Priority-Aware Scheduling for Packet-Switched Optical Networks in Datacenter

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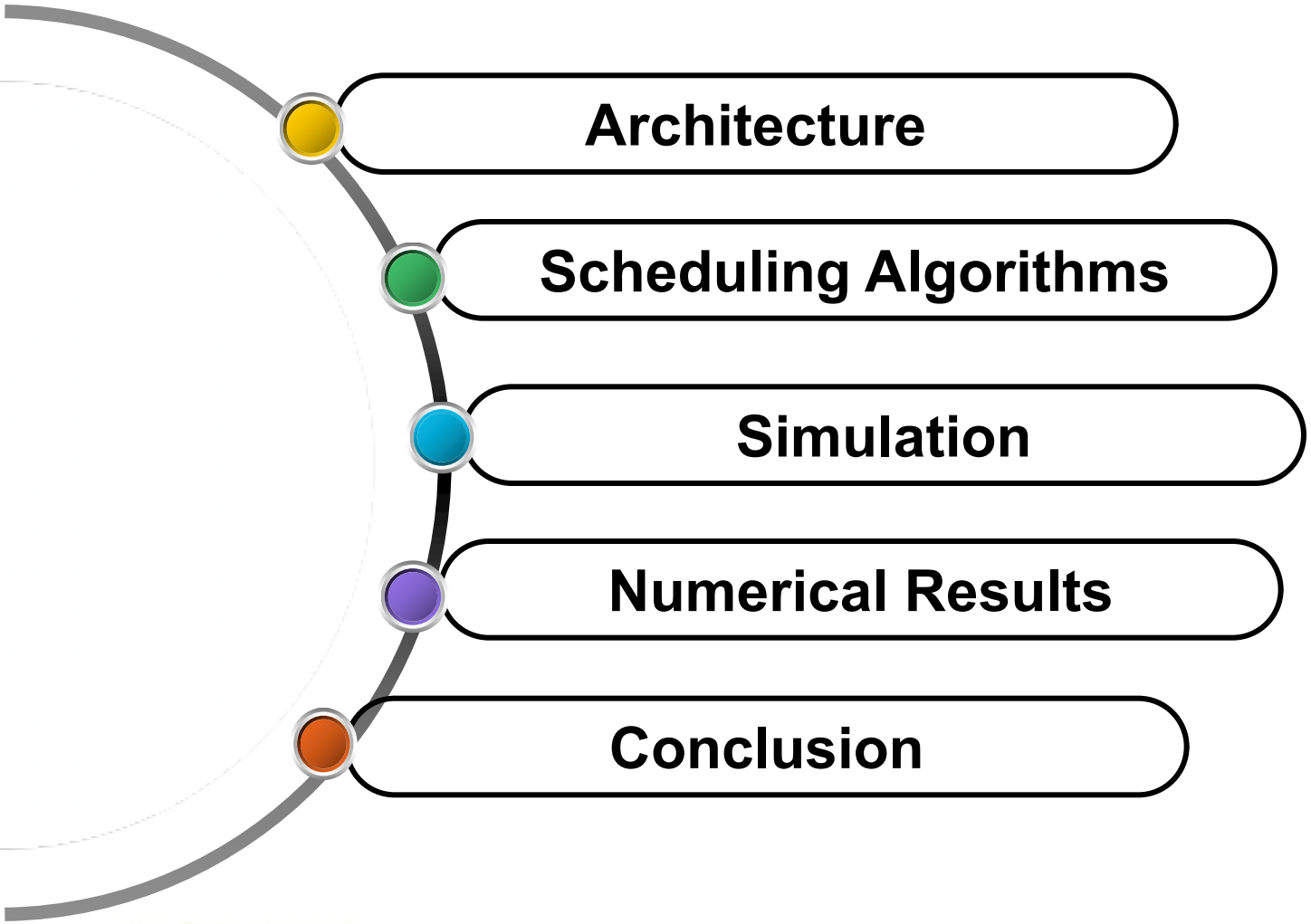
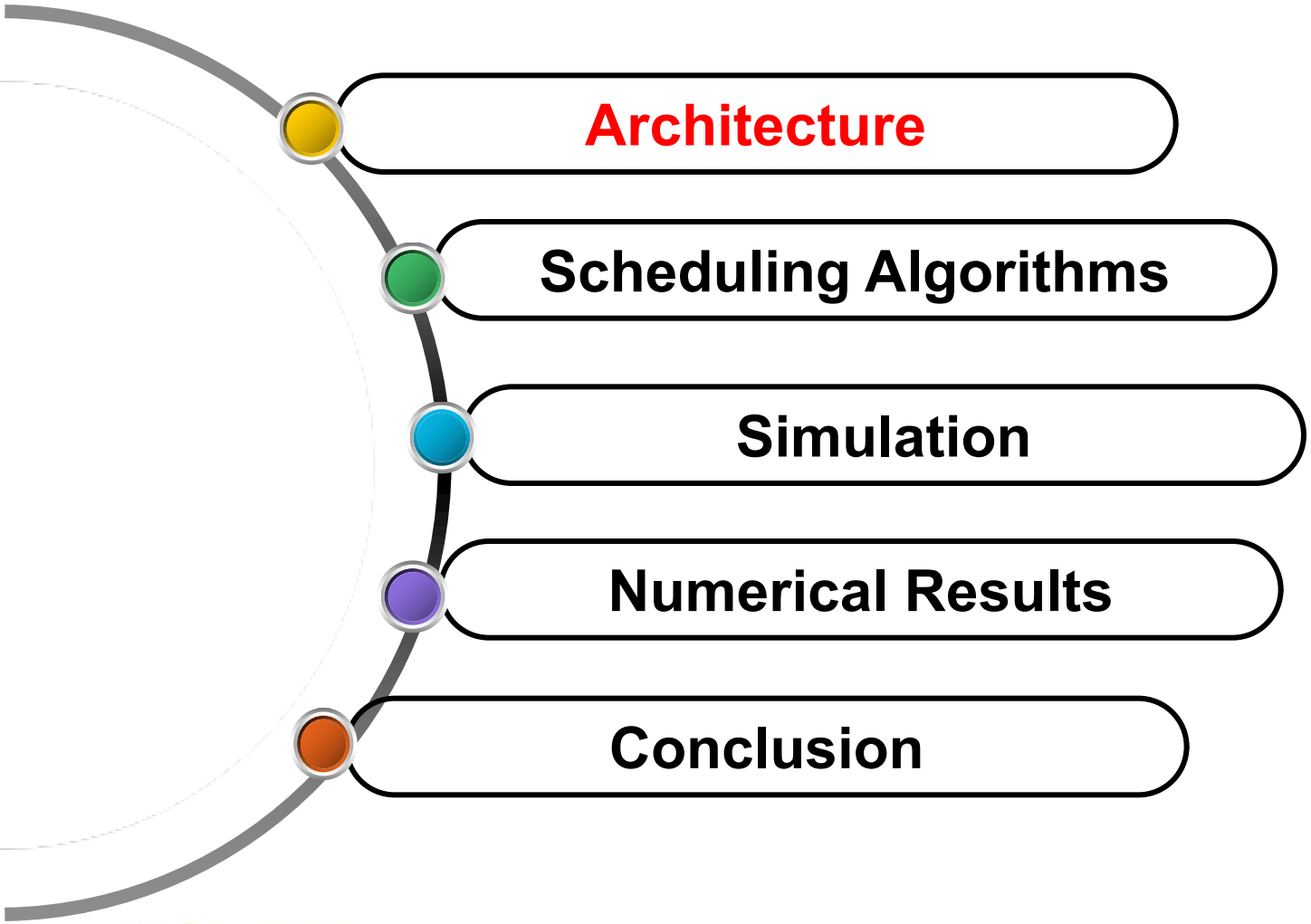

