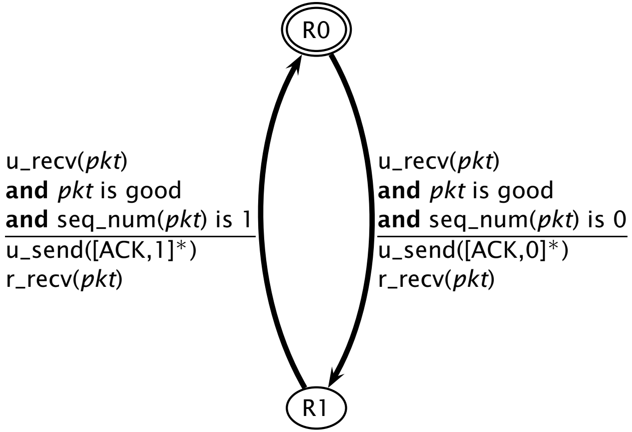

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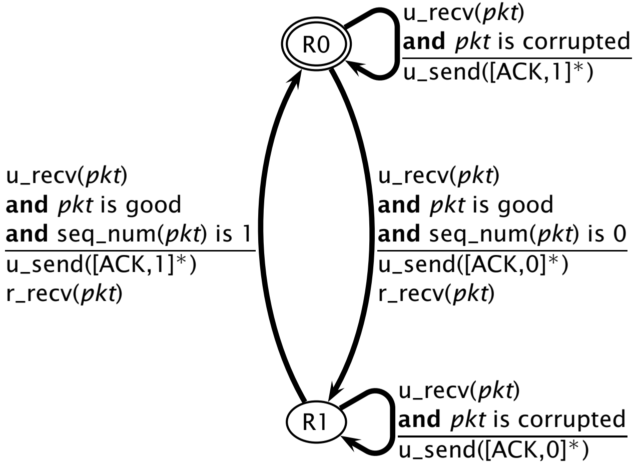
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u_send([ACK,1]*)
r_recv(pkt)
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u_send([ACK,0]*)
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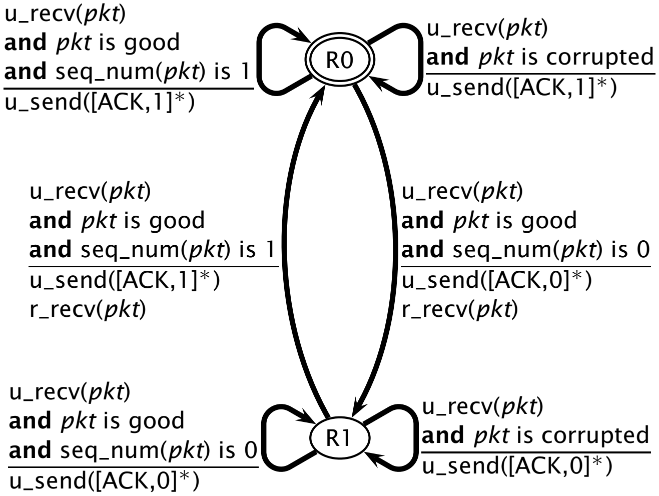
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- *ACKs, retransmission, and sequence numbers:* lost packets can be easily treated as corrupted packets

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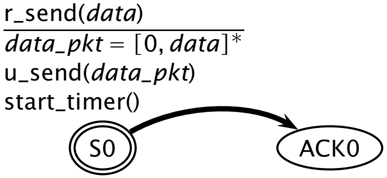

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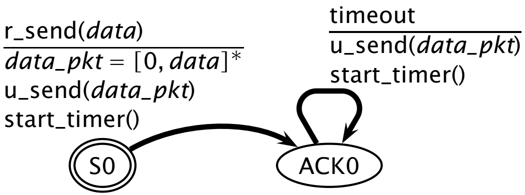

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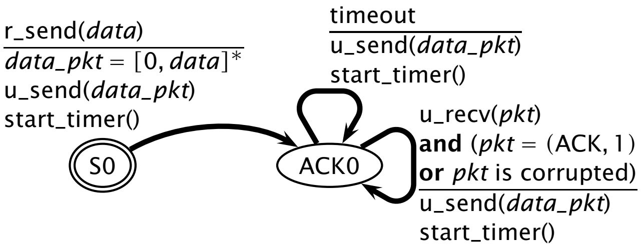

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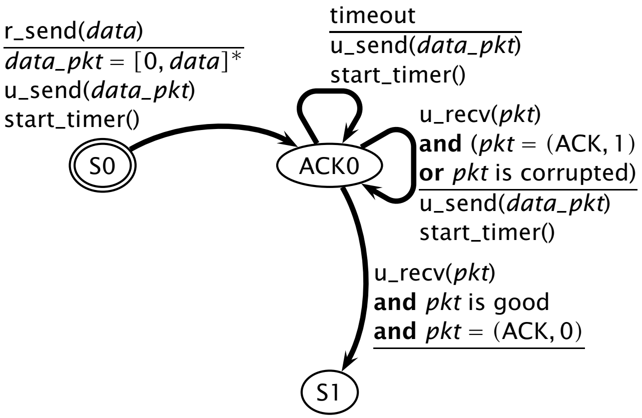

