Institut für
Kommunikationsnetze

Cyclic-Reservation Beats all MACs

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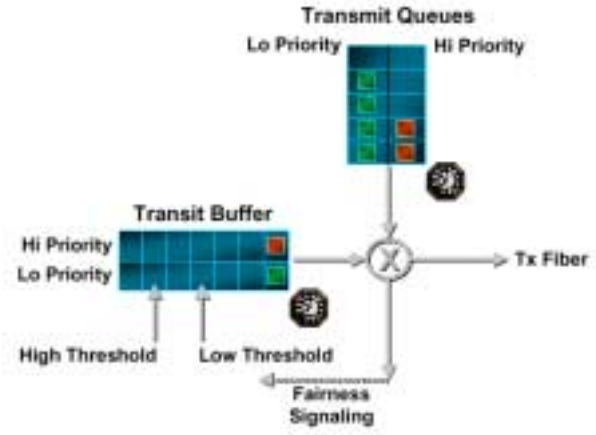
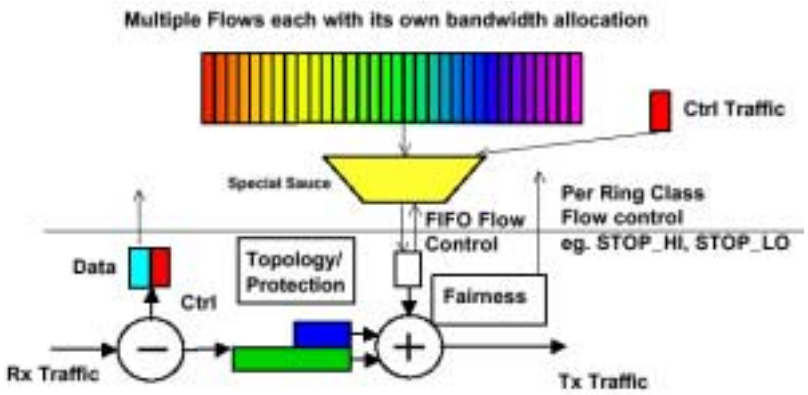
Gandalf: Main Mechanisms





Transit buffers:

- Used for collision avoidance, high-priority bypassing, and packet scheduling

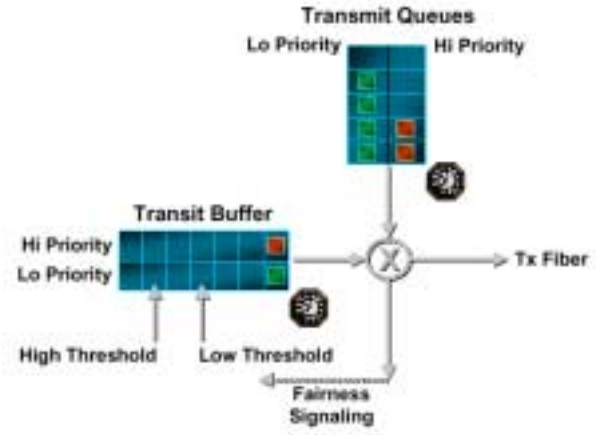
Buffer thresholds:

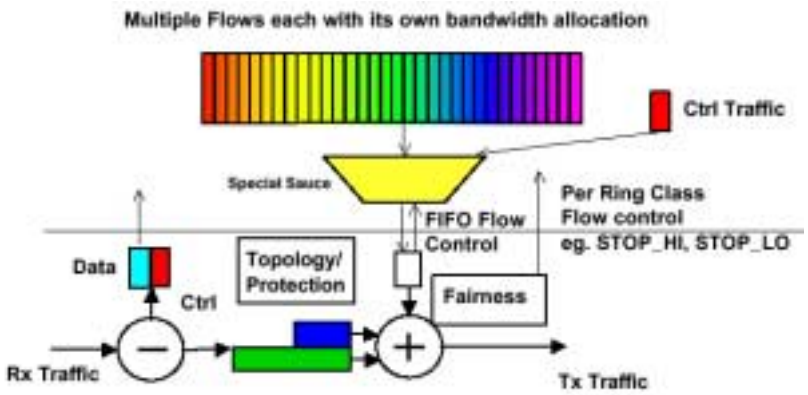
- Rules? Heuristic determination? Depending on traffic pattern?
- Depending on buffer occupancy transfer time on medium may vary strongly

Reactive fairness control

- Bottleneck link fairness control is triggered by backpressure messages
- Individual messages; no message coordination; temporary explosion?
- Fairness not well achieved

Darwin: Main Mechanisms





Transit buffers:

- Used for collision avoidance, high-priority bypassing, and packet scheduling

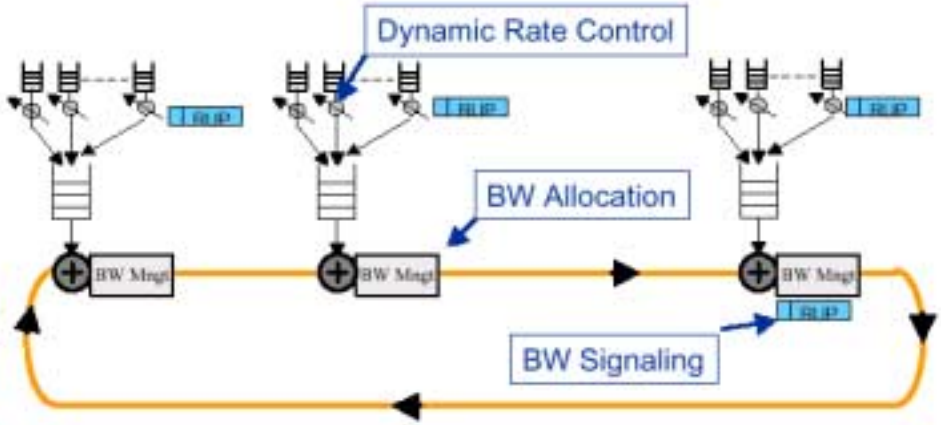
Buffer thresholds:

- Rules? Heuristic determination? Depending on traffic pattern?
- Depending on buffer occupancy transfer time on medium may vary strongly

Proactive and reactive fairness control

- **Load demand is advertised**
- Bottleneck link fairness control is triggered by backpressure messages
- Fairness achieved ?

