Choosing an appropriate buffer strategy for OPS with a feed-back FDL buffer

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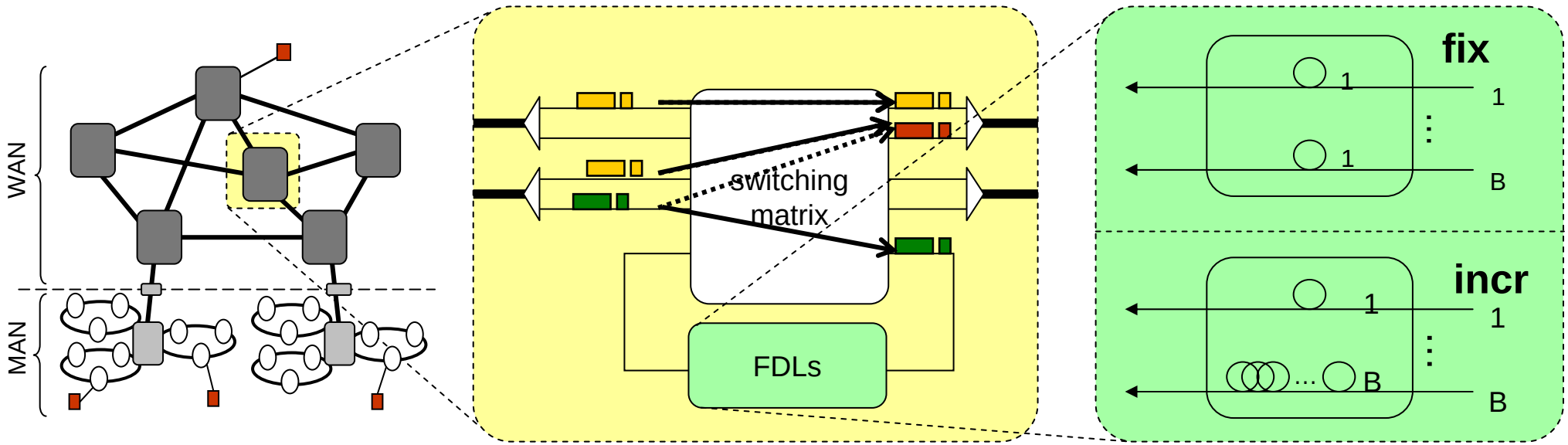
Outline

- Network and node architecture
- Operation of the switch
- Simulation set-up
- Choosing a buffer configuration
- Choosing a buffer strategy
- QoS differentiation
- Where’s the catch?
- Conclusion

