Analysis of end-to-end delay for aggregate RCSP (ARCSP)

Max Azarov

v1.01

SMSC

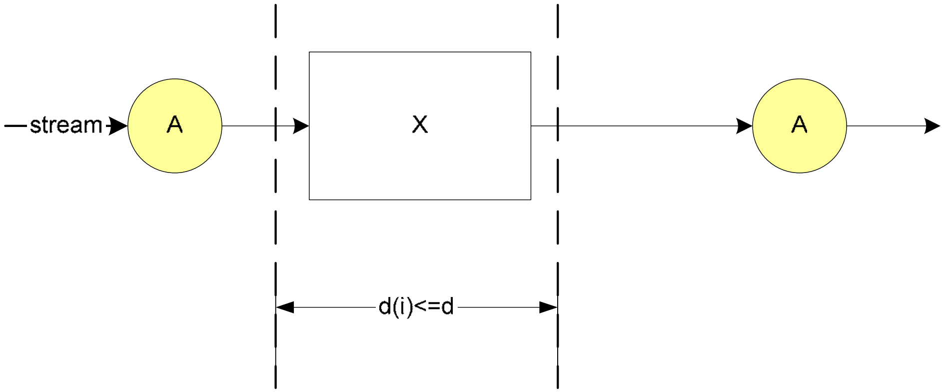
Purpose

- We need to show for ARCSP
  - that regulators do not increase worst-case latency
- This behavior is identical to per-flow RCSP

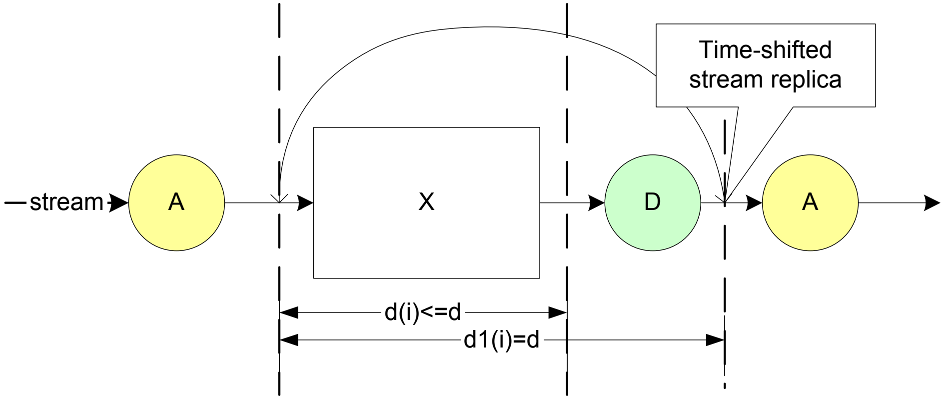
- Knowing that regulators do not contribute to the latency bound, ARCSP network designer can focus on proving local per-hop latency bound performance, as well as establishing buffer requirements

Regulator impact analysis in general

- Suppose we have system with two regulators “A” and some network element “X”, which causes delays for packets *d(i)<=d*, where *d* is the upper bound
- We assume *d* is finite
- Would second regulator “A” delay packets beyond *d* ?

