Multicast Congestion Control: how did we solve the crying baby problem?

ICN Congestion Control

ACN Course

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Acknowledgement

SAID: A Control Protocol for Scalable and Adaptive Information Dissemination in ICN

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Congestion

Congestion


ZIP
The urge to merge
When traffic is heavy
travel in two lanes
to the merge point
then take turns merging.
MERGE
HERE

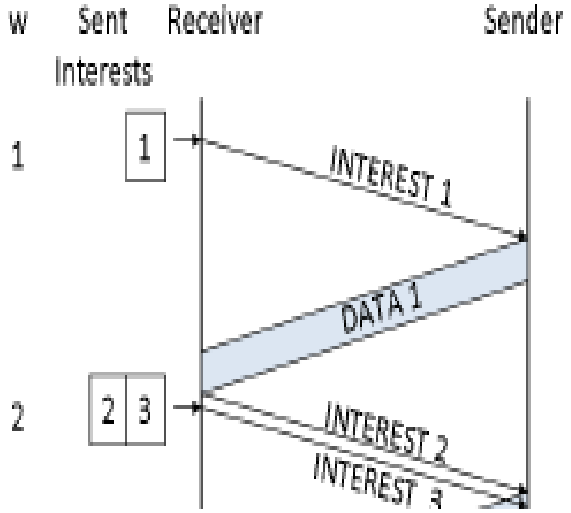
ICP [1]

- Interest control protocol
- Receiver Driven
- AIMD- similar to TCP
- Retransmission timer
- Congestion is detected when timer expires
- Reliable
- Fair
- Efficient usage of bandwidth

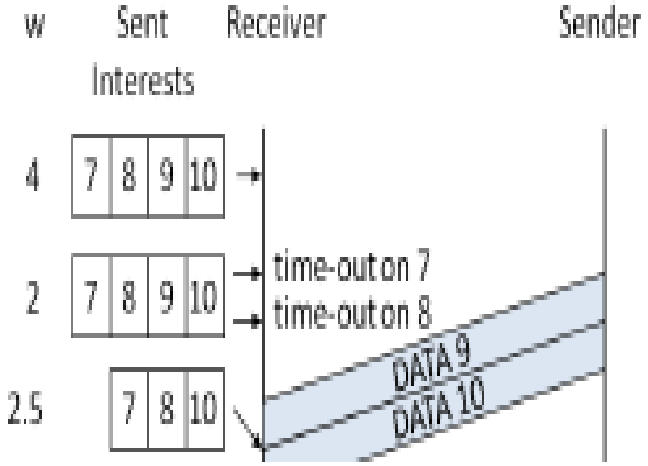
[1] G. Caroglio, M. Gallo, and L. Muscariello. Icp: Design and evaluation of an interest control protocol for content-centric networking. Computer Communications Workshops (INFOCOM WKSHPS), 2012 IEEE Conference on. IEEE, 2012

Working

Additive Increase

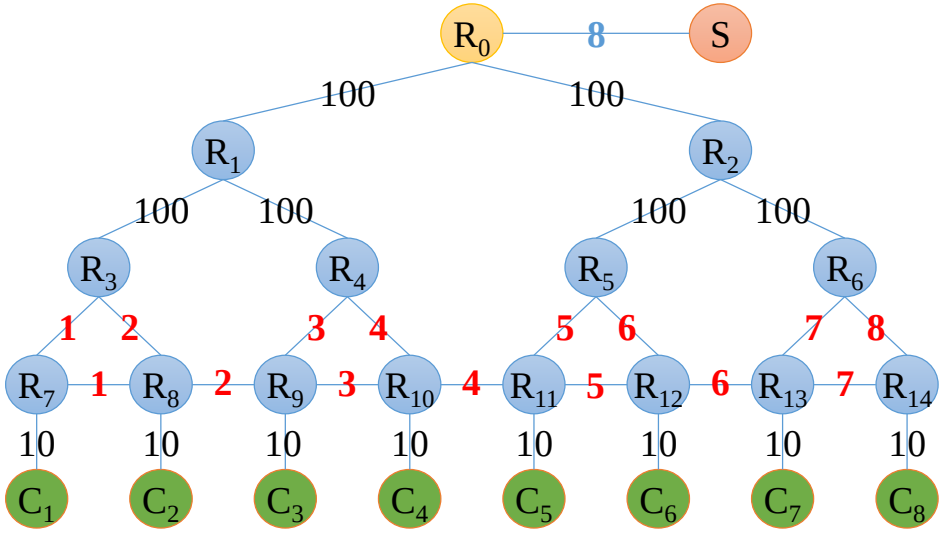


Multiplicative Decrease



Multicast Congestion Control

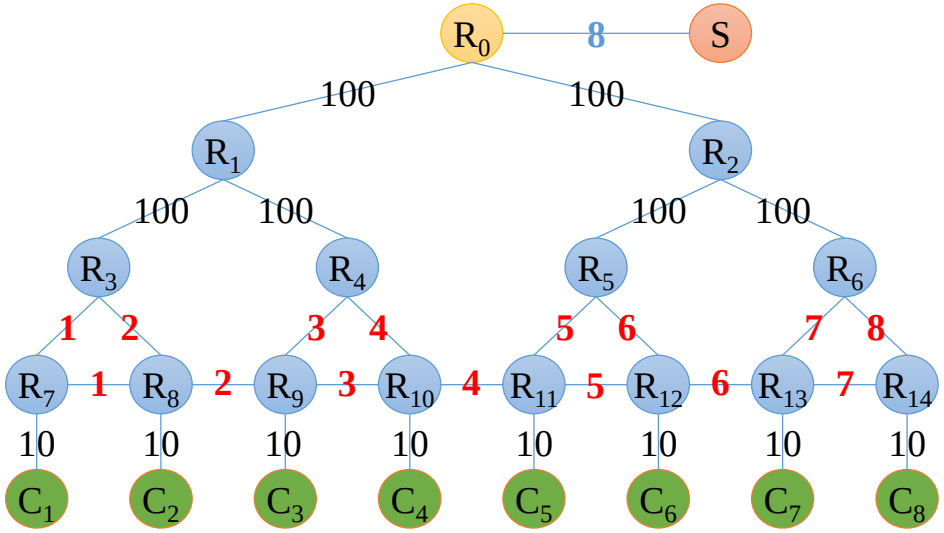
Efficient In-network Multicast – Desired, yet Difficult