Aladin: Main Mechanisms



Transit buffers:

- Only used for collision avoidance and high-priority bypassing

Proactive fairness control

- Each node monitors its output link to measure rates of each flow
- Control message is circulating
- Each node is notified about the fair source/destination rates

Drawbacks: - rate scheduling is done based on old information
- dynamic traffic causes throughput loss

IKN: Main Mechanisms

Transit buffers:
Only used for collision avoidance and high-priority bypassing

Proactive fairness control
Control packet with traffic demand matrix is circulating

Upon arrival of control packet:
Node schedules its fair source/destination rates from the traffic demand matrix
Node advertises the remaining load for each flow waiting in the transmit buffers

Immediate access: in same cycle i for flows over links which are no bottleneck
Reservation access: in next cycle i+1 for bottleneck flows

Maximal performance because rate scheduling is done on waiting traffic demand, i.e., the mechanism also works when traffic pattern completely changes in every cycle

IKN: Main Properties

Support of
- Multiple traffic classes (real-time strict, real-time loose, best-effort)
- Service Level Agreements
- Heterogeneous link speeds on same ring

Control flow and data flow in same direction
(easy for single ring and any configuration of multiple rings)

Simple and predictive operation
- Simple and straightforward algorithm
- No heuristic thresholds
- No traffic measurements

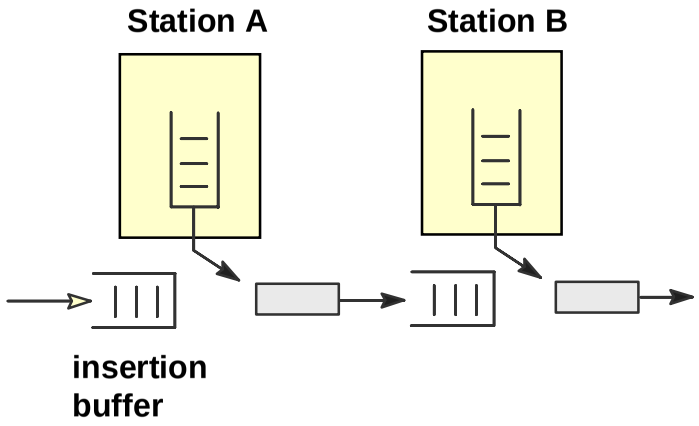
Best performance
- Optimal bottleneck fairness
- Near to fair theoretical throughputs for flow
- Guaranteed delays
- Very dynamic traffic adaptation

IKN: Protocol Properties

Performance properties:

- Control of flow-based source-destination traffic
- No HOL blocking
- Very high ring throughput
- Node throughputs approximate theoretical fairness values
- Low delays
- No losses on medium
- No backpressure required
- Small insertion buffer size
- Immediate and reserved access
- Unfairness due to immediate access can be corrected
- Immediate access in case of loss of fairness control packet