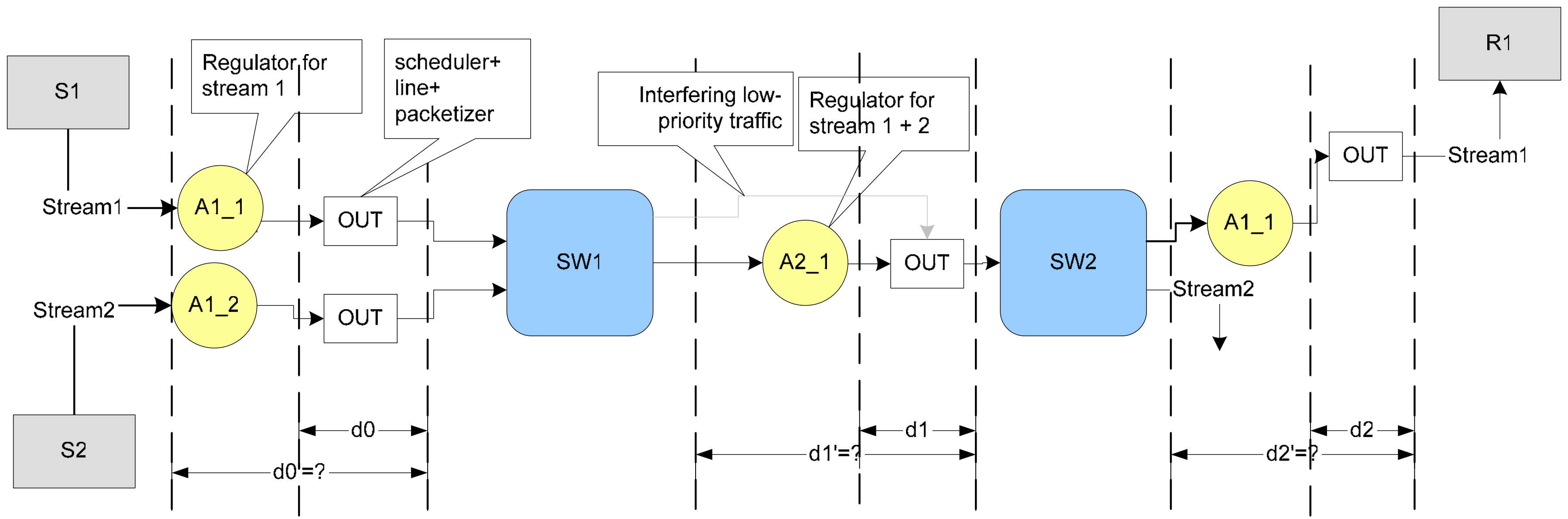


- We create modified system with element “D”, which delays packets and releases them so that total delay *d1(i)=d*
- After “D” we have time-shifted replica of the stream after first regulator “A”
- This version is constrained by “A” already, hence:
  - **second “A” will not delay any packets beyond *d* !**
- This method is used below



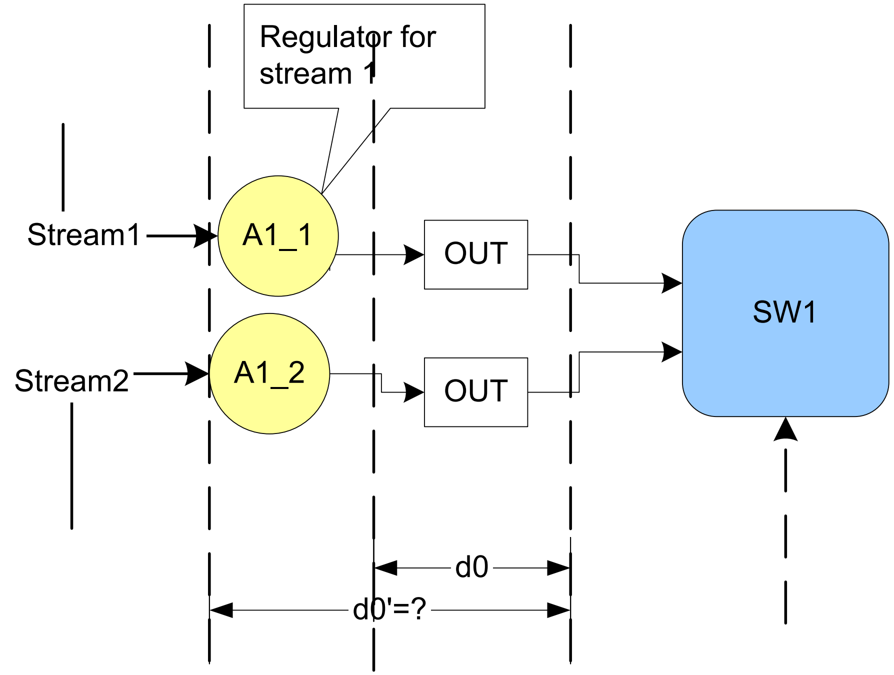
Note: Full proof needs to show validity of adding D :additional Lemma (see reference paper)