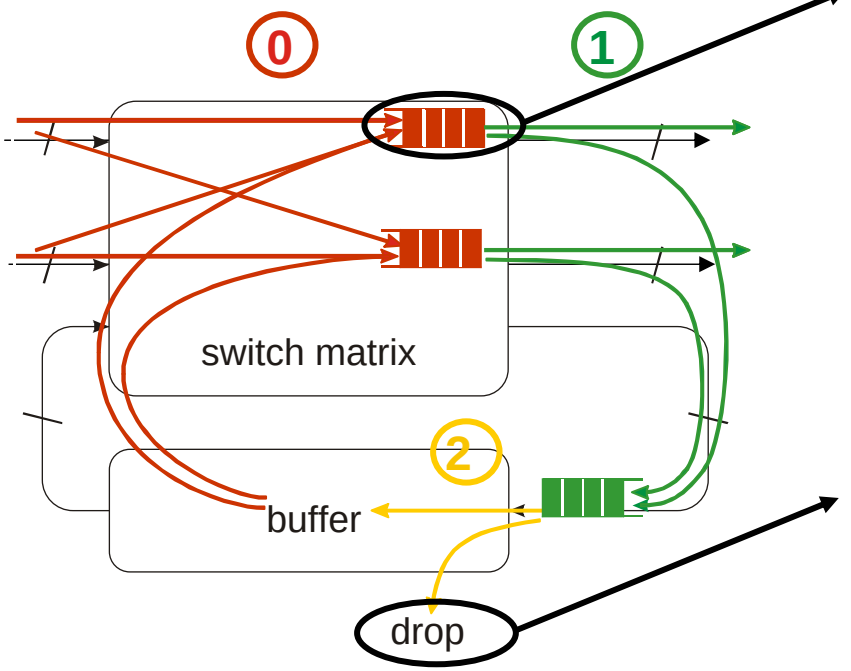
Network and node architecture

- Node in core OPS network (backbone), e.g. DAVID
- Switch functionality:
  - fixed length packets, slotted operation (DAVID:1μs), WDM ports
  - fully non-blocking switching matrix (SOA based)
  - wavelength conversion to solve contention
  - FDLs, int. multiple of slot, to provide buffering



Control of the switch

- Scheduling: each timeslot:
  - **(0)** collect packets (from inputs + FDLs) per destination output port
  - **(1)** select packets for **forwarding** along outgoing fibres; collect remaining (excess) packets
  - **(2)** elect packets for **buffering**; drop remaining packets



"priority queue":
1) first higher priority packets;
2) same priority: first "oldest"
3) same timestamp: random (uniform over same pri and tstamp)

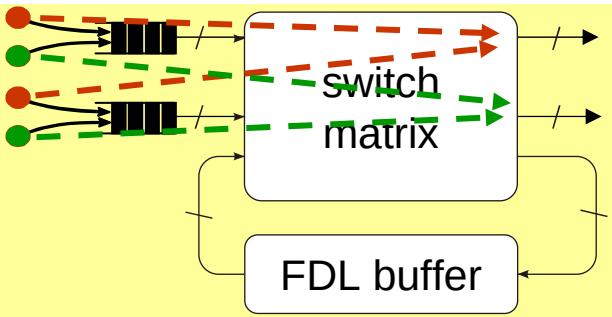
tstamp = when packet enters switch

we want to evaluate performance of switch in terms of Packet Loss Rate (PLR)

Simulation set-up (1)

- F=6 input/output fibres
- W=32 wavelengths per fibre
- 256x256 switch: max. 64 buffer ports ($B \leq 64$)

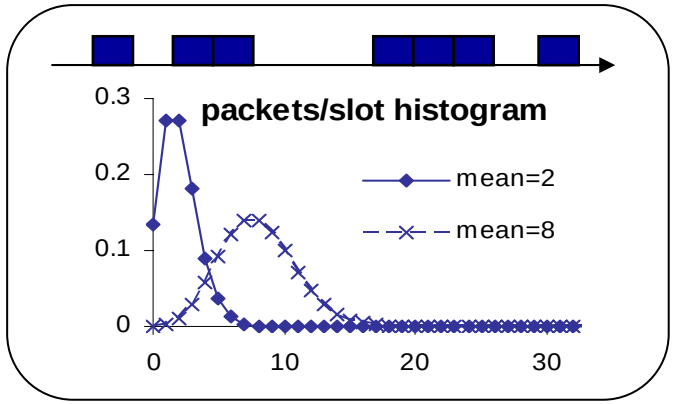
- P=3 priority classes
  - 25% lowest pri 0
  - 25% middle pri 1
  - 50% highest pri 2