- Efficient multicast is always a desired feature of the network
  - Applications: live streaming (e.g., livecoding.tv), file delivery (e.g., system updates), gaming, *etc.*

Key advantage: optimal in-network replication of packets

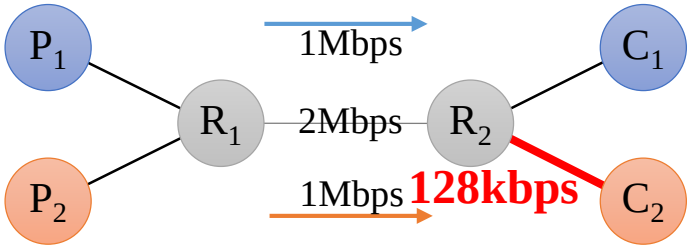
Efficient In-network Multicast – Desired, yet Difficult



Difficulty: Requirement of Reliability, Fairness

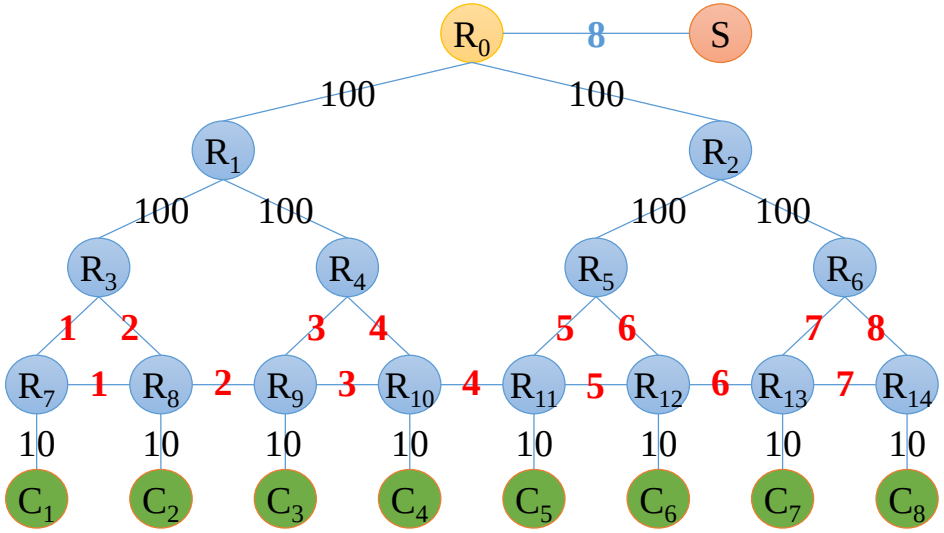
- Heterogeneous consumers
  - Bottleneck: location and fair-rate varies over time

Efficient In-network Multicast – Desired, yet Difficult



- Hop-by-hop reliability & flow-based fair queueing is not a good solution either
  - Hop-by-hop reliability is inefficient in forwarding since each router has to check the content
  - Fair queueing can cause inefficiency (compared to max-min)

Efficient In-network Multicast – Desired, yet Difficult

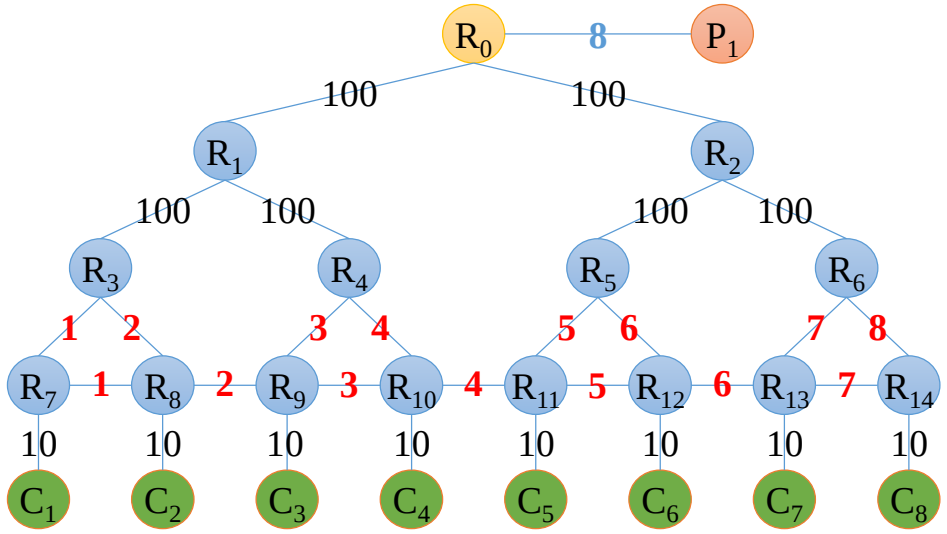


- *pgmcc* – a working solution
  - Aligns the sending rate to the slowest consumer
  - Ensures (and couples) reliability and fairness