RCSP network



- For network with regulators, need to determine values of d0’, d1’, d2’
- Values d0, d1, d2 are known

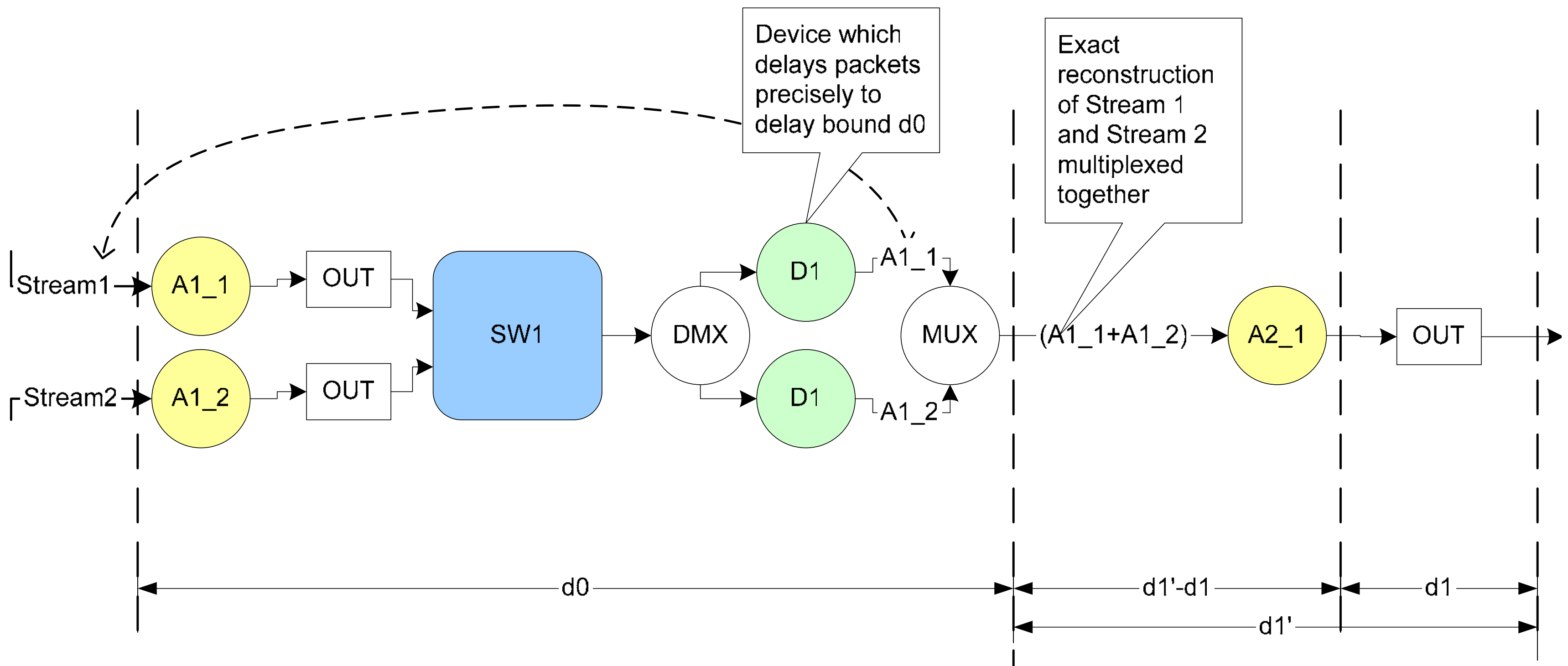
Delay d0'



- Assume streams 1 and 2 comply with constraint envelopes A1_1 and A1_2 respectively
- This means that regulators will not delay any packets, so