Simultaneous Access by buffer insertion



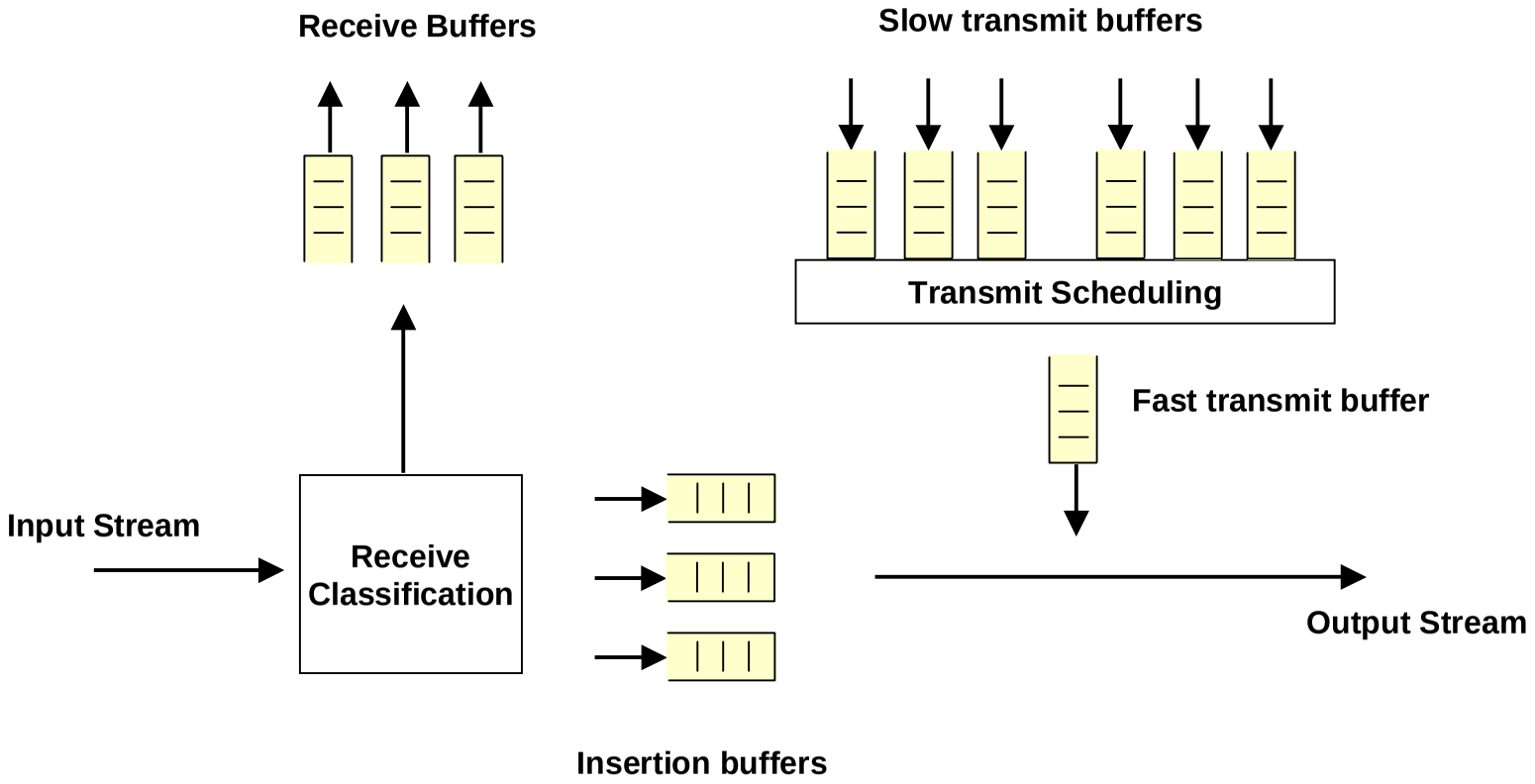
- Insertion buffer in transmit path is only used to resolve collision during packet transmission

- Cut-through mode

- Maximum size of insertion buffer is 1 MTU

- Insertion buffers (low and high) must both be empty before medium access takes place

Node Structure



- Ring priority
- Priority bypassing on ring

Access mechanism

-Insertion buffer solves only packet collision problem. Not used for scheduling.

- Transmission path is used as a pure transmission link, i.e. ring priority

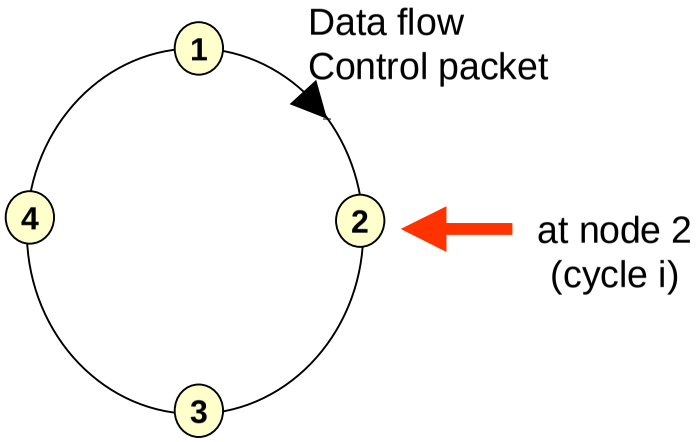
- Insertion buffer must be emptied before accessing the ring

- Immediate access for underutilized links

- Reserved access for bottleneck links

Fairness mechanism (1)

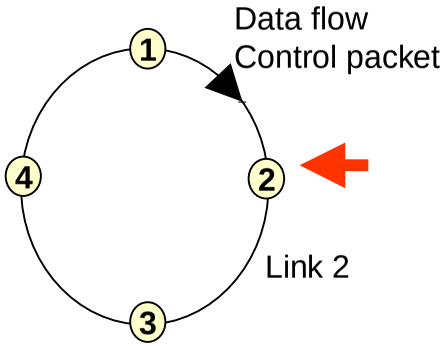
Example for single ring



Flow	High	Low	
1 -> 2	H12	L12	cycle i
1 -> 3	H13	L13	
1 -> 4	H14	L14	
2 -> 3	H23	L23	cycle i -1
2 -> 4	H24	L24	
2 -> 1	H21	L21	
3 -> 4	H34	L34	
3 -> 1	H31	L31	
3 -> 2	H32	L32	
4 -> 1	H41	L41	
4 -> 2	H42	L42	
4 -> 3	H43	L43	

- On each ring, a control packet circulates in data direction
- One entry for each traffic type and for each source-destination flow
- Circulating information is based on waiting load in each node (not on old measurements)

Fairness mechanism (2)



Flow	High	Low	
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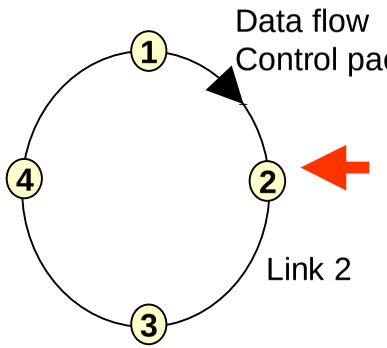
3 -> 4	H34	L34	
3 -> 1	H31	L31	
3 -> 2	H32	L32	
4 -> 1	H41	L41	
4 -> 2	H42	L42	
4 -> 3	H43	L43	

Actions in node 2:

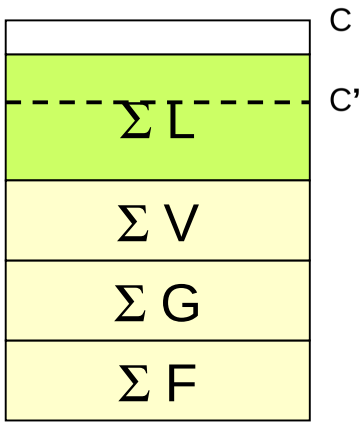
- Determine fair rates for all classes and for all flows from node 2
- Write new demand of node 2 into control packet
- Send control packet to next node at the scheduled time

- Transmit reserved traffic according to calculated fair flow rates
- Transmit immediate traffic up to fair flow rates rate

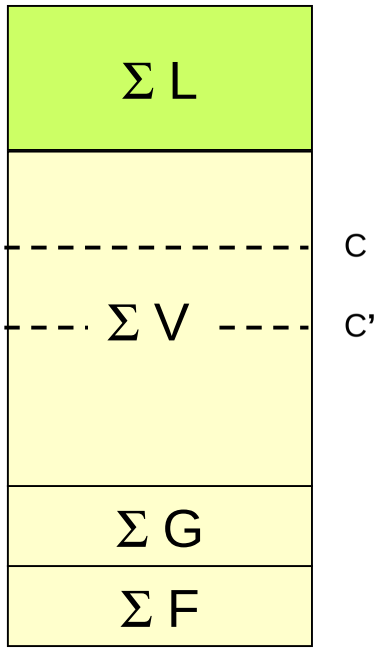
Fairness mechanism (3)



Σ L : all low-traffic flows
Σ V : all non-guaranteed high-traffic flows
Σ G : all guaranteed high-traffic flows
Σ F : all CBR traffic flows
$V_i = H_i - G_i$: variable part of high-priority traffic flow



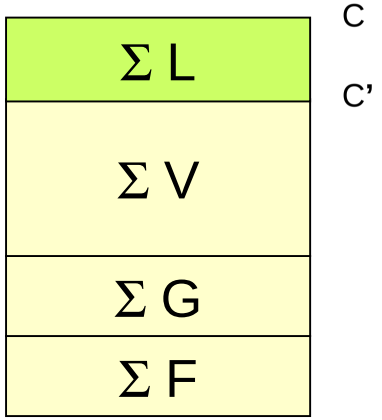
No correction



Link bottleneck
Correction required

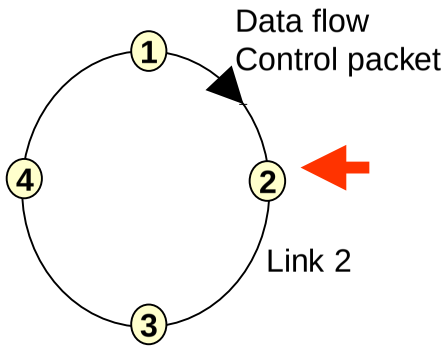
Link capacity C

C- C' is minimal capacity
for low priority when present

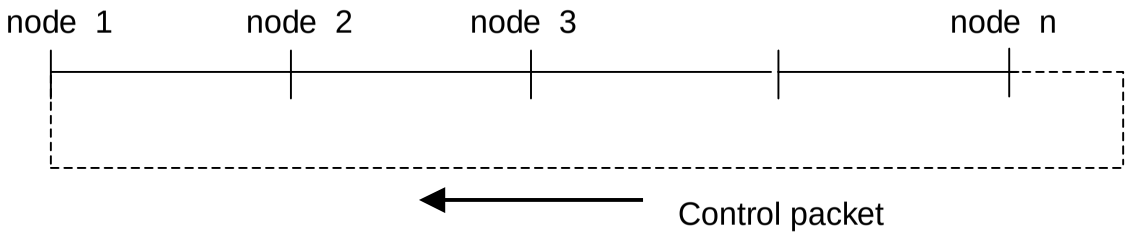


Link bottleneck
Coordinated flows

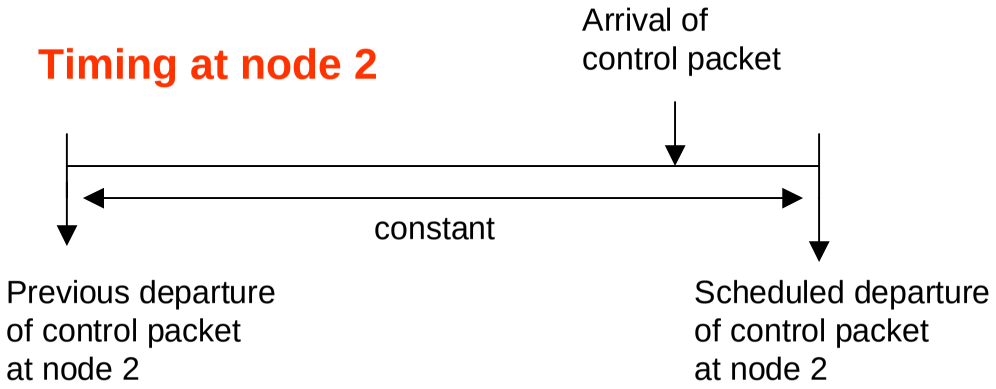
Fairness mechanism (4)