However, one slow receiver can affect the performance of the whole group

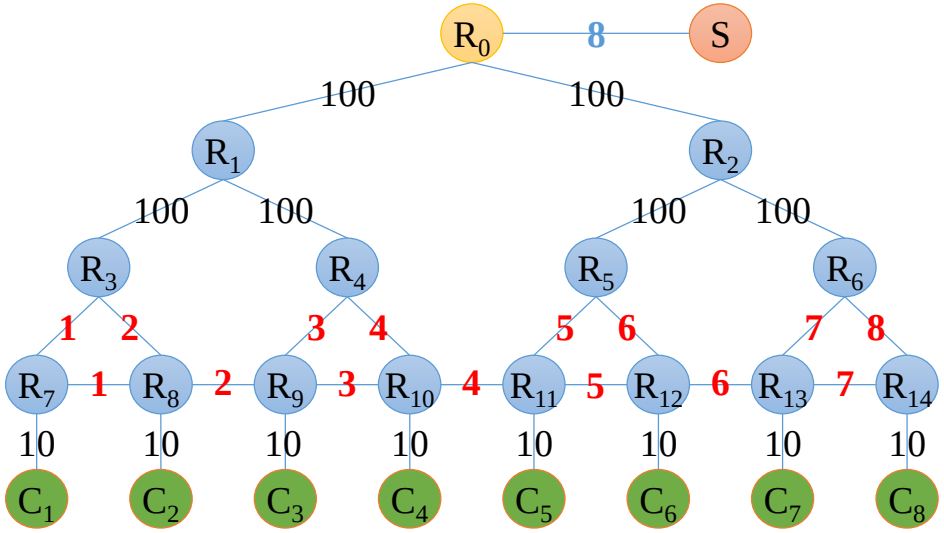
This is also known as the crying baby problem

NDN – An Architecture Born with Multicast Capability



- Solution for <u>fairness</u> and <u>reliability</u> in NDN
  - Flow balance – <u>*at maximum one*</u> Data per Interest
  - Constant packet size – 4KB/packet
  - Flow Control, Fairness: Consumers can indicate how much data they can receive by adjusting the # of Interests in flight
  - Reliability: Sequence number in each packet allows the consumers request for missing packets

NDN – An Architecture Born with Multicast Capability

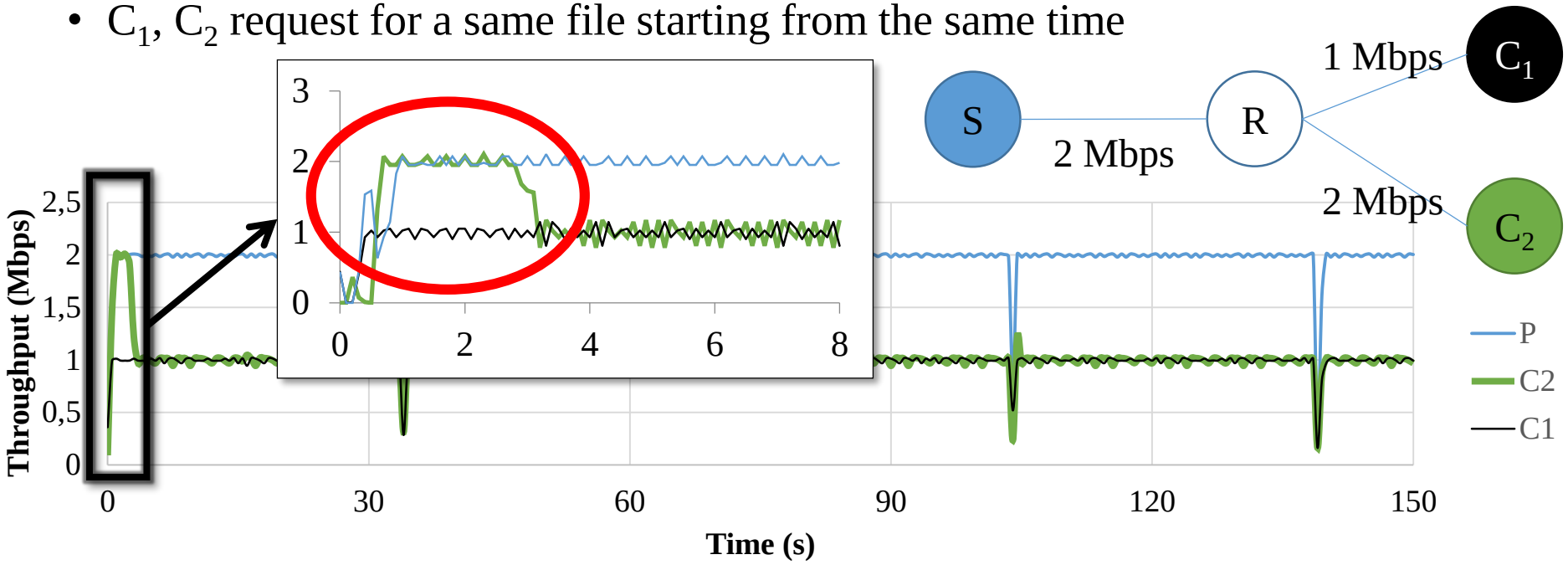


- NDN desires multicast: uses a stateful data plane
  - Pending Interest Table (PIT) – unsatisfied requests + corresponding incoming faces
  - Requests with temporal locality can be aggregated in the PIT
  - Data packets will be replicated in the network