  - d0'=d0

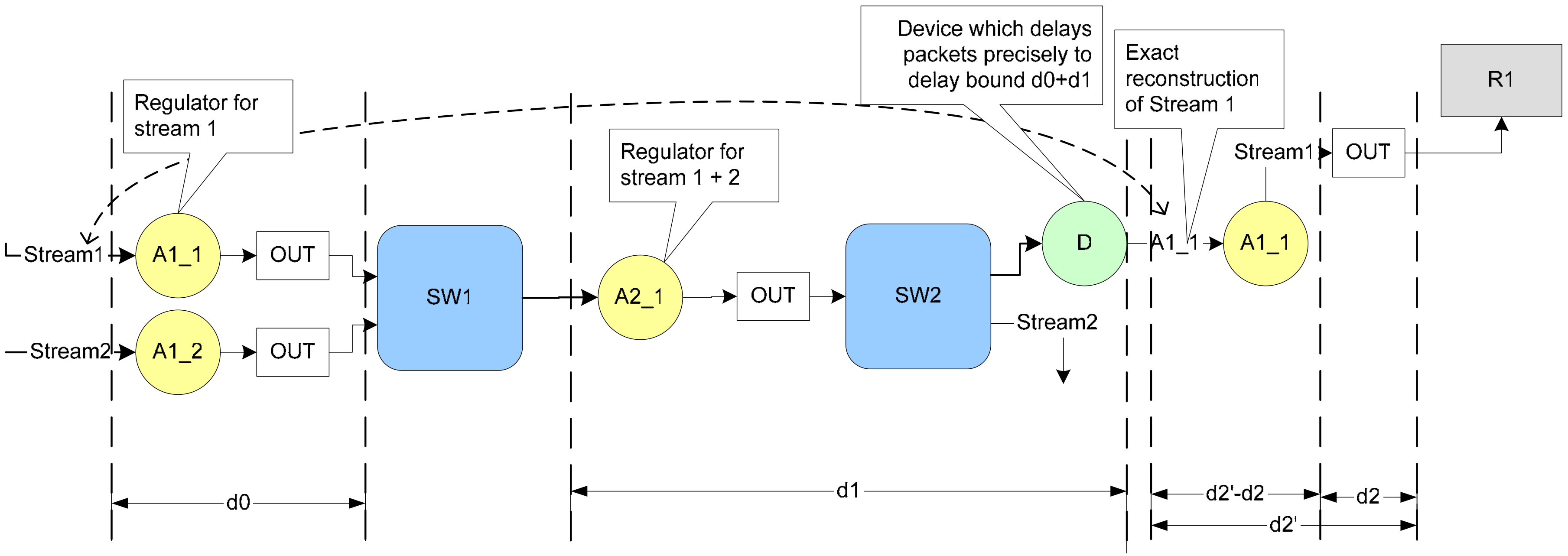
Delay d1’



- 2 elements D1, independently delay “early” packets of stream 1 and 2 and release exactly at the worst-case delay d0
- Since all packets are delayed in the system by the same amount of time = d0, on the output we have time-shifted exact replica of Stream 1 and Stream 2 respectively
- When we multiplex streams, their envelope will be <= (A1_1+A1_2)
- If A2_1 >= (A1_1+A1_2), then regulator will not delay any packets

- d1’=d1

Delay d2’



- Insert element D, which delays “early” packets of stream 1 and releases exactly at worst-case delay d0+d1
- On the output of D we have time-shifted replica of Stream 1 with constraint envelope A1_1
- This means that regulator A1_1 will not delay any packets

- d2’=d2

Conclusion

- => d0'=d0, d1'=d1 and d2'=d2
- Speculations can be straight-forwardly extended to a general network
- This proves that ARCSP similarly to per-flow RCSP does not increase worst-case delay compared with SP network
- Condition A2_1 >= (A1_1+A1_2) imposes requirements on envelope types suitable for aggregate RCSP
  - Maximum summary constraint envelope should not depend on number of streams in aggregate
  - (r, T) envelope is suitable
  - (σ,ρ) can be used if σ is not fixed, but calculated according to allocated bandwidth: min(L, BT)
    - L – max packet size
    - B – allocated bandwidth
    - T – time-constant, defining "scheduling period"

References

- Leonidas Georgiadis, Vinod Perk, “Efficient Network QoS Provisioning Based on per Node Traffic Shaping”, IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 4, NO. 4, AUGUST 1996

Questions?