Architecture
Scheduling Algorithms
Simulation
Numerical Results
Conclusion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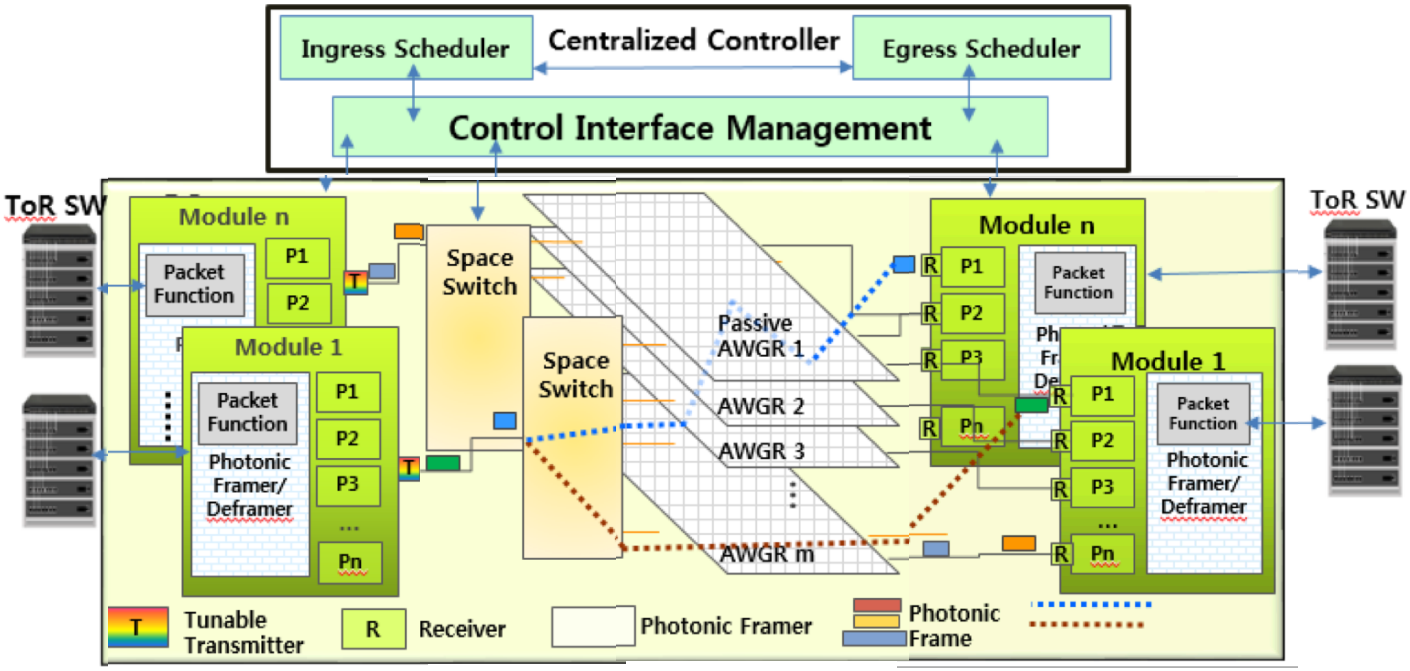
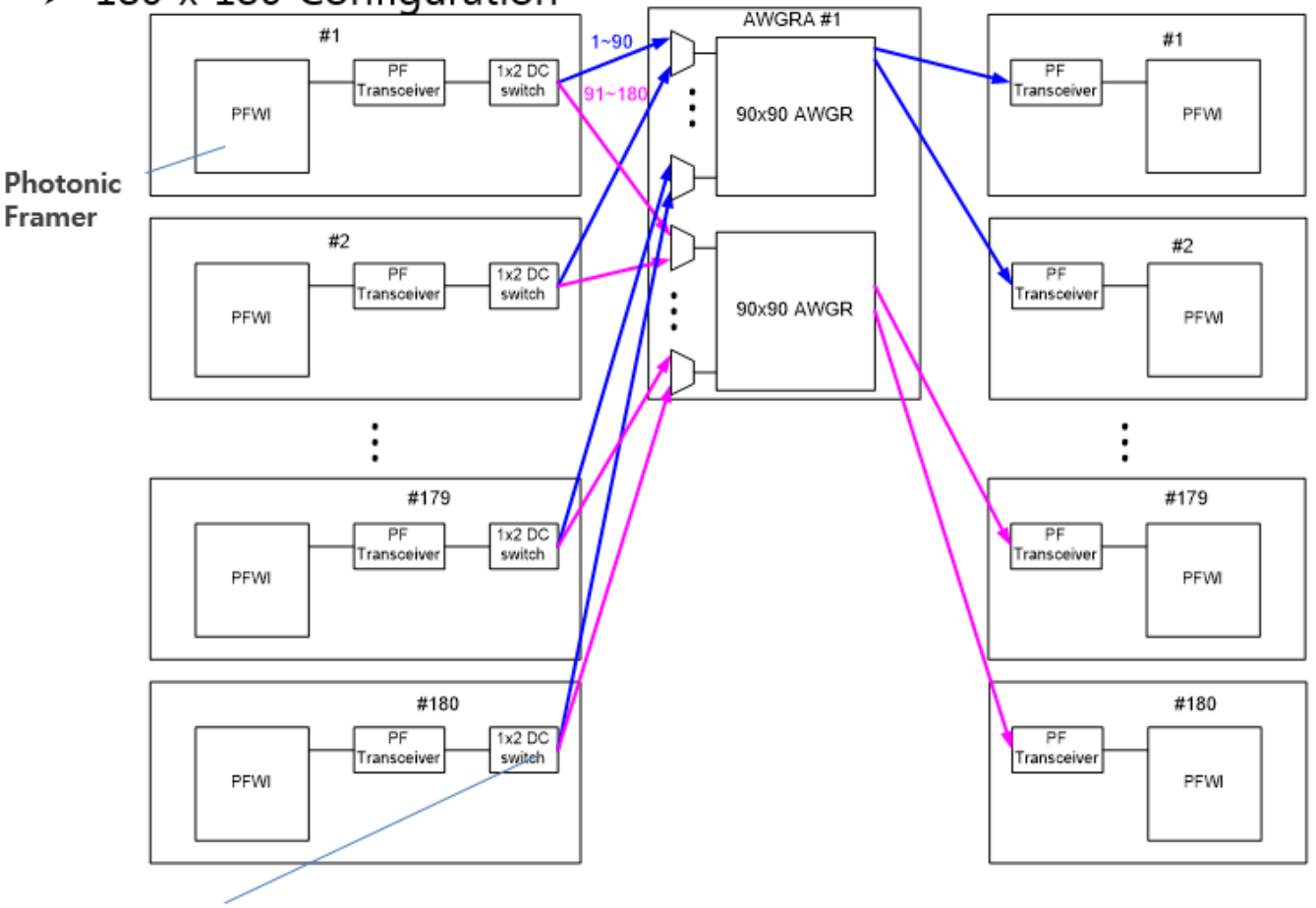
Packet-Switched Optical Network (PSON) Architecture

- Top-of-rack (ToR) switch connected with servers
- Ingress module/egress module with framer/de-framer per switch
- A space switch connects with *m* Arrayed Waveguide Grating Routers (AWGR)
- Scalable core switching consists of AWGRs
- Control interface management