Name	Faces
/ICN/16/papers/SAID.pdf/_s0	***R3, R4***
…	…

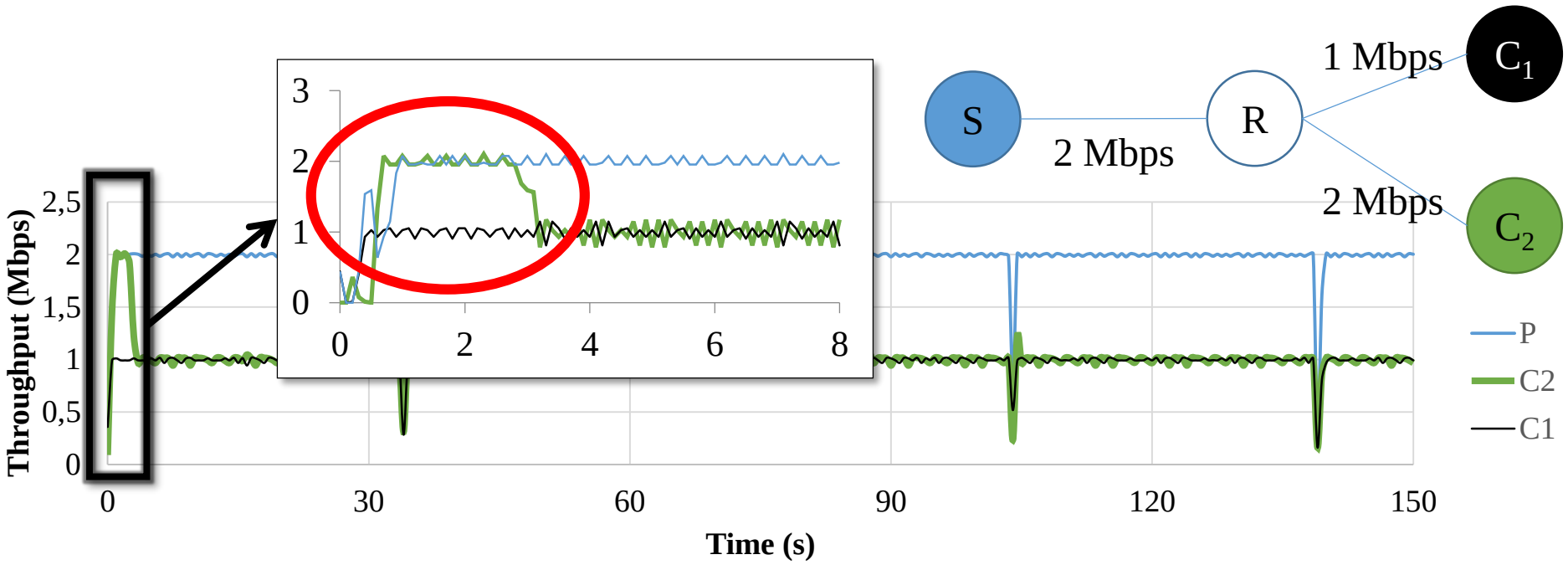
Problem with NDN Multicast – Consumers Getting Out-of-synch

- Testbed Evaluation with Simple Topology
  - C_1, C_2 request for a same file starting from the same time

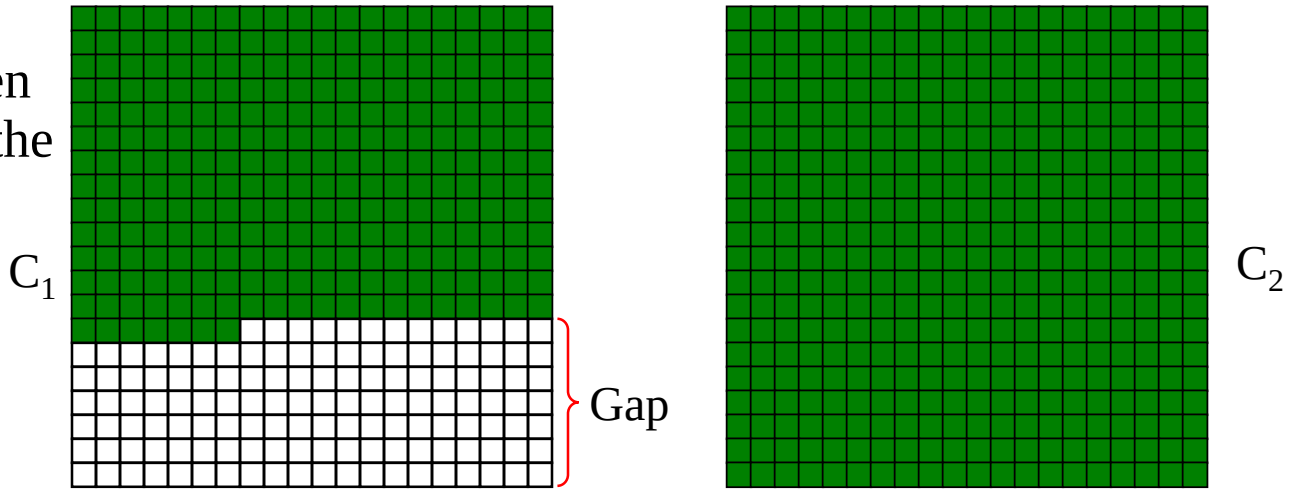


Why?

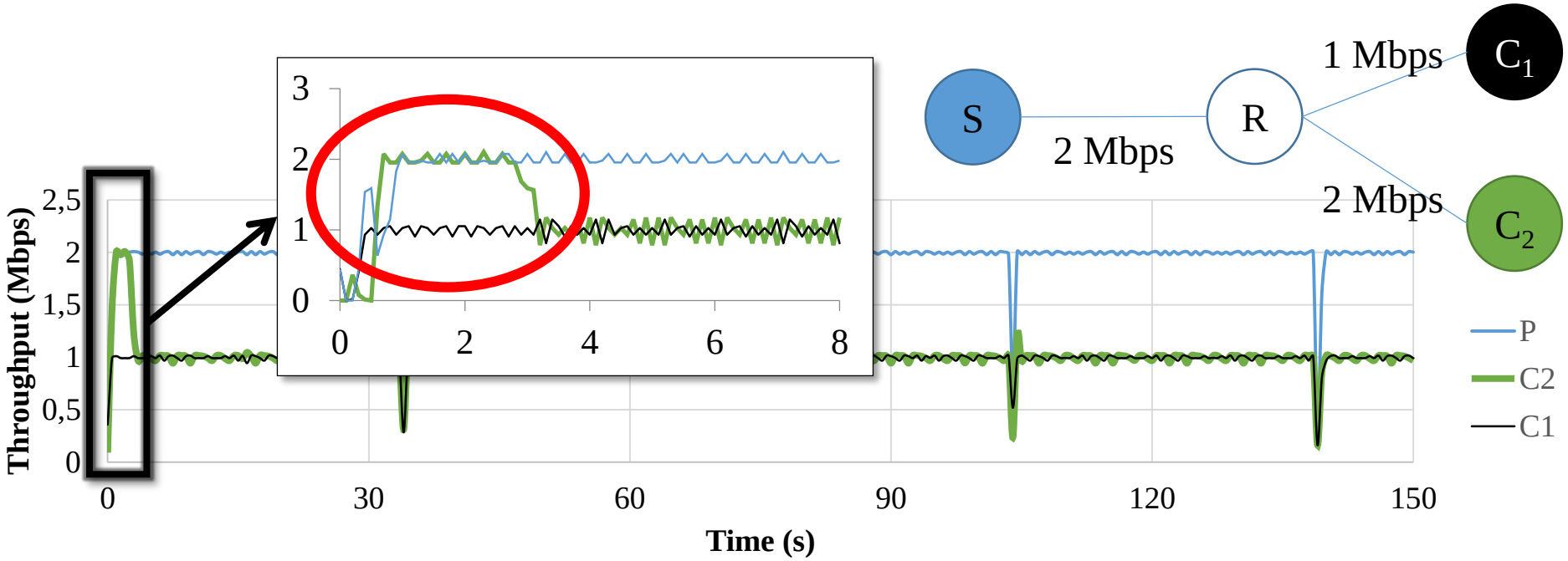
Problem with NDN Multicast – Consumers Getting Out-of-synch