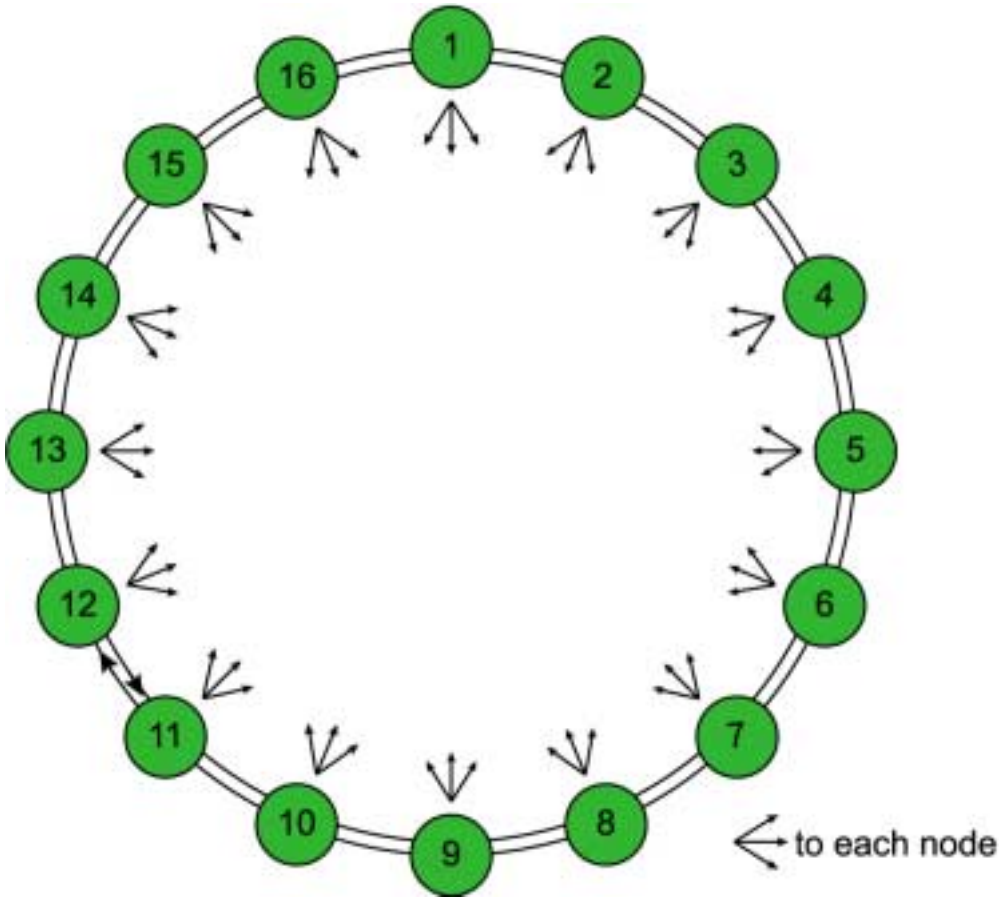
Fairness cycle



Timing at node 2



Dual-Ring - Traffic scenario 1

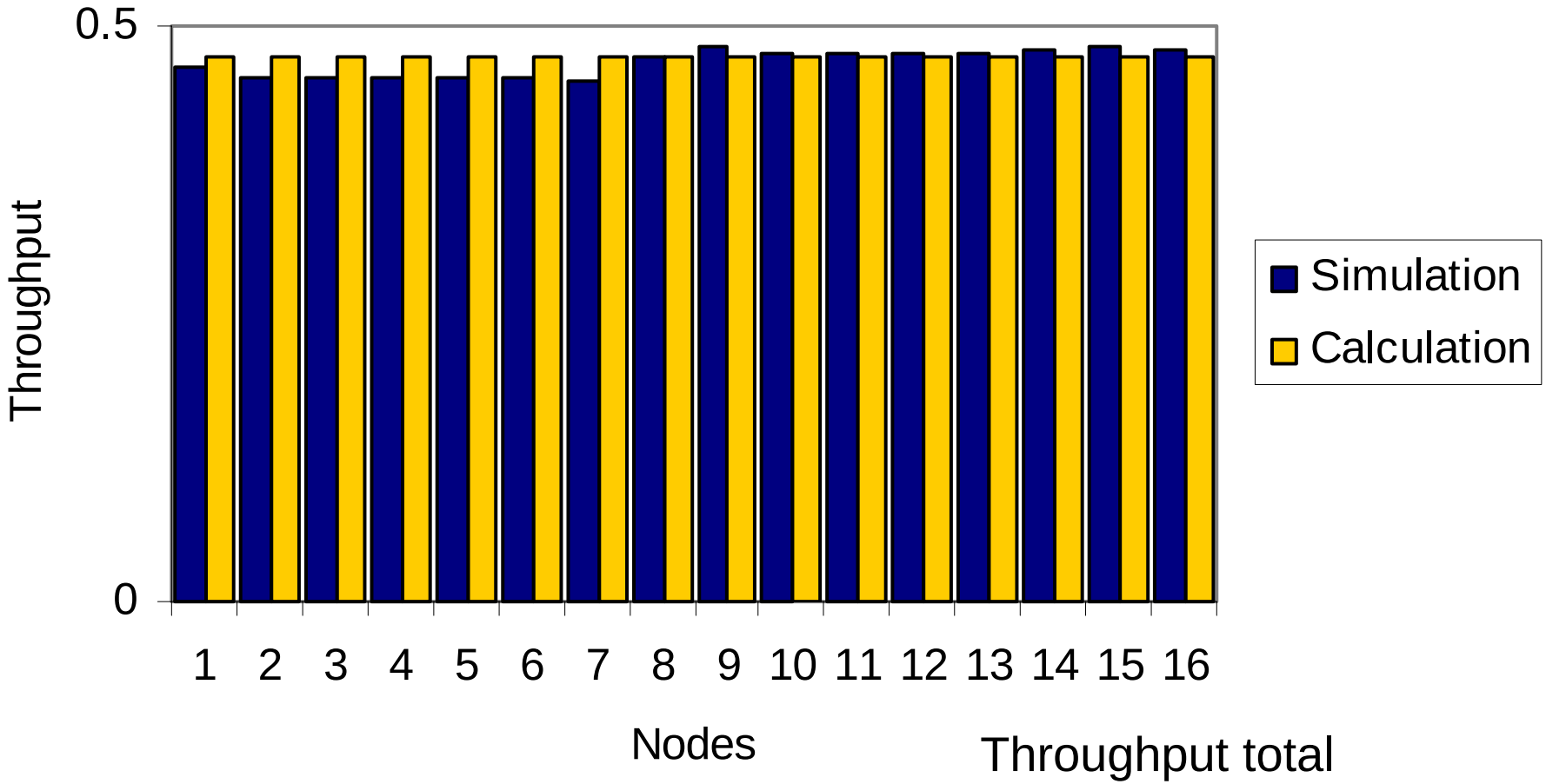


Uniform traffic
Saturated sources
16 nodes