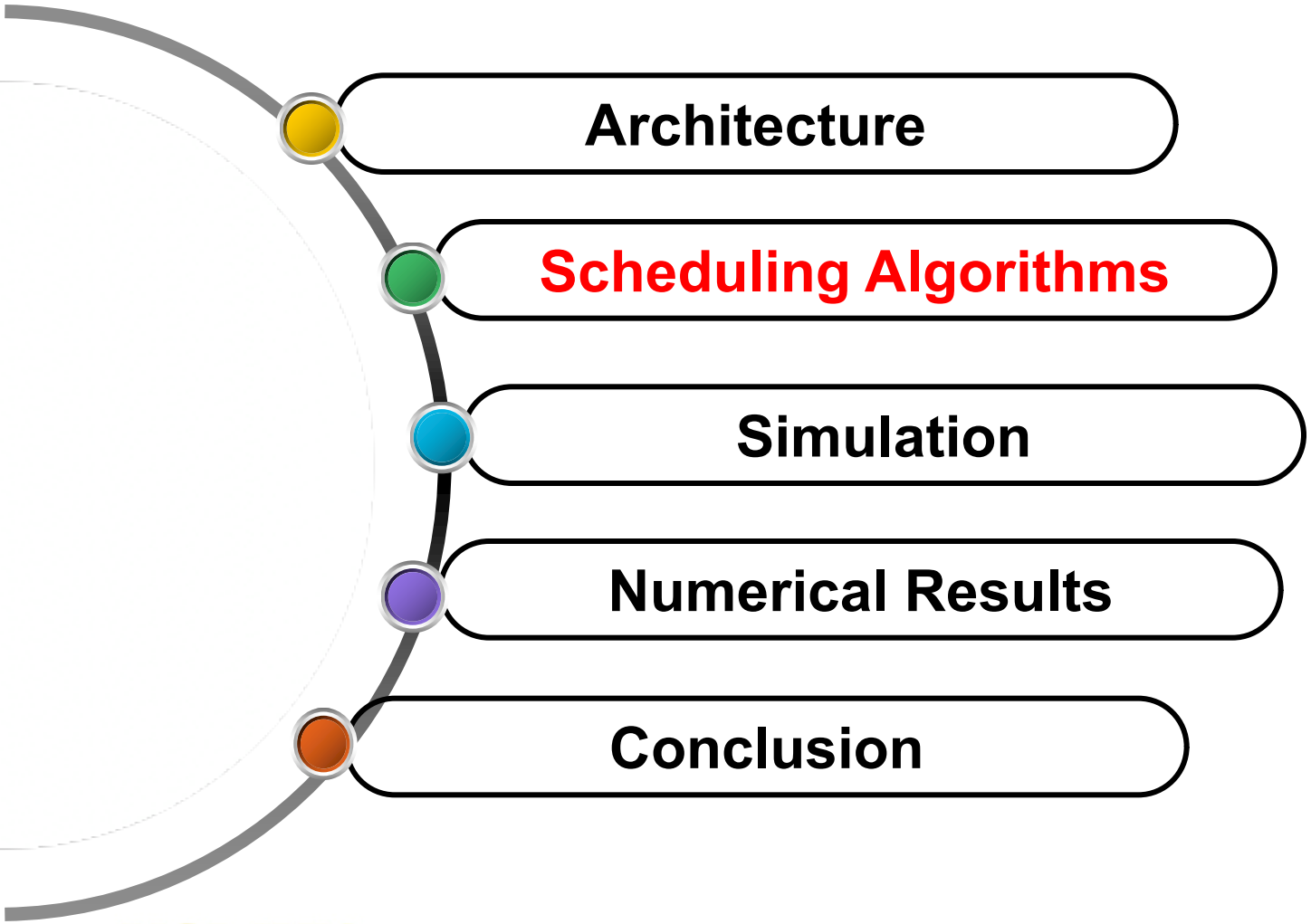


PSON data plane (with optical switch fabric)

- 180 x 180 Configuration



Space switch: Optical path switch to switch optical signal between module and AWGR at sub micro-second speed.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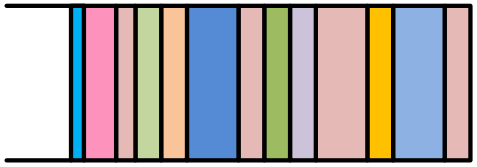
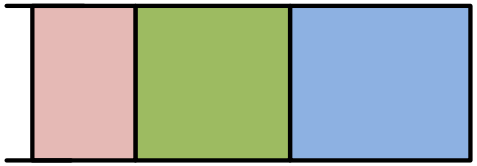
Mice VS. Elephant Flow



- Small size packet
- Large number
- Short flow
- Short-lived

transactional traffic, web browsing, search queries (≈ 80% traffic)

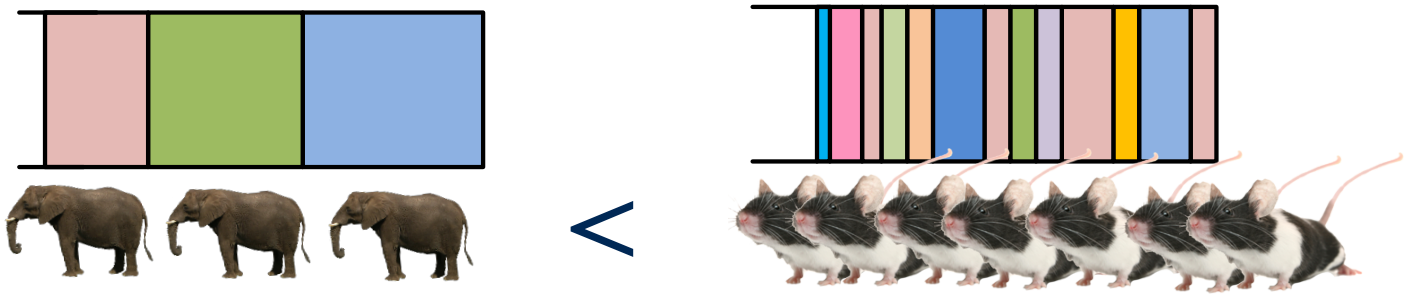


- Large size packet
- Small number
- Large volume flow
- Long-lasting

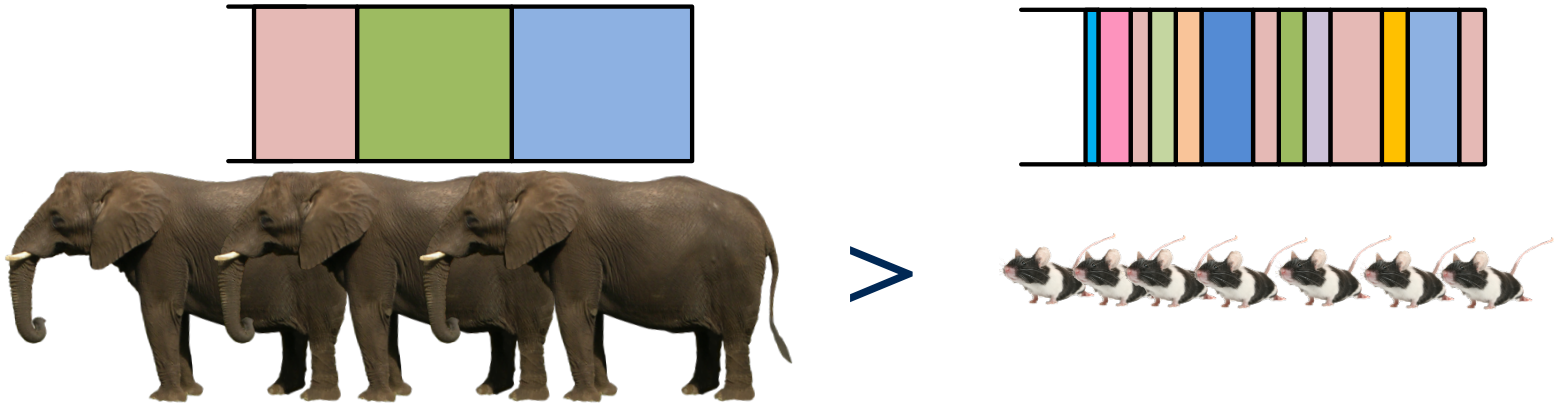
bulk data transfer, data backup, virtual machine migration (≈ 20% traffic)