- Why?
  - Out-of-synch – when the gap is larger than the cache size
  - Cache cycling therefore the two consumers are seen as different flows



Problem with NDN Multicast – Consumers Getting Out-of-synch



The "two flows" compete the bandwidth between P and R

The "when" can vary according to the scenario, but it will eventually happen.

How to Prevent Out-of-Synch?

- Why out-of-synch is happening in NDN (Congestion Control Solutions)?
  - Couple *in-sequence reliability* with *fairness*

- We argue that:
  - Not every application requires reliability (e.g., games), but every application requires fairness
  - Even fewer applications require in-sequence reliability
    - E.g. file transfer, it is ok to eventually get the whole file
    - E.g. Live streaming, it is sufficient for the playout buffer to be full

Therefore, reliability can be decoupled from fairness in multicast dissemination.

Intuition of our solution (SAID)

- The consumers control *how much* data they are going to receive, but *NOT which exact packets*
  - Control rate – adjust the # of in-flight requests (receiver window based flow balance)
- A new request type – Any Next Packet (ANP) request
  - Let the network decide which packets to send, but fresh packets

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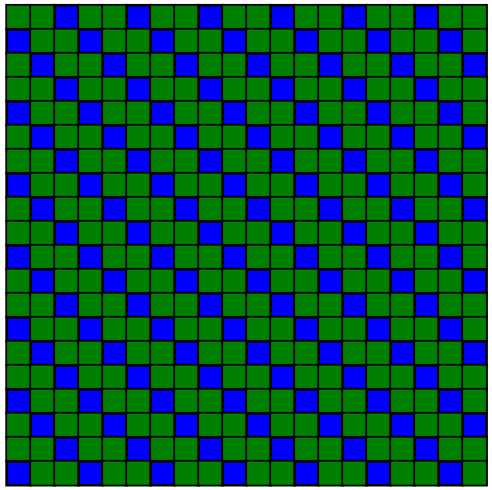
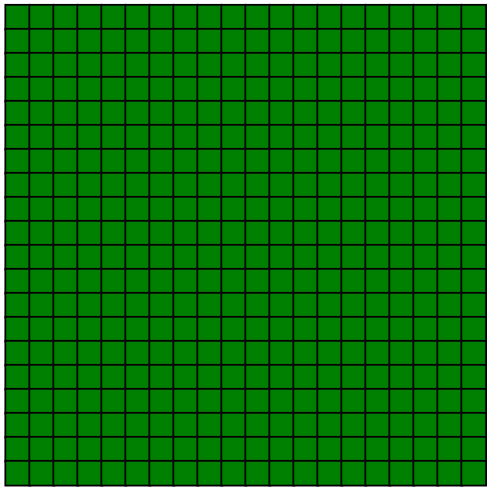
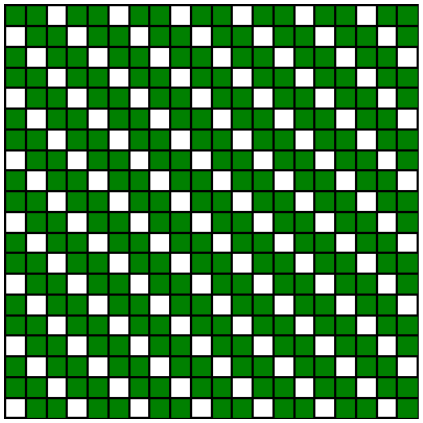
- A new request type – Any Next Packet (ANP) request
  - Let the network decide which packets to send, but fresh packets
- ***Maximize the utility* of the packets that are sent *at the first time***
  - We can get 2/3 of the packets used twice regardless of the file size and no cache
- Seek to repair these holes later