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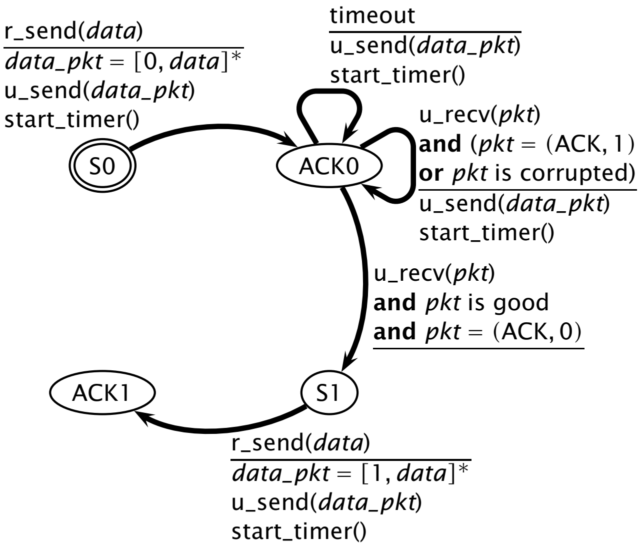

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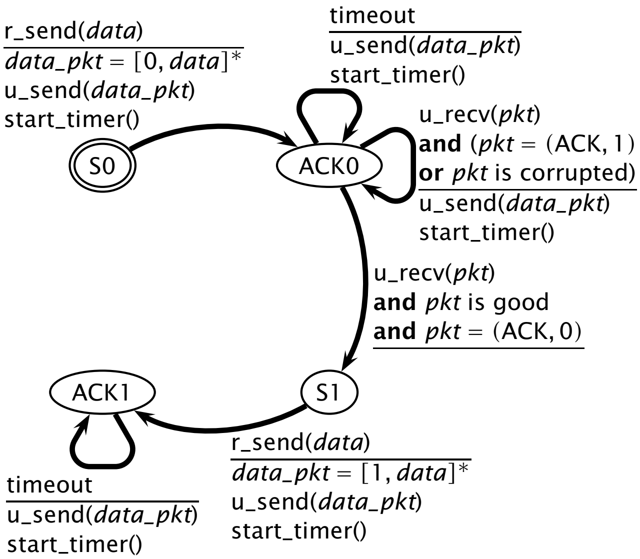

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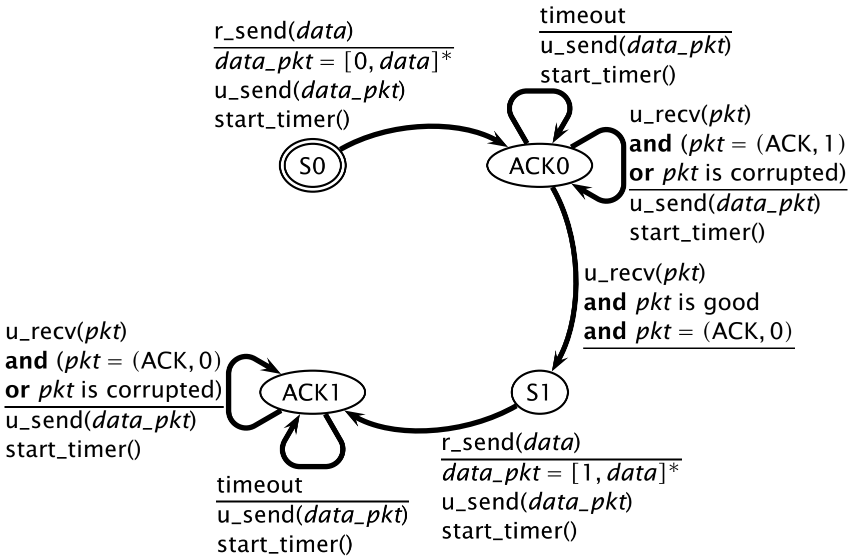

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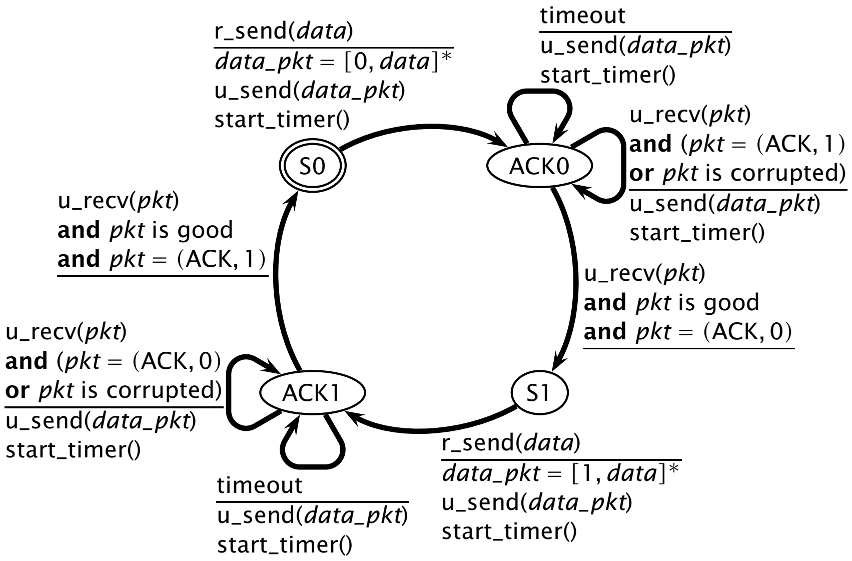
S0
ACK0
S1
ACK1
r_send(*data*) / *data_pkt* = [0, *data*]* u_send(*data_pkt*) start_timer()
timeout / u_send(*data_pkt*) start_timer()
u_recv(*pkt*) **and** (*pkt* = (ACK, 1) **or** *pkt* is corrupted) / u_send(*data_pkt*) start_timer()
u_recv(*pkt*) **and** *pkt* is good **and** *pkt* = (ACK, 0)
r_send(*data*) / *data_pkt* = [1, *data*]* u_send(*data_pkt*) start_timer()
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