Mice VS. Elephant Flow

- If schedule first queues with larger **number** of packets, elephant flows will be penalized



- If schedule first queues with larger **total size** of packets, mice flows will be penalized

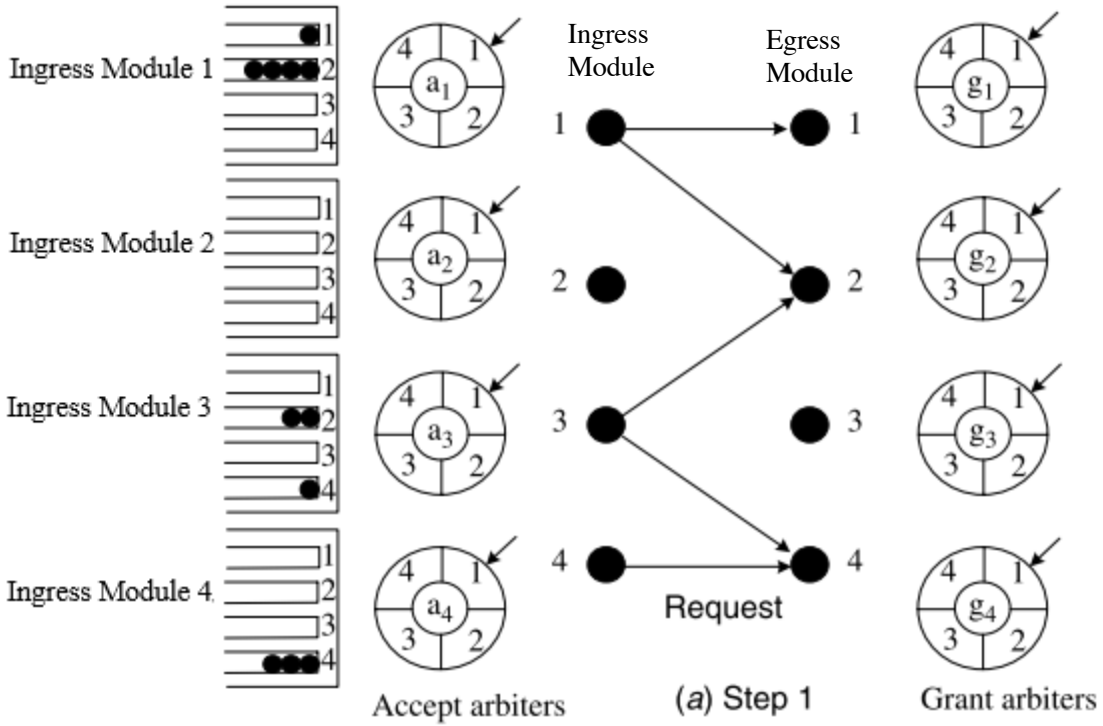


Round Robin Algorithm

- **Iterative Round Robin algorithm**
  - ✓ Step 1: *Request*
  - ✓ Step 2: *Grant*
  - ✓ Step 3: *Accept*

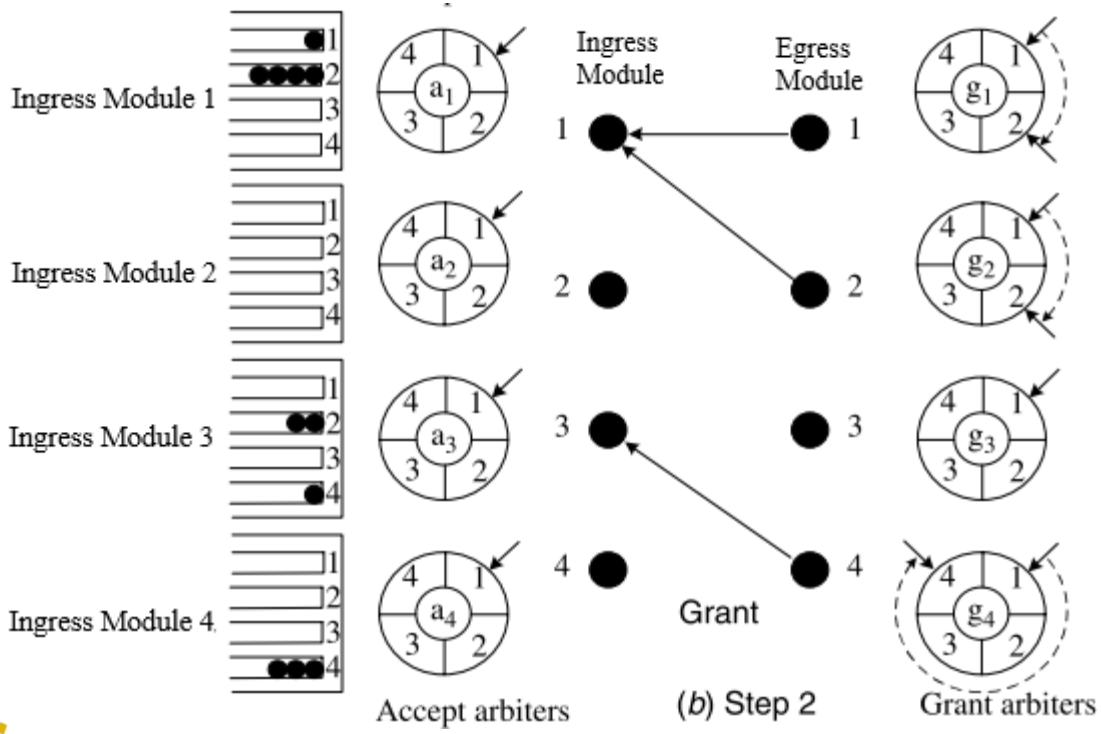
Round Robin Algorithm

- **Step 1. Request**
  - ✓ Each ingress module maintains a queue for each egress module
  - ✓ Send request, if the queue at ingress module is not empty