Constant packets
8000 bits

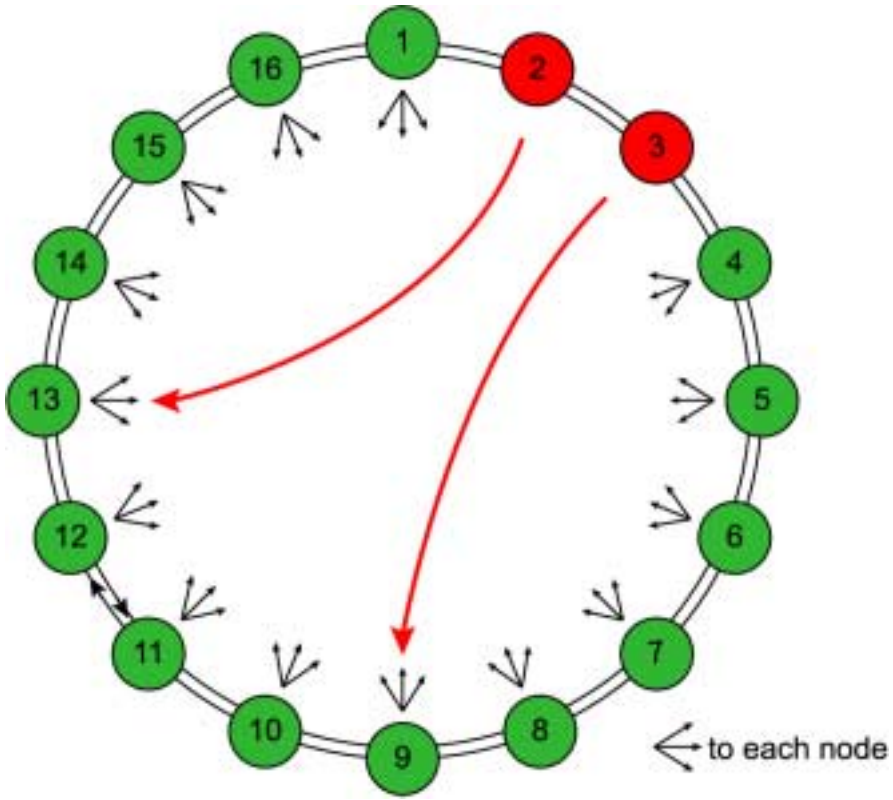
Cyclic reservation protocol

Dual-Ring - Traffic scenario 1



Throughput total
Simulation : 7.5
Calculation : 7.55

