

Implementing Real-Time Transport Services over an Ossified Network

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Approach

- Top-down: start with application, work down to transport layer
- What services do real-time multimedia applications need?
- How can these services be provided by UDP **and** TCP?

Real-Time Multimedia Applications

- Maximum delay bound, depending on interactivity
- Interactive applications: low hundreds of milliseconds (for VoIP) — depends on human perceptibility
- Non-interactive: tens of seconds (for VoD) — depends on desired experience
- Services need to respect timeliness constraint, and add minimal latency

Timing and Deadlines

- Data has set time that it needs to have arrived by, otherwise it won't be used
- If the transport layer doesn't know about this deadline, useless data might be sent
- With the deadline, likelihood of data arriving on time can be estimated
- Requires network delay estimate, receive buffer size
- Fundamental service: others follow from this

Partial Reliability

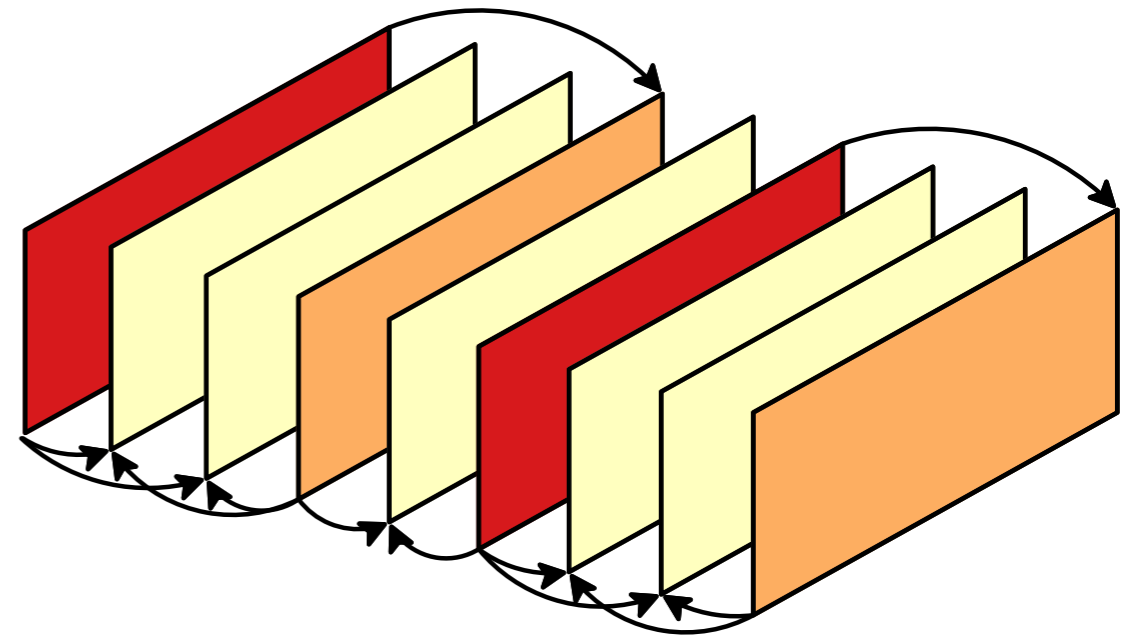
- IP provides best-effort packet delivery, so some packets will be lost
- Timeliness constraint means that data is useless after its deadline
- Guaranteed reliability would result in useless data being sent, deadlines not being met
- Need *partial* reliability: retransmit lost data, but only if it will arrive within its deadline

Message-oriented

- Partial reliability means that some packets may not be delivered
- The packets that do arrive need to be independently useful
- Implies application-level framing, with application data units (ADUs) being sent
- Given independent utility, and need to reduce latency, ADUs can be delivered in the order they arrive
- Support for multiple sub-streams

Dependencies

- Partial reliability means that not all data will arrive successfully
- Interdependencies exist within data
- Data shouldn't be sent if it relies on a previous transmission that was not received
- Utility difficult to define for some applications



MPEG-1: I, P, and B frames

Connections & Congestion Control

- Congestion control important to protect the network and other applications
- Need to select algorithm appropriate to application
- Connection-oriented service is useful in some scenarios
- Enables explicit setup and teardown of in-network state (e.g., for NAT mappings)