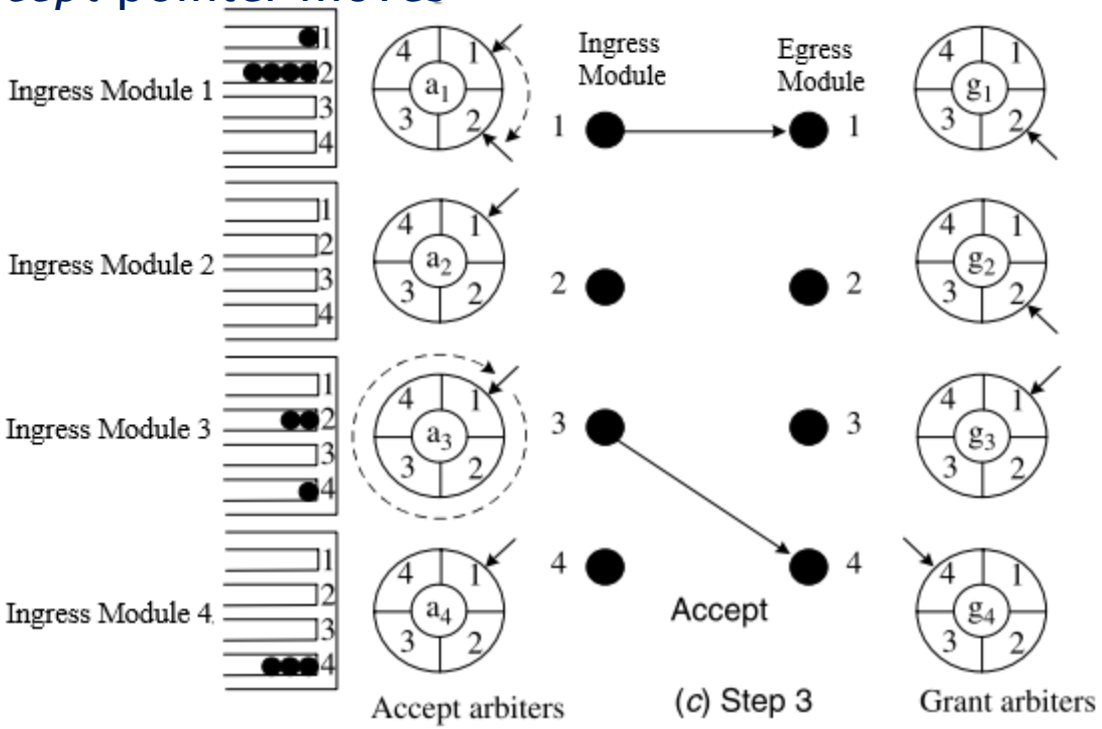
Round Robin Algorithm

- **Step 2. Grant**
  - ✓ Output maintains a *grant* pointer
  - ✓ Output chooses requesting input closest to the grant pointer
  - ✓ *Grant* pointer moves



Round Robin Algorithm

- **Step 3. Accept**
  - ✓ Input maintains a *accept* pointer
  - ✓ Input accepts granting output closest to the accept pointer
  - ✓ *Accept* pointer moves



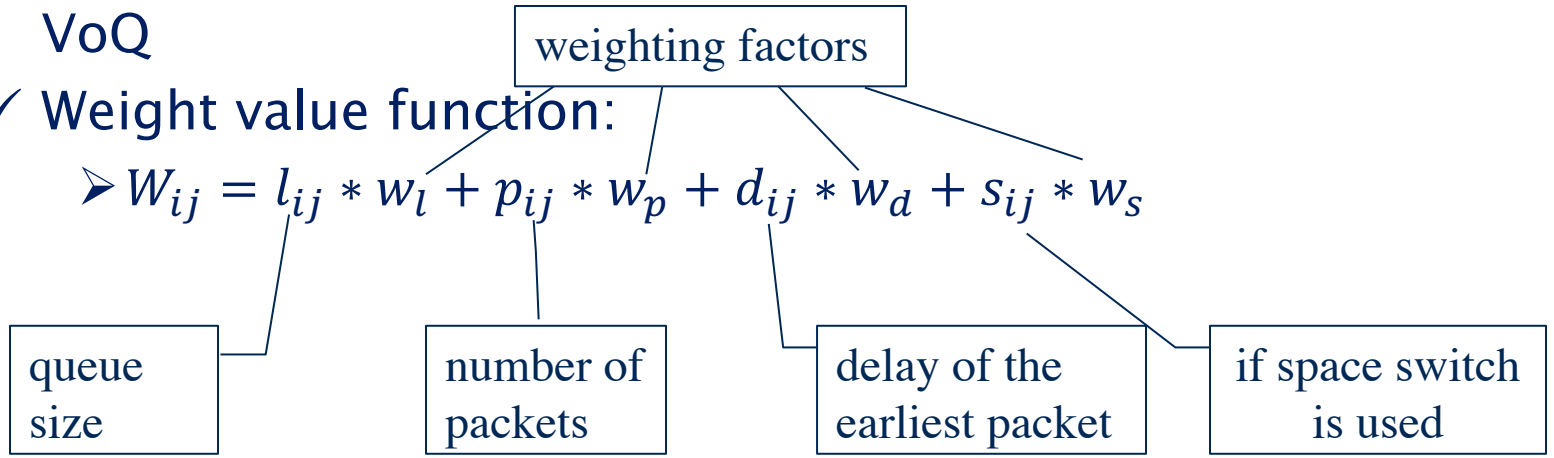
Round Robin Algorithm

- Pro's
  - Simple
  - Fast

- Con's
  - does not consider traffic characteristics
  - results in high delays and unfairness

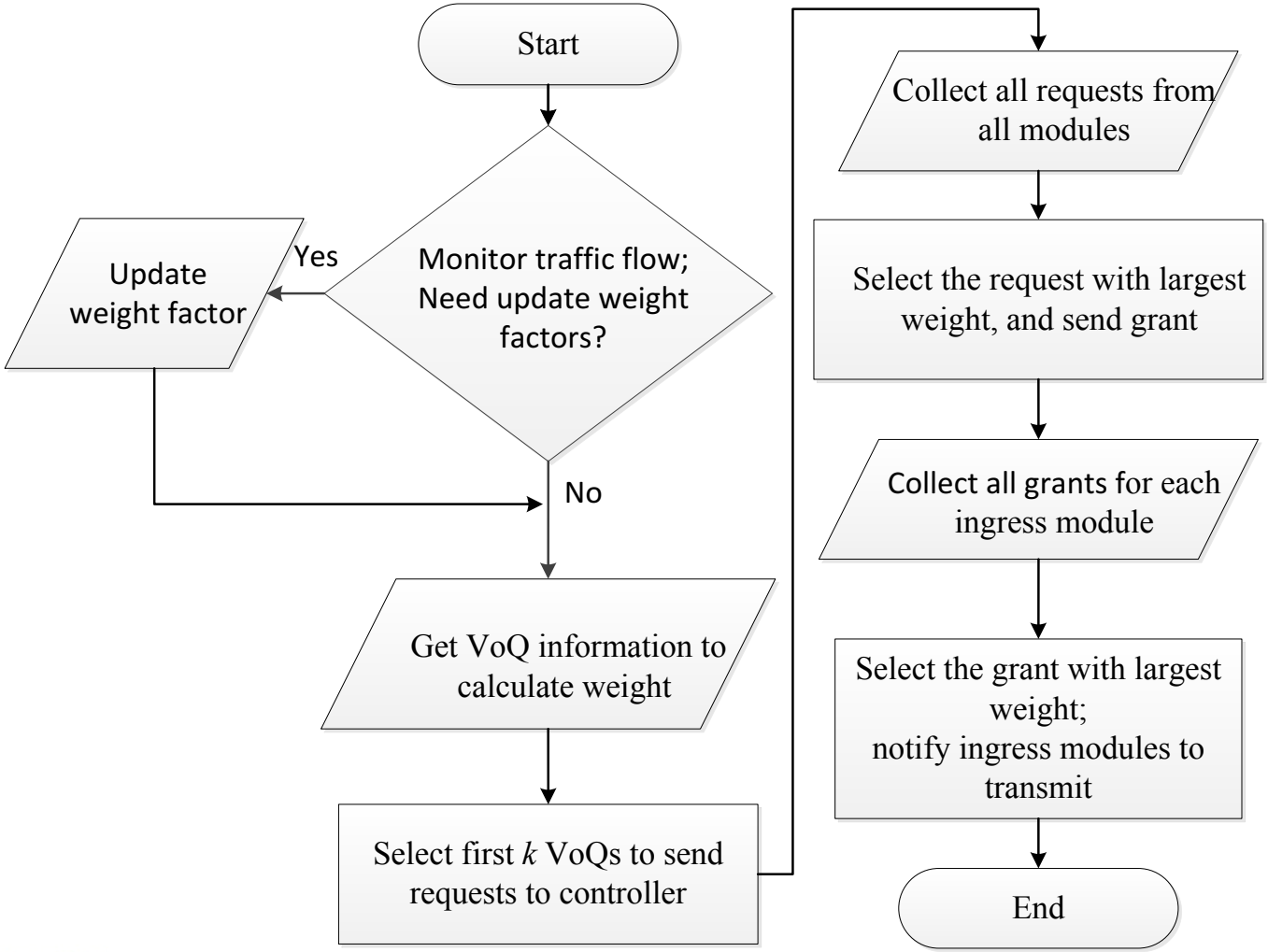
A Priority-Aware Scheduling Algorithm for PSON