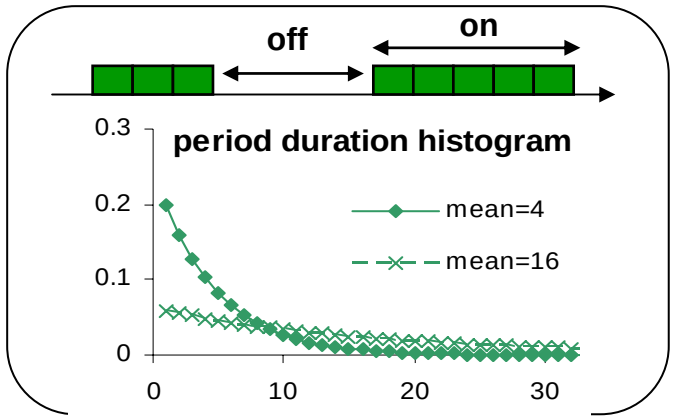


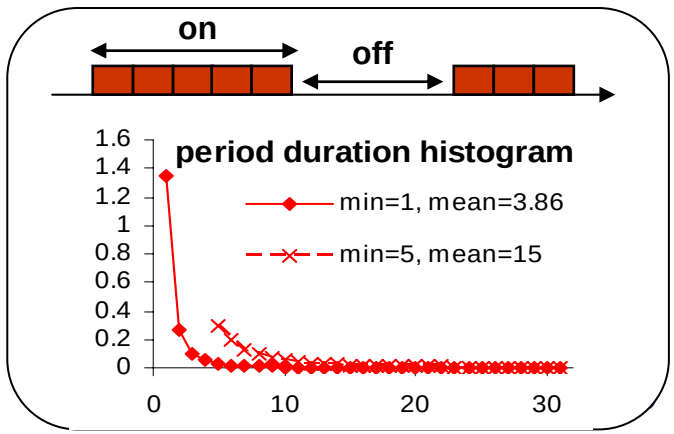
- traffic sources
  - source generates traffic for certain (in,out)-pair and with fixed priority ⇒ F·F·P=6·6·3=108 sources
  - uniform pattern: avg. amount of traffic is same for all (in,out)-pairs

Simulation set-up (2)

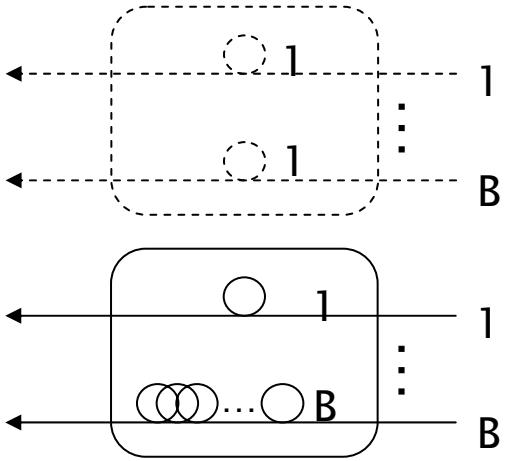
- Different traffic source types
- Poisson:
  - classical Poisson process (exp. distr. IATs)
  - no correlation between successive timeslots
- GeoOnOff:
  - bursty
  - strictly alternating On/Off periods, with packet every timeslot during On-period; no packets during Off-period
  - geometric distribution for period lengths
- ParetoOnOff:
  - bursty, self-similar
  - strictly alternating On/Off periods
  - Pareto distribution (heavy tailed) for period lengths