Dual-Ring – Traffic scenario 2



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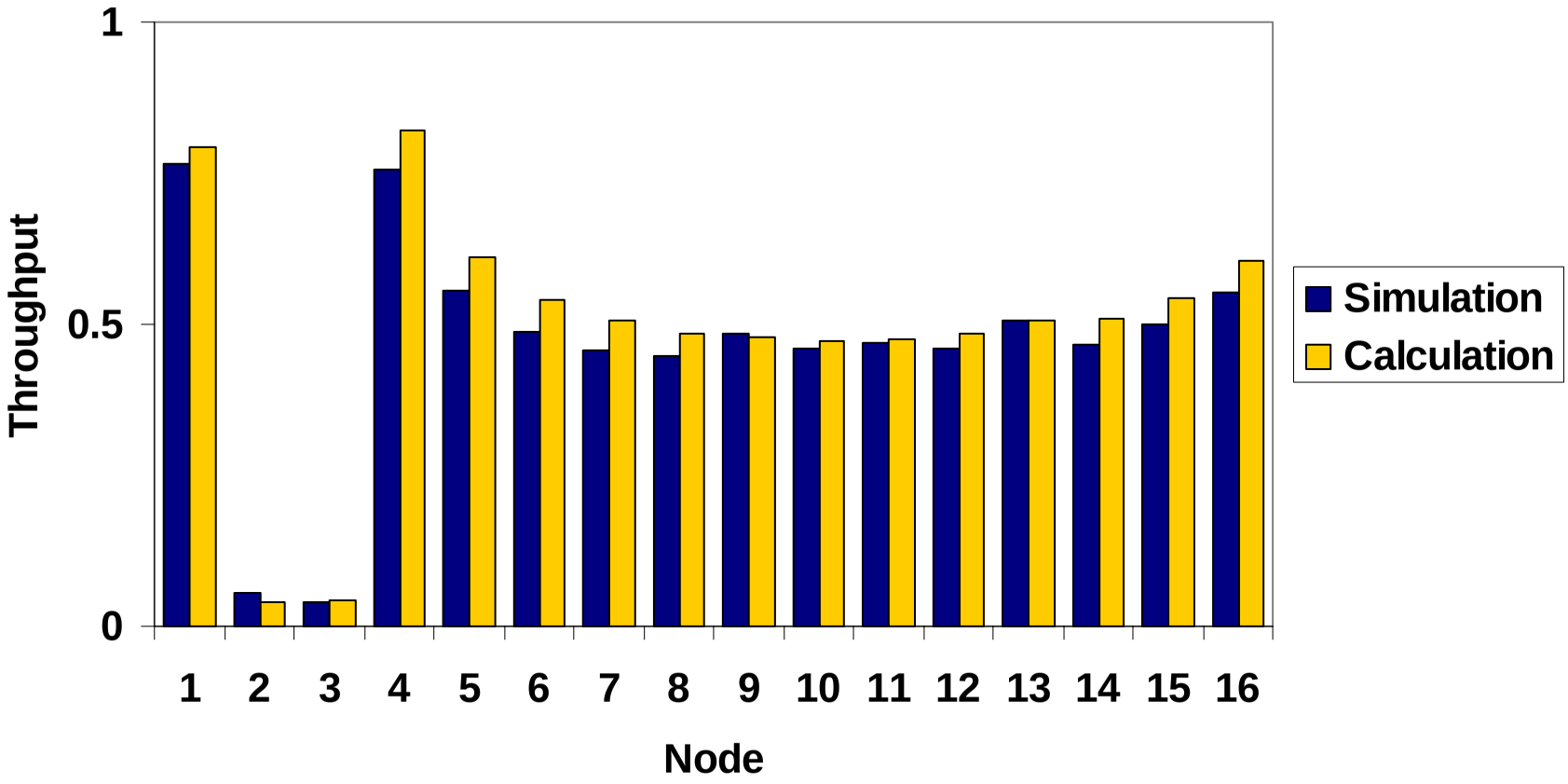
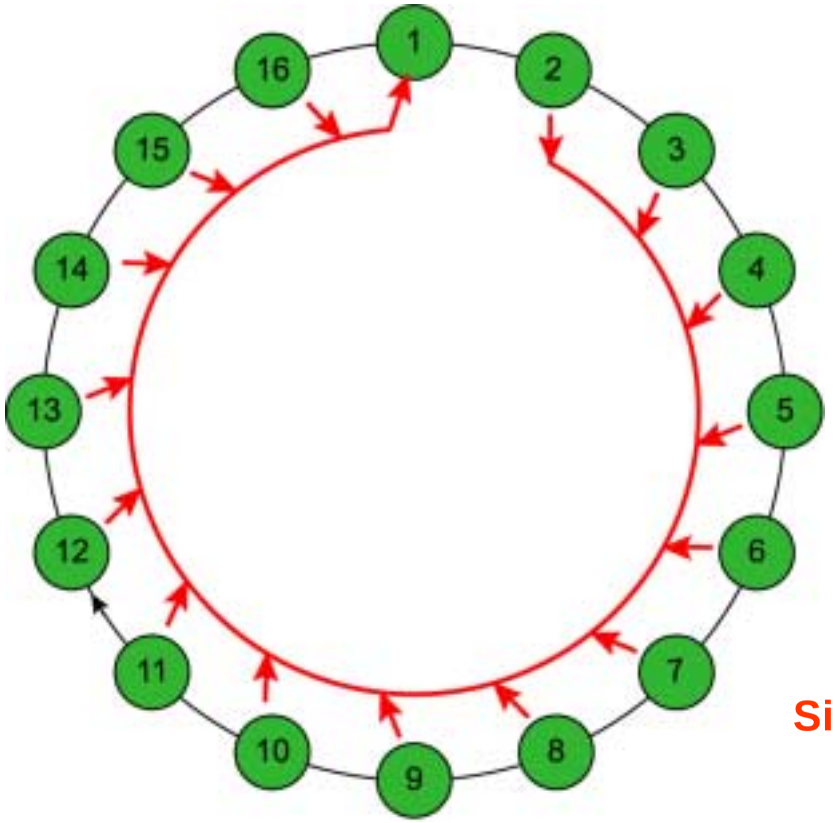
Dual-Ring – Traffic scenario 2