- ✓ Uses status information to calculate weight values for each VoQ
- ✓ Weight value function:
  - $W_{ij} = l_{ij} * w_l + p_{ij} * w_p + d_{ij} * w_d + s_{ij} * w_s$

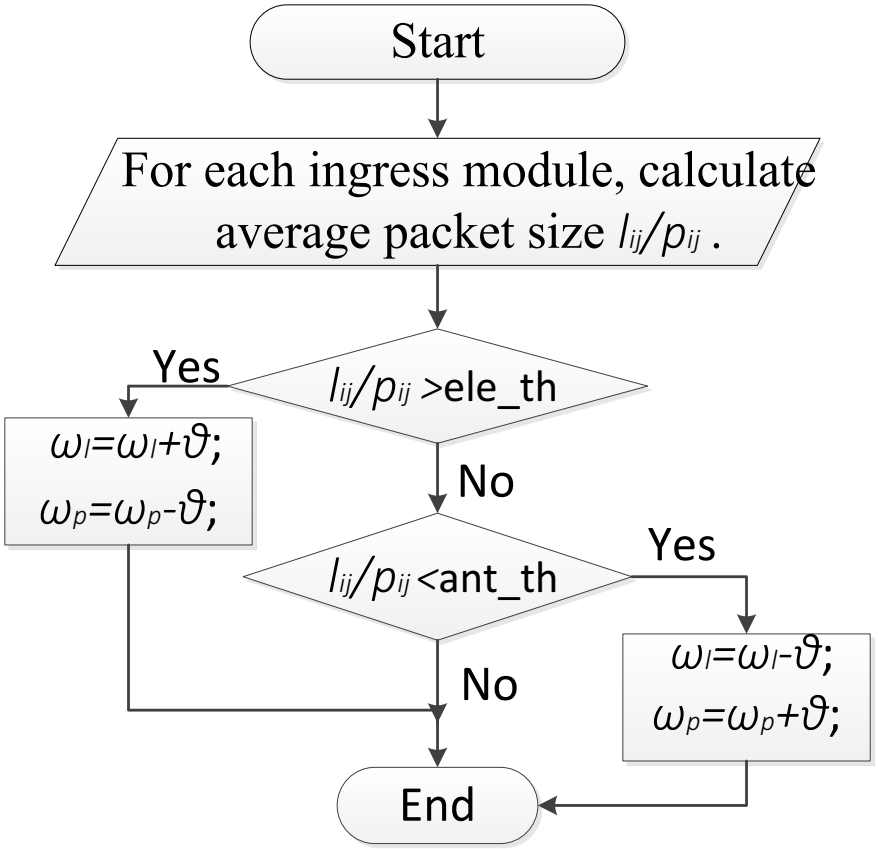


- ✓ Send only first k VoQs with highest weight

Scheduling Algorithm for PSON



Scheduling Algorithm for PSON

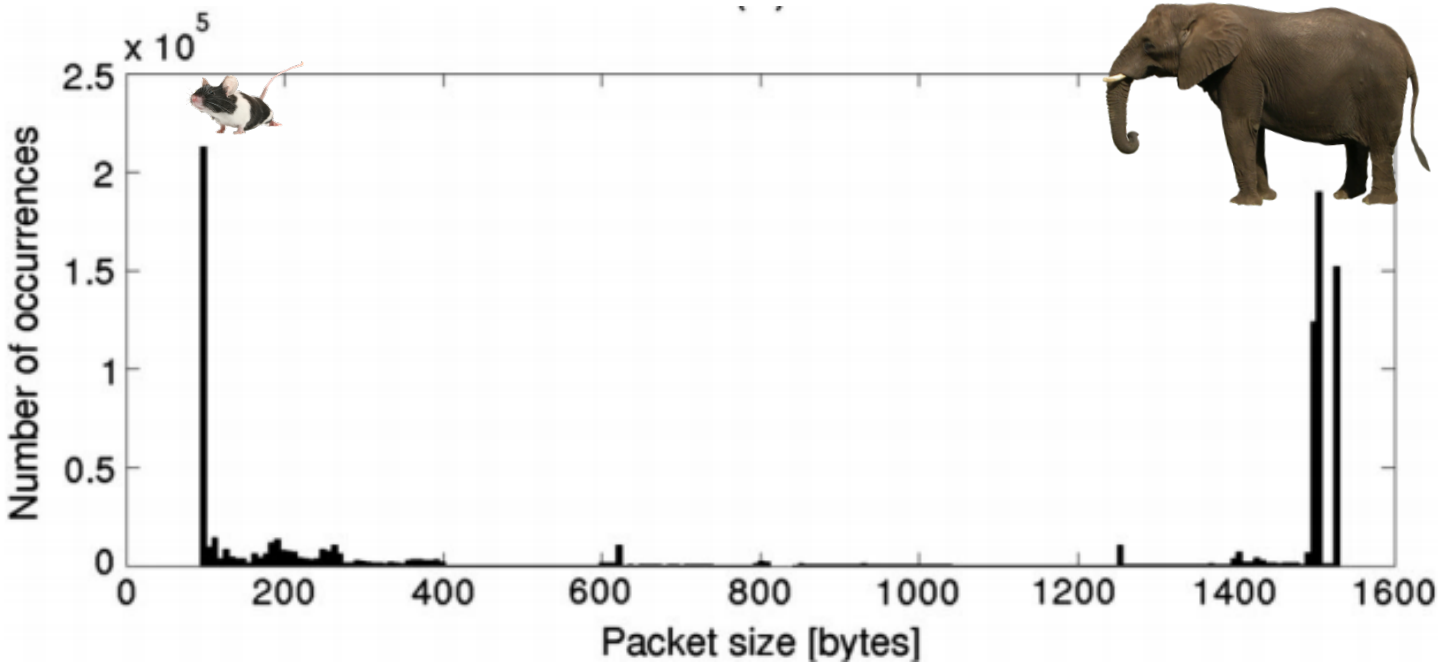


Topology for Simulation

- **PSON:** *n=80* ToR switches, *40×40* AWGRs, and *1×2* space switches.
- **Each ToR receives input traffic generated by 36 servers.**
- **Classify 36 servers of each ToR into three groups:**
  - **1st group: generates packets which contain 80% elephant flow and 20% mice flow;**
  - **2nd group generates packets with 20% elephant flow and 80% mice flow;**
  - **3rd group generates packets with 50% probability.**