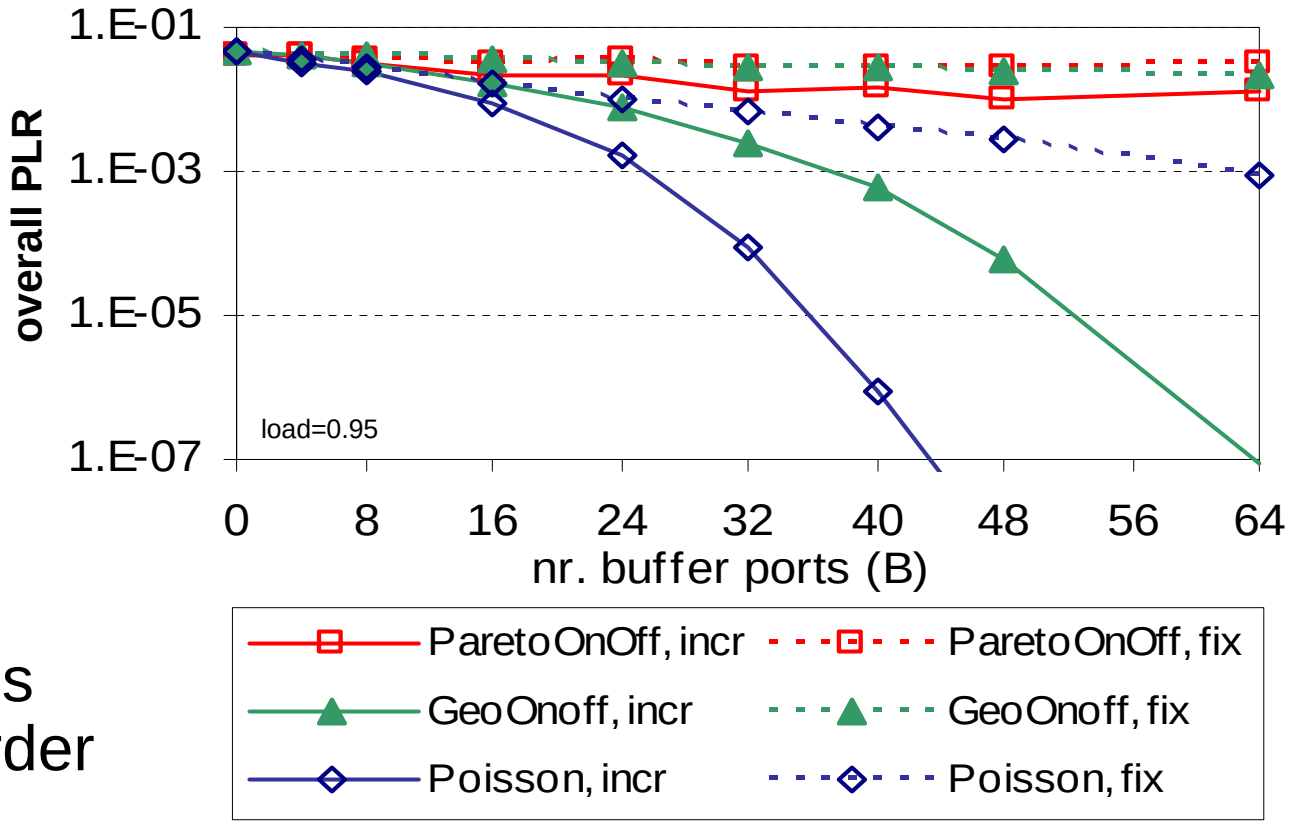






Buffer configuration

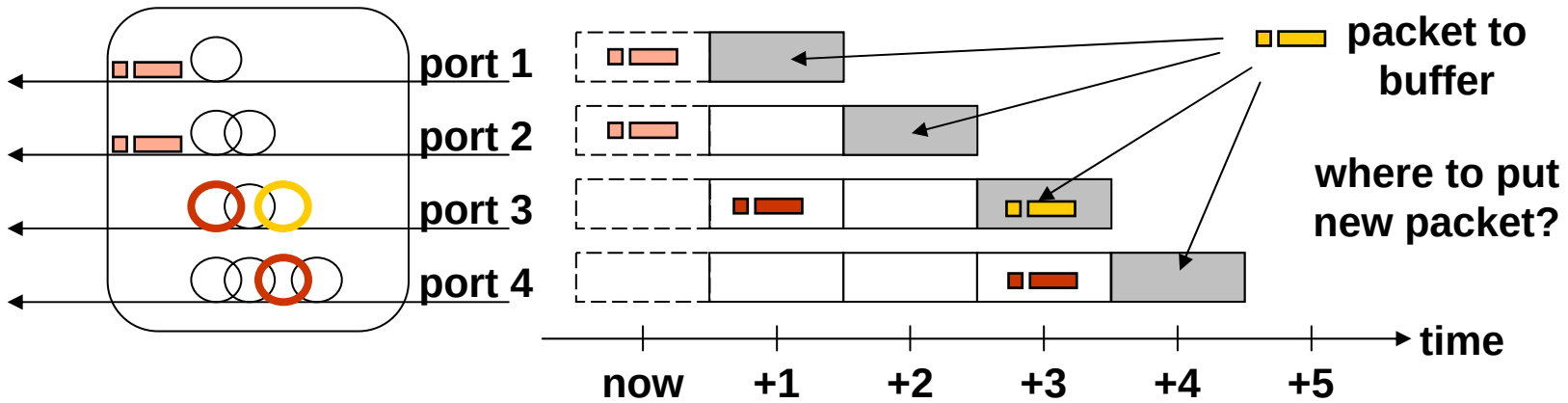




- **Increasing** FDL lengths give far lower PLRs (order of magnitude or more)
- **ParetoOnOff:** difference is limited (factor ~2) and doesn't vary much with increasing nr. buffer ports

Buffer strategy (1)

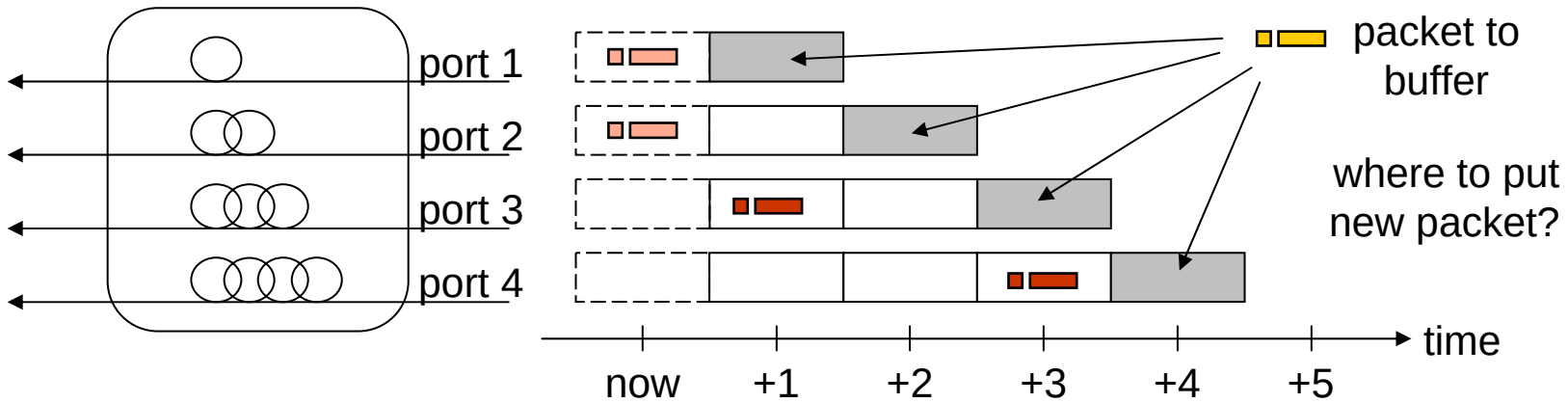
- Problem (for increasing FDL):
  - FDLs are shared over all output ports: use buffer as efficient as possible (only single copy in FDL)
  - choosing FDL length = deciding when it will re-enter the switch (and have another attempt at forwarding)
  - multiple packets will leave FDL buffer block at same time
- Need to choose “appropriate” FDL



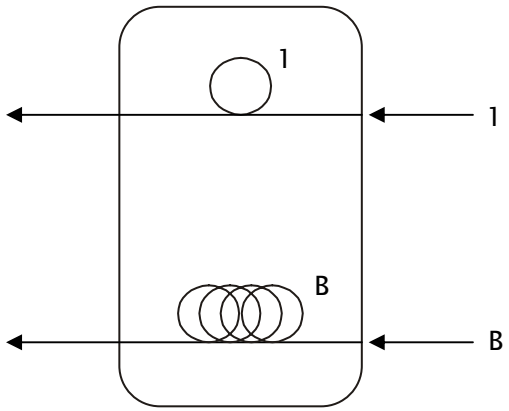
Buffer strategy (2)