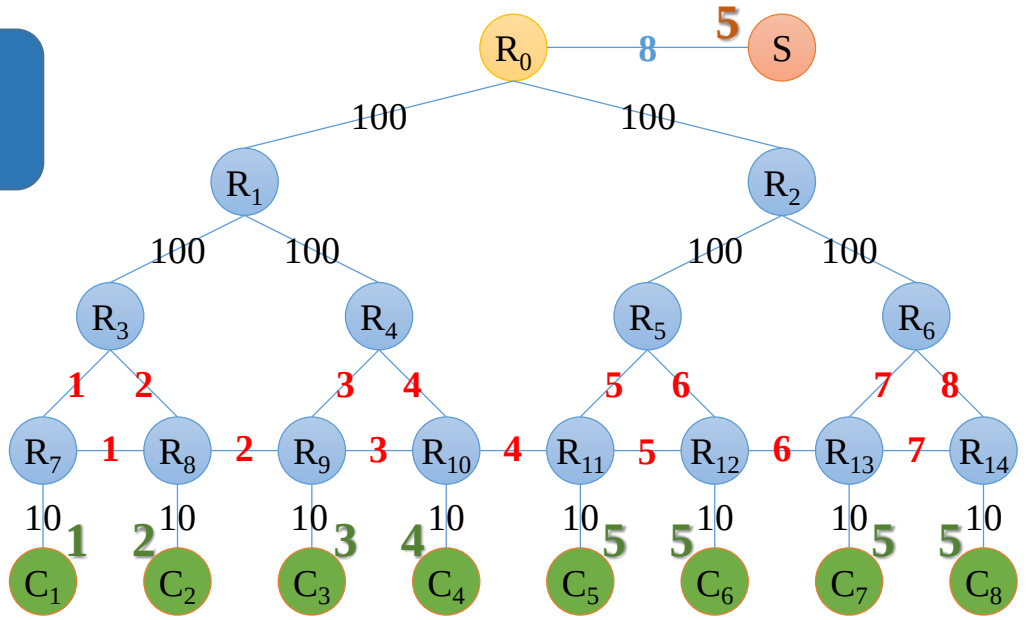
This occurs even if C1 or C2 start later





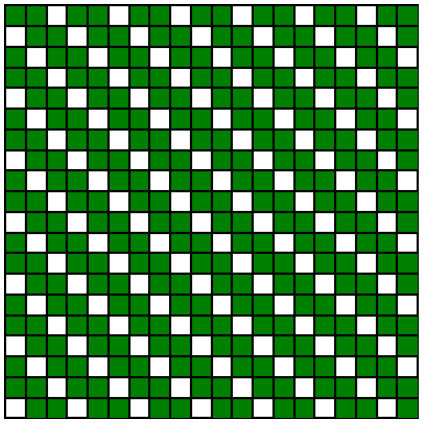
Fairness: Efficient Multicast Module (using ANP request)

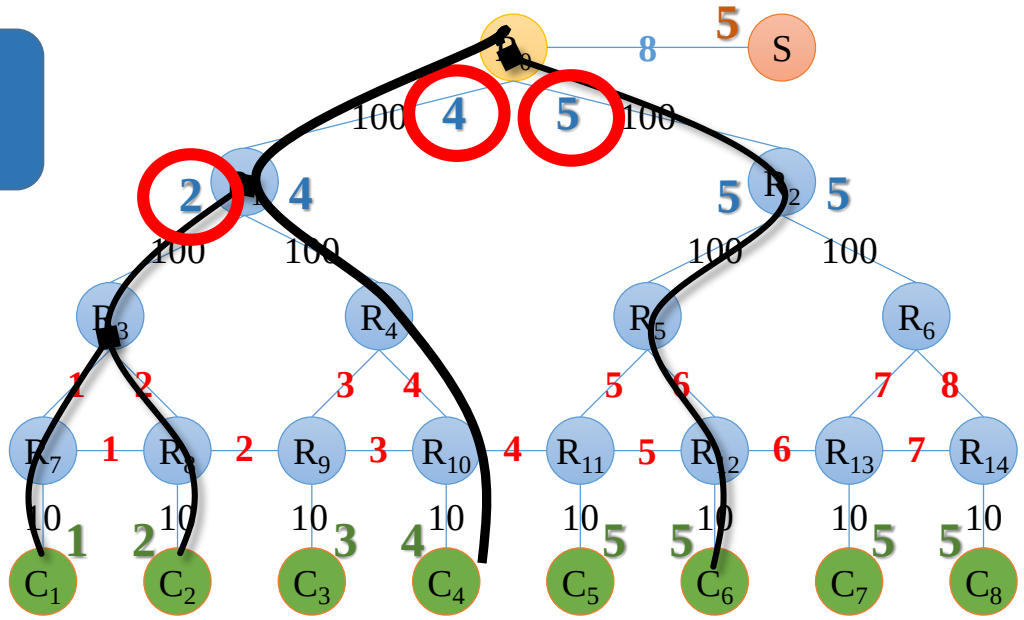




- With fairness, but no reliability guarantee
- Each consumer should receive (whichever is smaller):
  - Fair share on the bottleneck between sender and the consumer (no matter where the bottleneck is)
  - Sending rate of the sender

Fairness: Efficient Multicast Module (using ANP request)