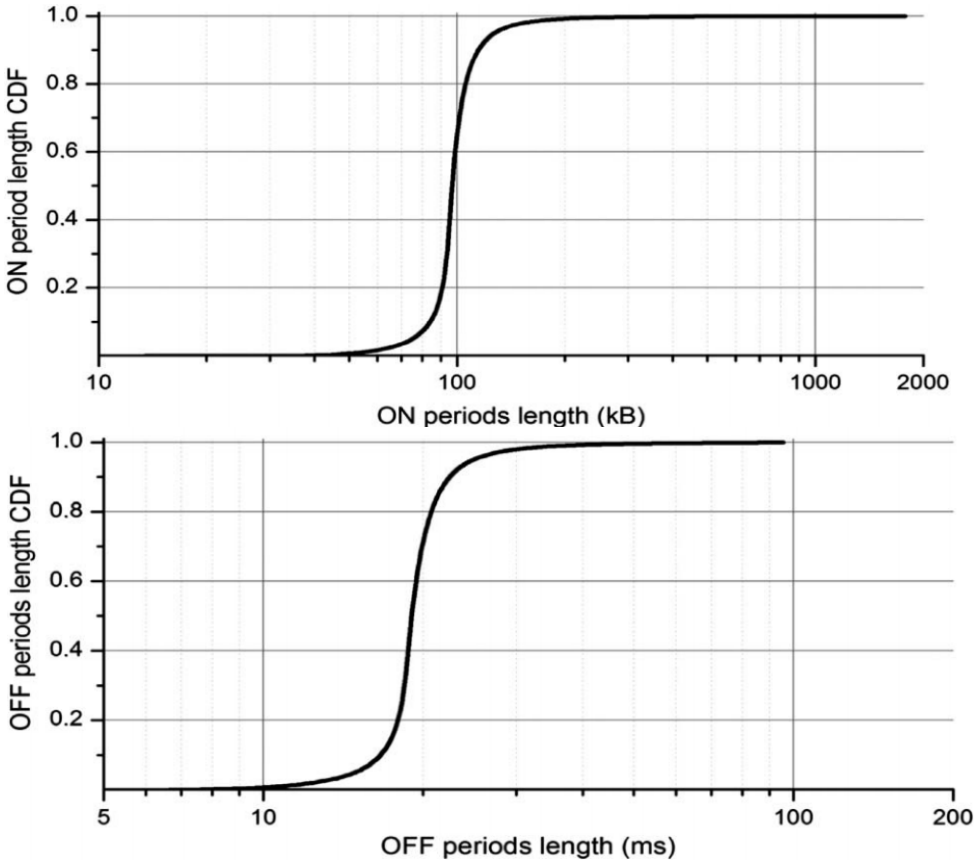
Traffic Generation (1)

- Packet length follows a bimodal distribution around 40 bytes and 1500 bytes



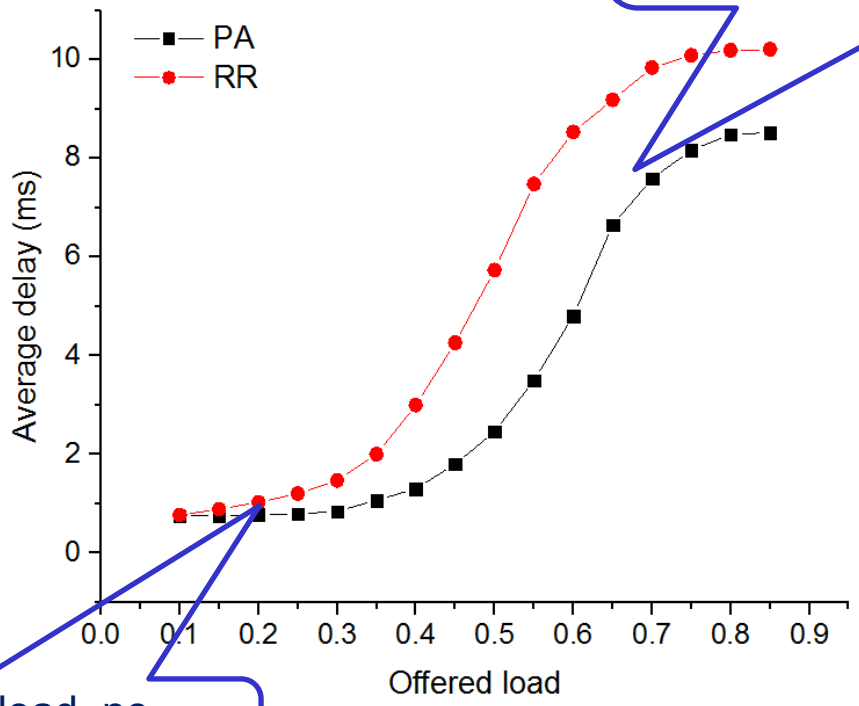
Traffic Generation (2)

- Packet arrival times are modeled matching ON/OFF periods
- ON/OFF periods follows Pareto distribution



Results: Average Delay

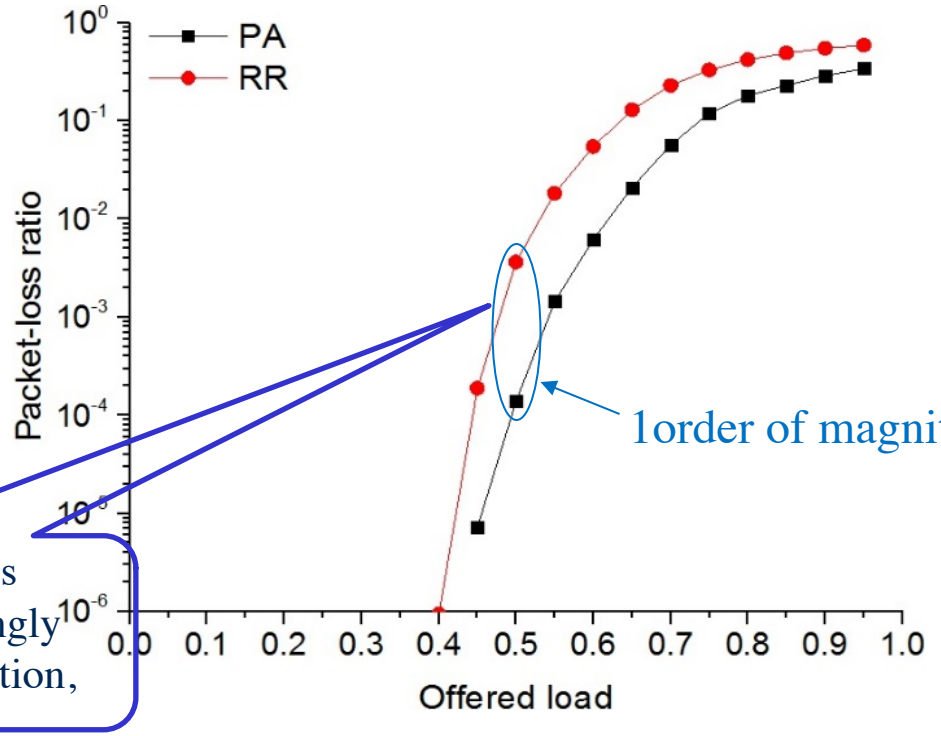
Take-Away 2: Significant delay decrement (more than 50% for intermediate loads)