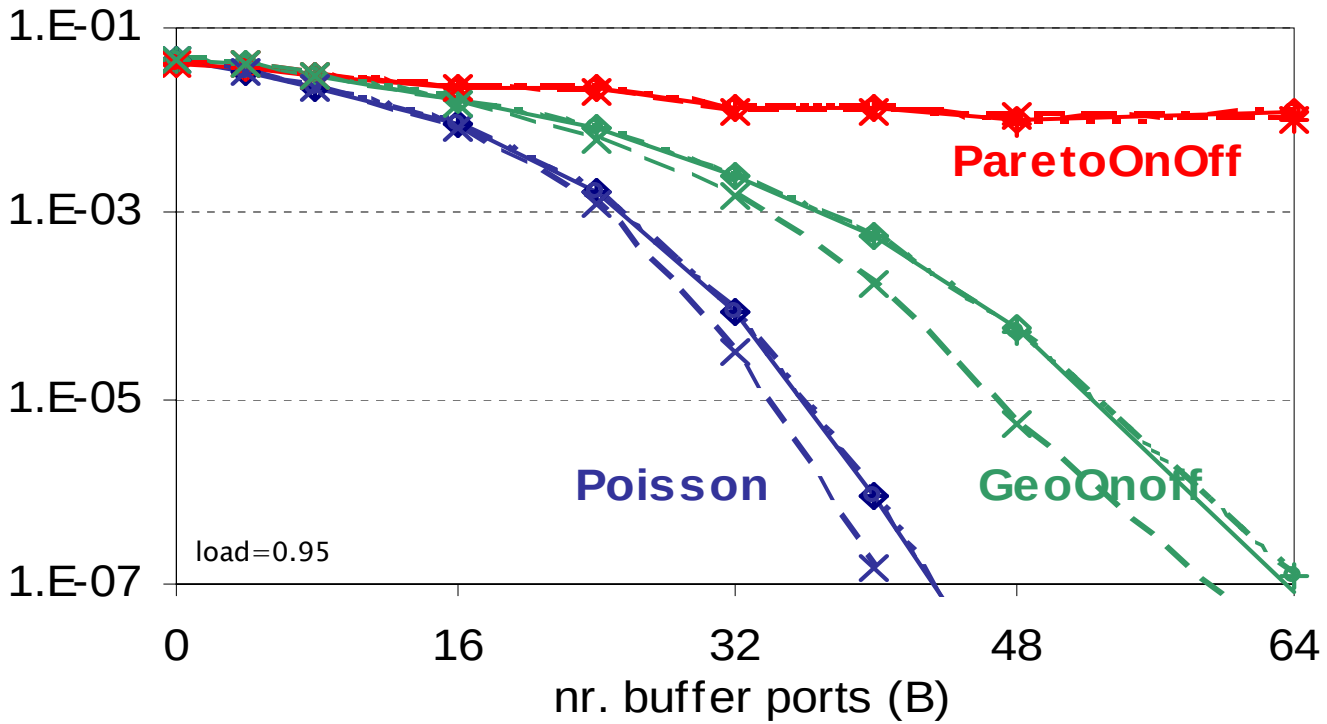
- Comparison of 4 strategies:
  1) **MinDelay**: minimal delay (not intelligent, but fast)
  2) **NoOvr**: do not allow overload (buffer output will never contain more than W=32 packets destined for same fibre)
  3) **AvoidOvr**: avoid overload if possible; if not: use smallest delay
  4) **Balance***:* use FDL with length L such that nr. of packets leaving buffer simultaneously (at now+L), is minimal

  Note: if B≤W, then no overload is possible: 1,2,3 are equivalent



Buffer strategy (3)