Real-Time Transport Services

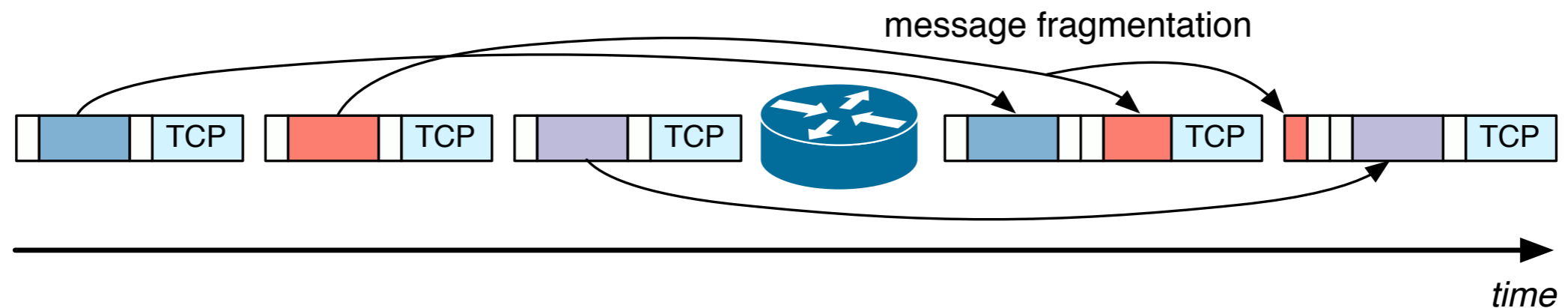
Transport Service	Requirement
Deadlines	Core
Partial reliability	Core
Message-oriented	Core
Sub-streams	Core
Dependencies	Core
Congestion controlled	Core
Connection oriented	Subsidiary
Keep-alive	Subsidiary

Realising transport services: UDP

- Already supports the sending of datagrams/messages
- Support for partial reliability requires detecting loss, retransmitting if message will arrive before deadline
- Need an estimate of one-way network delay
- Sub-stream support requires small header in each message
- Connections and congestion control can be added

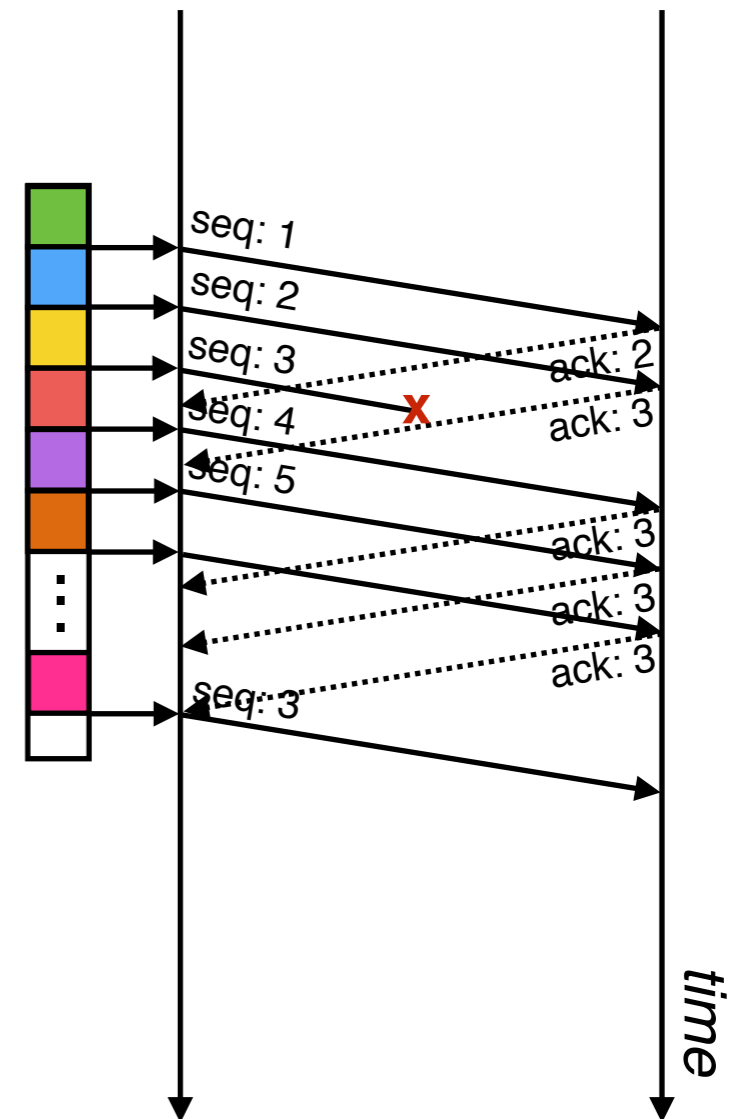
Realising transport services: TCP

- Messaging requires a framing mechanism, to support resegmenting middleboxes — e.g., COBS, as in Minion/uTCP
- Sub-stream support requires small header in each message
- Already supports connections
- Congestion control supported, but algorithm fixed: support for other algorithms as in DCCP



Realising transport services: TCP

- Middleboxes ossified around TCP do not expect gaps in the TCP sequence space
- Need to “retransmit” missing TCP sequence numbers, without retransmitting payloads — *inconsistent retransmissions*
- Small scale evaluations conducted using TCP Hollywood prototype



Summary

- Defined set of services required by real-time multimedia applications
- Services can be provided by both UDP and TCP
- Allows fallback to TCP where UDP not available
- Paper:
<https://irtf.org/anrw/2016/anrw16-final25.pdf>

Transport Service

Deadlines

Partial reliability

Message-oriented

Sub-streams

Dependencies

Congestion controlled

Connection oriented

Keep-alive