Take-Away 1: at low load, no difference

Average delay of PA and RR algorithms

Results: Packet Loss Ratio

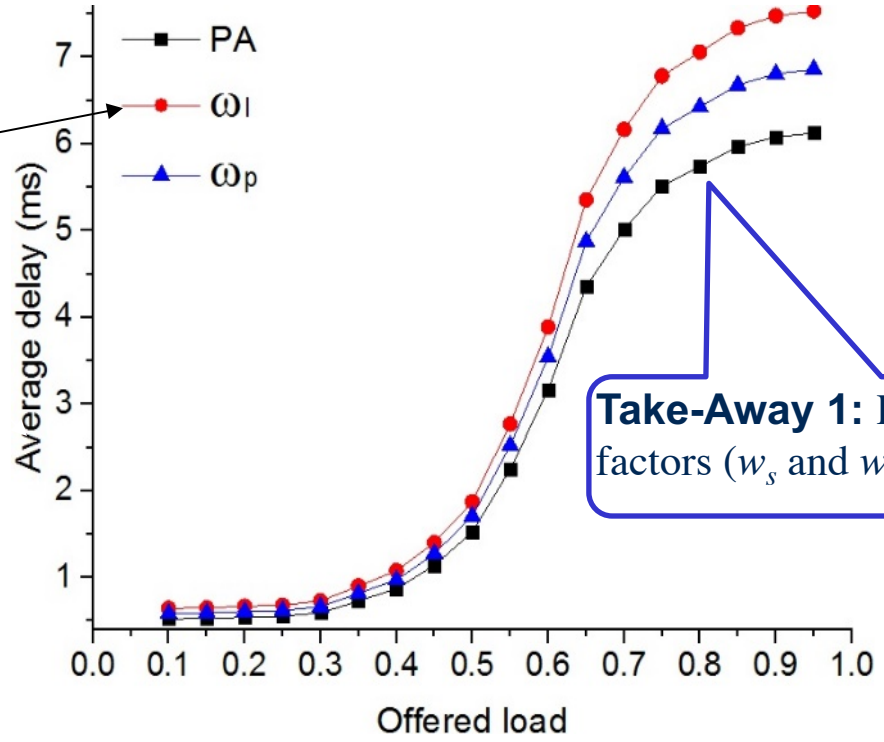


Take-Away 2: PA achieves smaller PLR, and thus strongly improves bandwidth utilization,

Packet-loss ratio of PA and RR algorithms

Results: Average Delay (comparison of ω)

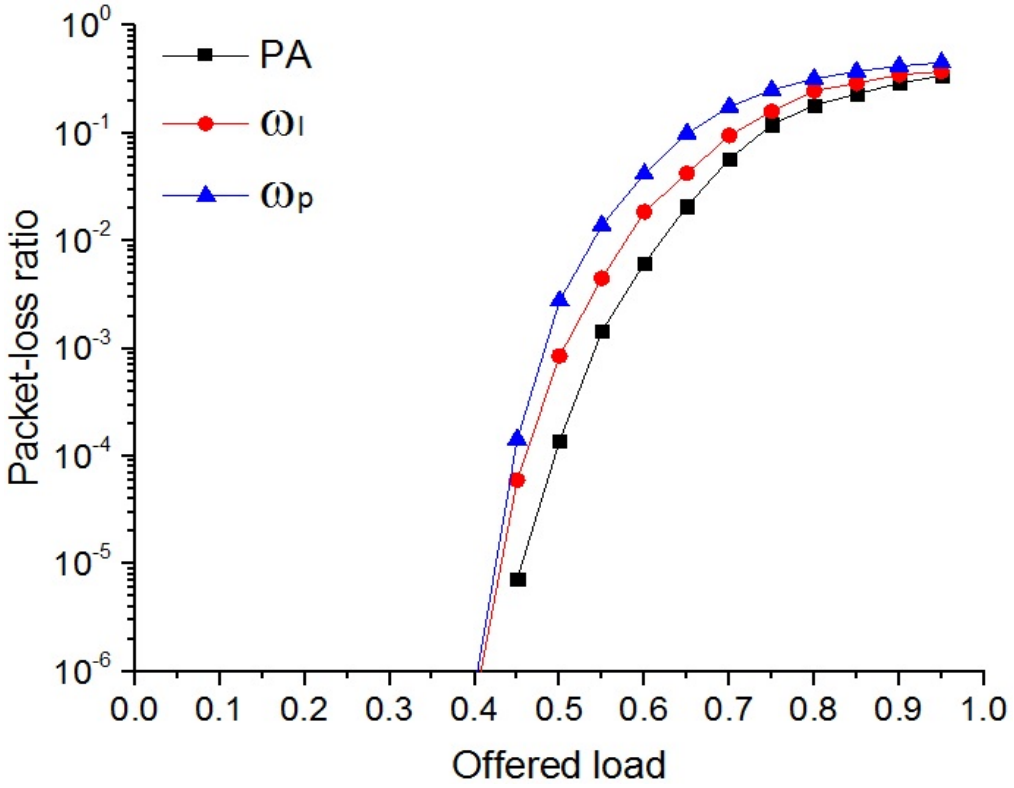
All weight factors are set to zero except w_l, (similarly for the curve of "w_p")



Take-Away 1: PA considering both factors (w_s and w_d) performs the best

Influence of weight factors on average delay of PA algorithms

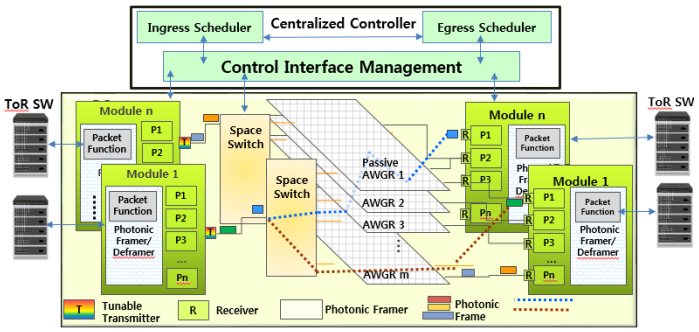
Results: Packet Loss Ratio (comparison of ω)

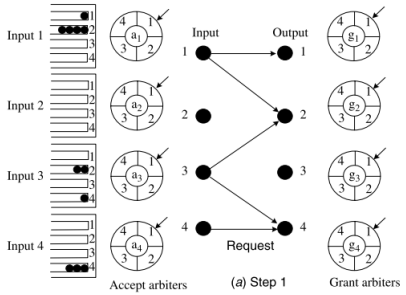


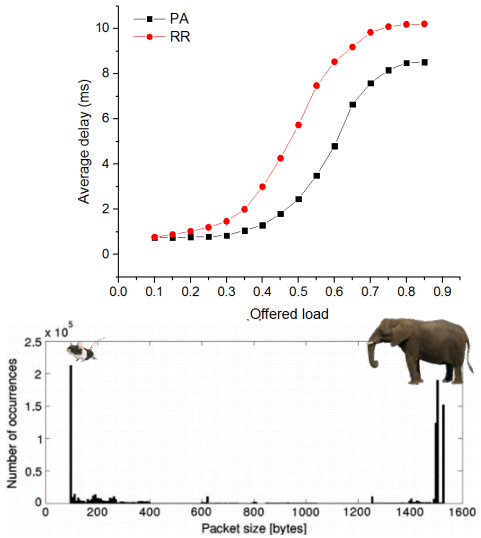
Influence of weight factors on packet-loss ratio of PA algorithms

Conclusion

- We studied scheduling for PSON architecture
- Proposed a Priority-aware (PA) scheduling algorithm
  - Extension of Round Robin to account for «mice vs elephant» flows
- Performed performance evaluation of PA algorithm
- Significant savings: up to one order of magnitude on blocking and up to 50% on delay







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Scheduling Algorithm for PSON