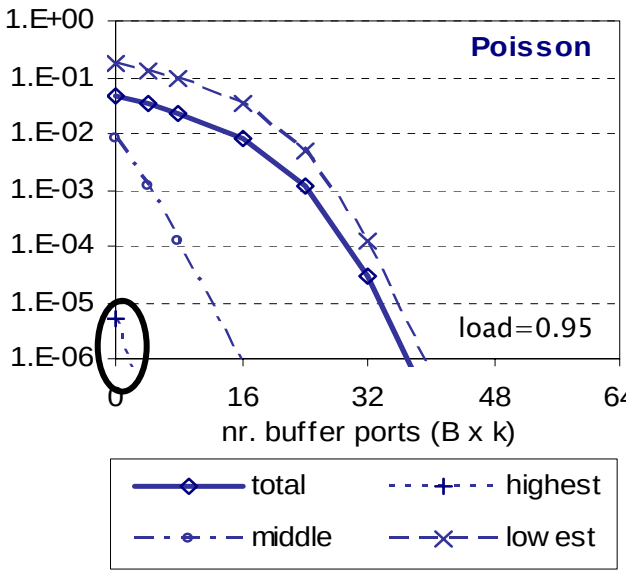


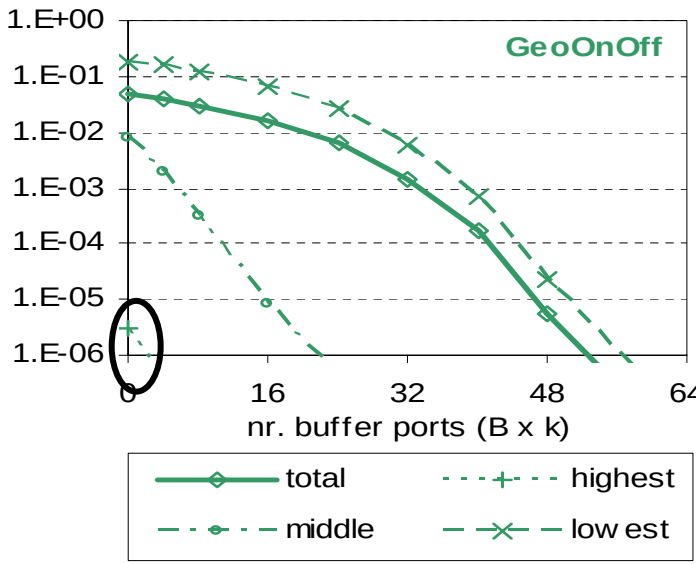
- **Balance** outperforms other strategies for GeoOnoff and Poisson
- **ParetoOnOff:** no matter what, PLR can't be reduced significantly

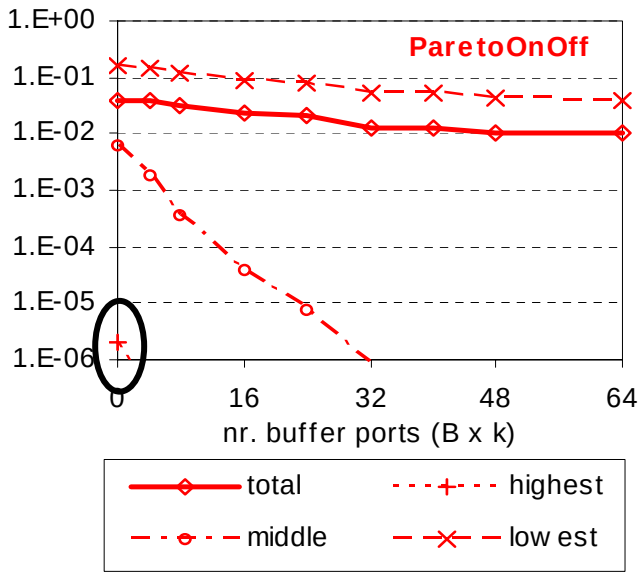
QoS differentiation

- three priority classes: High, Middle, Low
- scheduling: strict priority mechanism; only take into account packets of same or higher priority