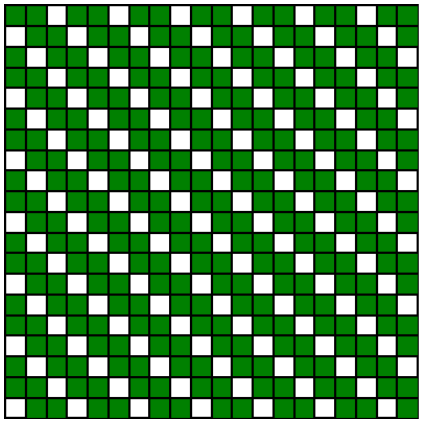


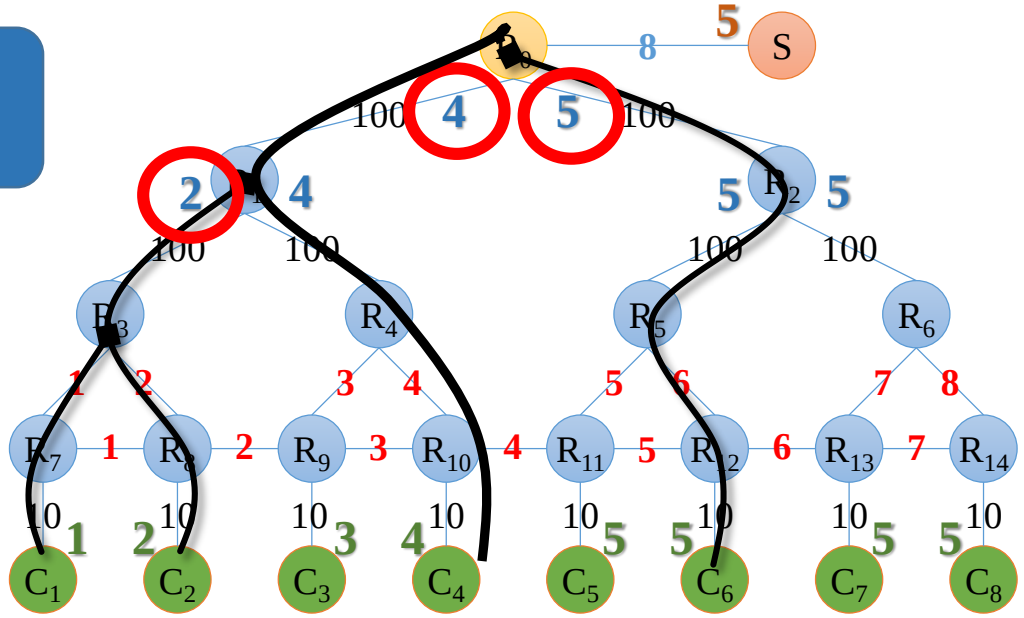
- Efficient link utility
  - The network transmits *at the receive rate on each hop* between the branching point and the consumer
  - For a consumer C, its branching point BR_C is defined as:
    - The bifurcation router nearest to C that has another consumer that can receive faster than C
    - 1st hop router of the provider when the receive rate is equal to the sending rate

Essentially Max-Min Fairness

SAID – Building Blocks

Fairness: Efficient Multicast Module (using ANP request)

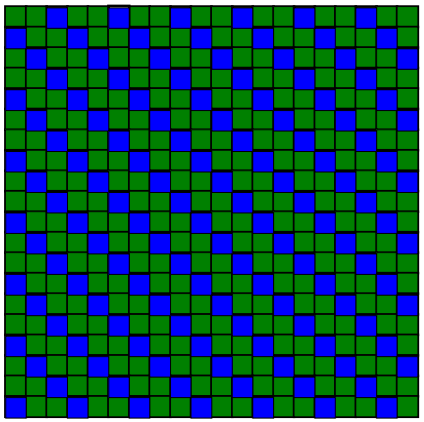


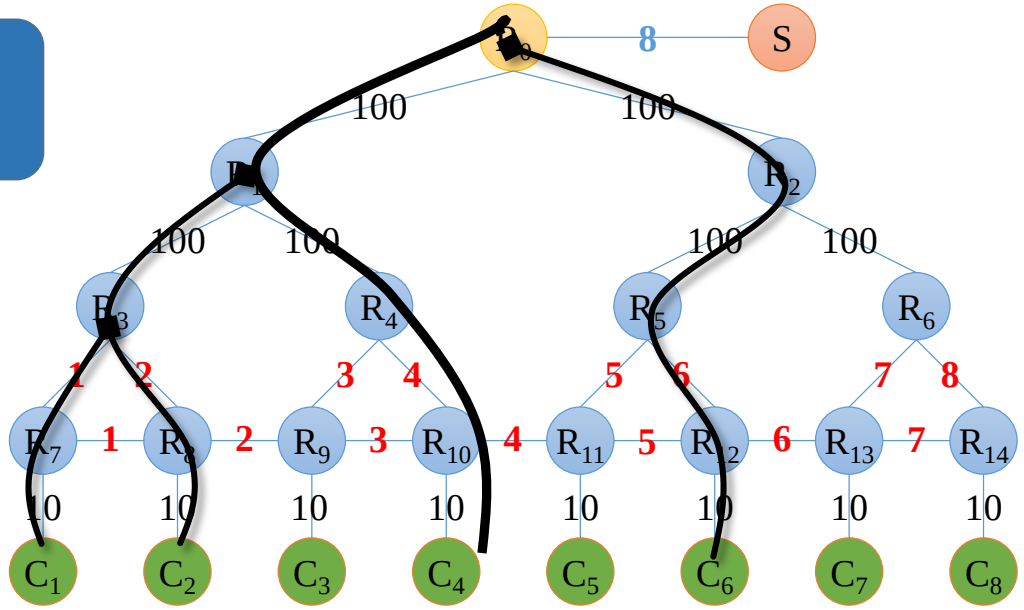


Issue: Holes are not an indication of congestion

SAID – Building Blocks

Fairness: Efficient Multicast Module (using ANP request)



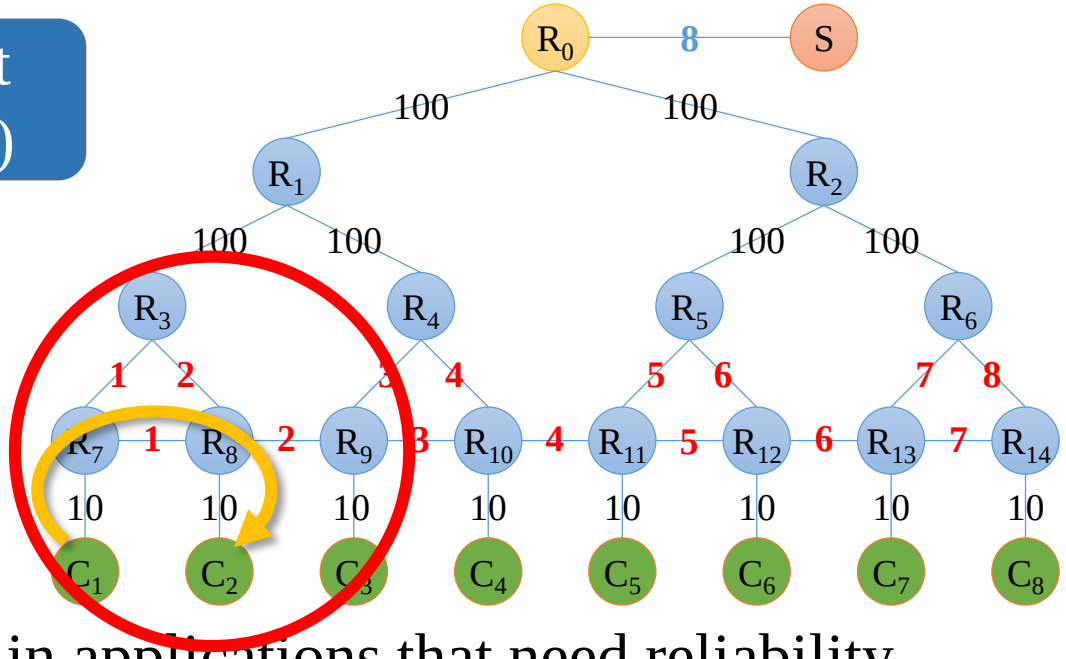


Reliability: How do we get these missing packets ?