⇒ **effective QoS differentiation**





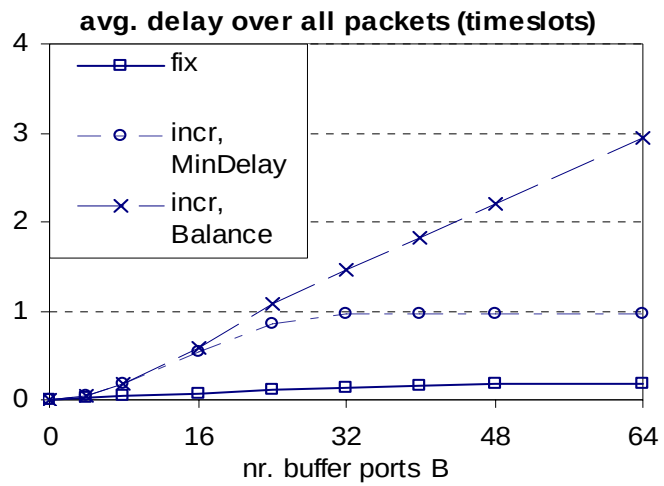


Where's the catch?

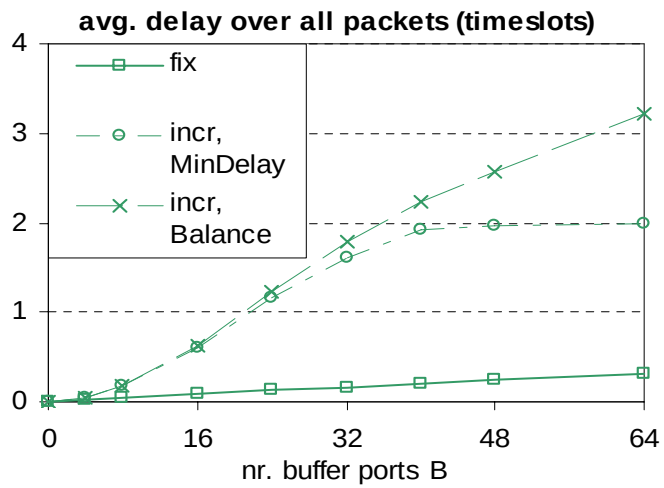
- Incr vs Fix; Balance vs MinDelay
  - larger delay, but still limited to avg. of a few timeslots (= few μs for DAVID case)
  - out-of-order for Incr, but Balance somewhat lower than MinDelay; again limited: ~10% of all packets
    (less than 10^{-6} of highest, less than 1% of middle priority packets)

⇒ **No significant penalty**

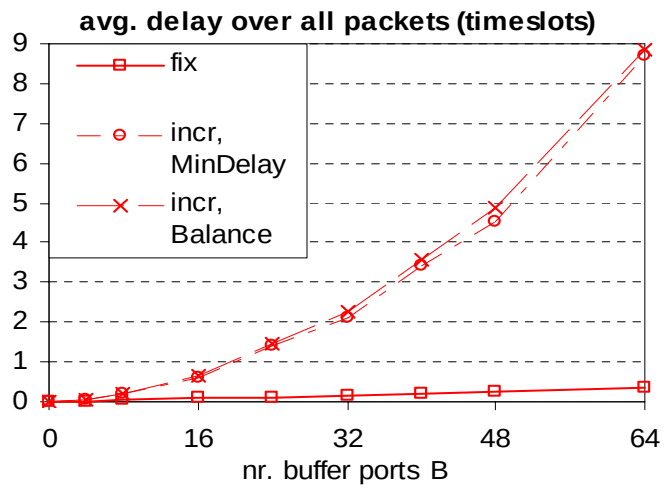
Poisson



GeoOnOff



ParetoOnOff



Conclusions

- **ParetoOnOff traffic: minor PLR reduction through buffering**
  - **consistent with other results from e.g. electrical packet switching;**
  - **self-similarity will be reduced by traffic shaping / aggregation at ingress of OPS network**
- **buffer structure: using different FDL lengths gives significantly better PLR performance for same switch fabric port count**
- **increasing FDL lengths: Balance strategy is best in terms of PLR performance**
- **associated “penalty” in terms of delay and out-of-order delivery is limited**