SAID – Building Blocks

Fairness: Efficient Multicast Module (using ANP request)

Reliability: Repair Module



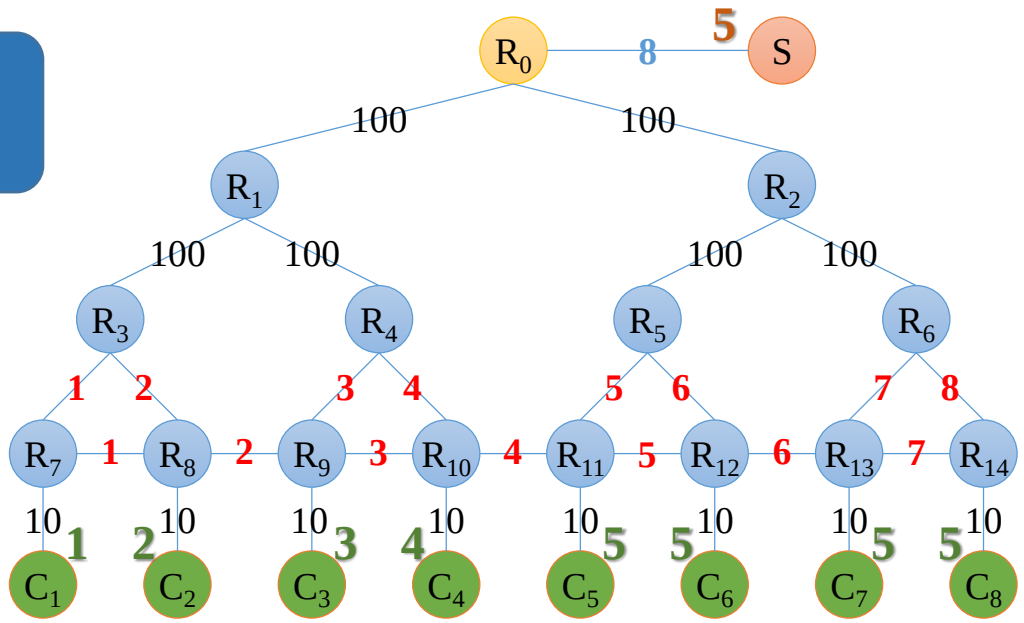
- Request for missing packets in applications that need reliability
- Each consumer can decide when to repair and which packets to repair
  - E.g. Live streaming in order to keep the playout buffer of 1s is full
- Use basic NDN specific sequence request model that can fully utilize the benefits of NDN
  - Preserves privacy and trust
  - Get repair from best sources (including other consumers) via different paths

SAID – Building Blocks

Fairness: Efficient Multicast Module (using ANP request)

Reliability: Repair Module

Sending Rate Module (Optional)



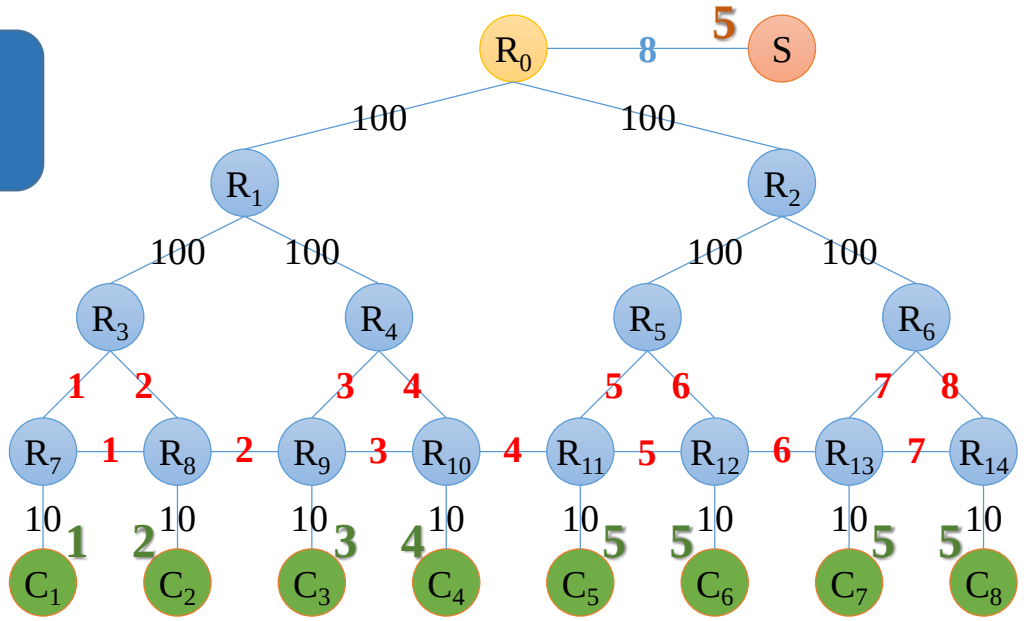
- Sender can send at any rate (upper bounded by the fastest receiver)
  - Align to slowest, fastest, intermediate
  - Constant application suitable rate
- Tradeoff between session completion time (for faster receivers), additional sources & amount of repair traffic

SAID – Building Blocks

Fairness: Efficient Multicast Module (using ANP request)

Reliability: Repair Module

Sending Rate Module



Thank you for your attention!