Throughput total
Simulation : 7.46
Calculation : 7.91

Single Ring-Traffic scenario 3



Single ring

Uniform traffic
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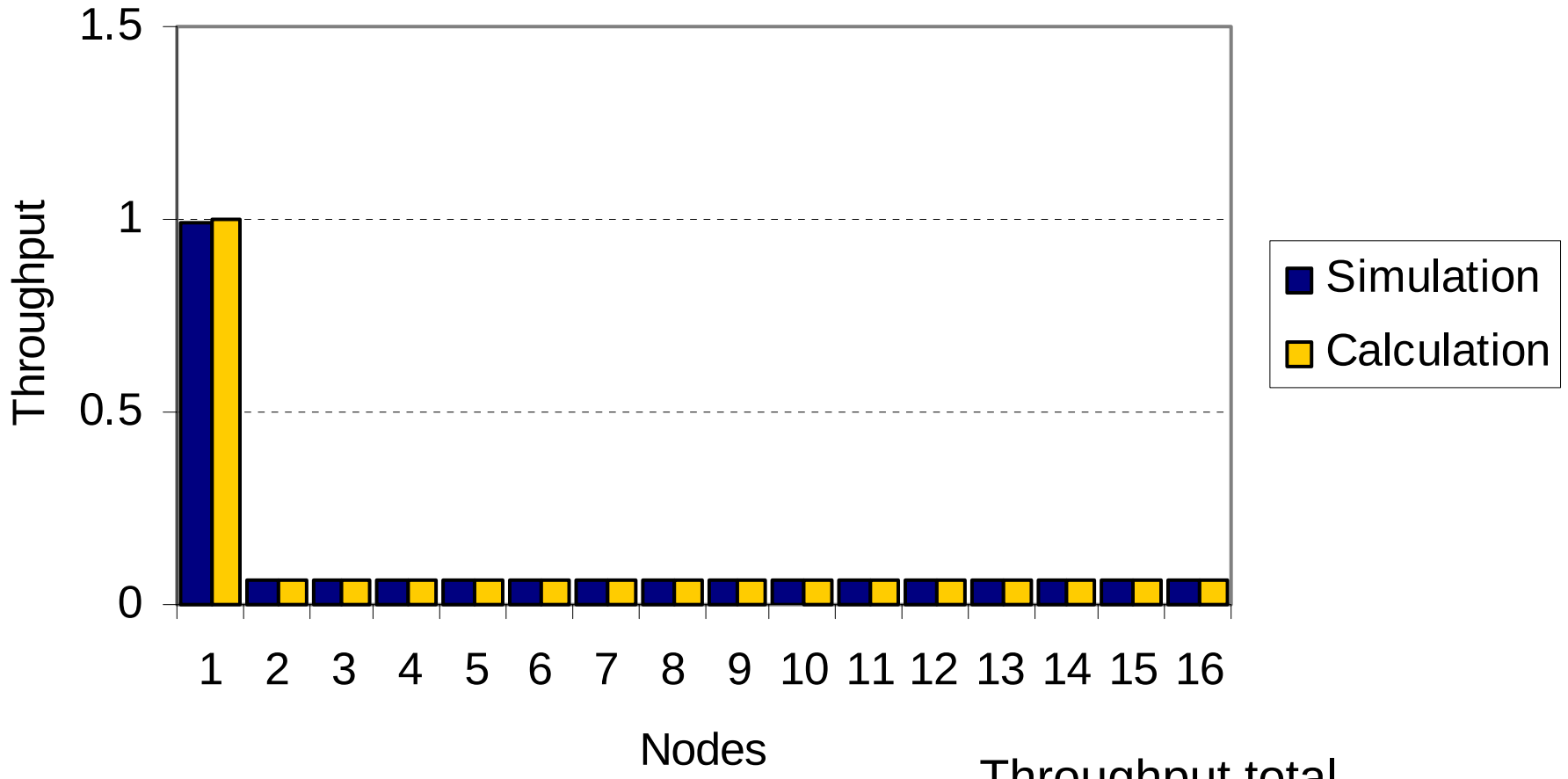
16 nodes

Constant packets
8000 bits

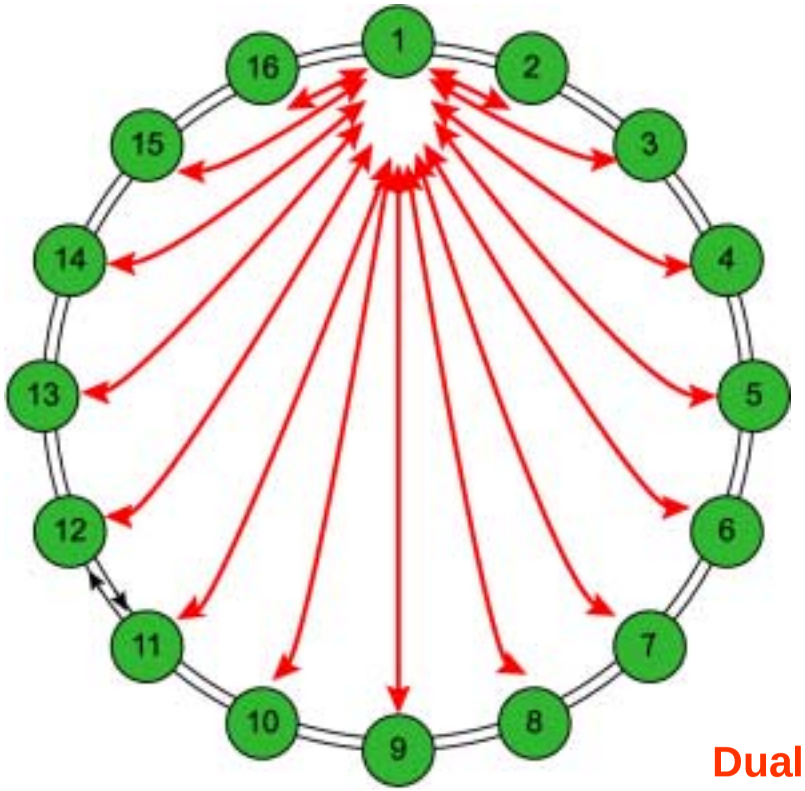
Cyclic reservation protocol

Single Ring-Traffic scenario 3



Throughput total
Simulation : 1.98
Calculation : 1.99

Dual-Ring – Traffic scenario 4



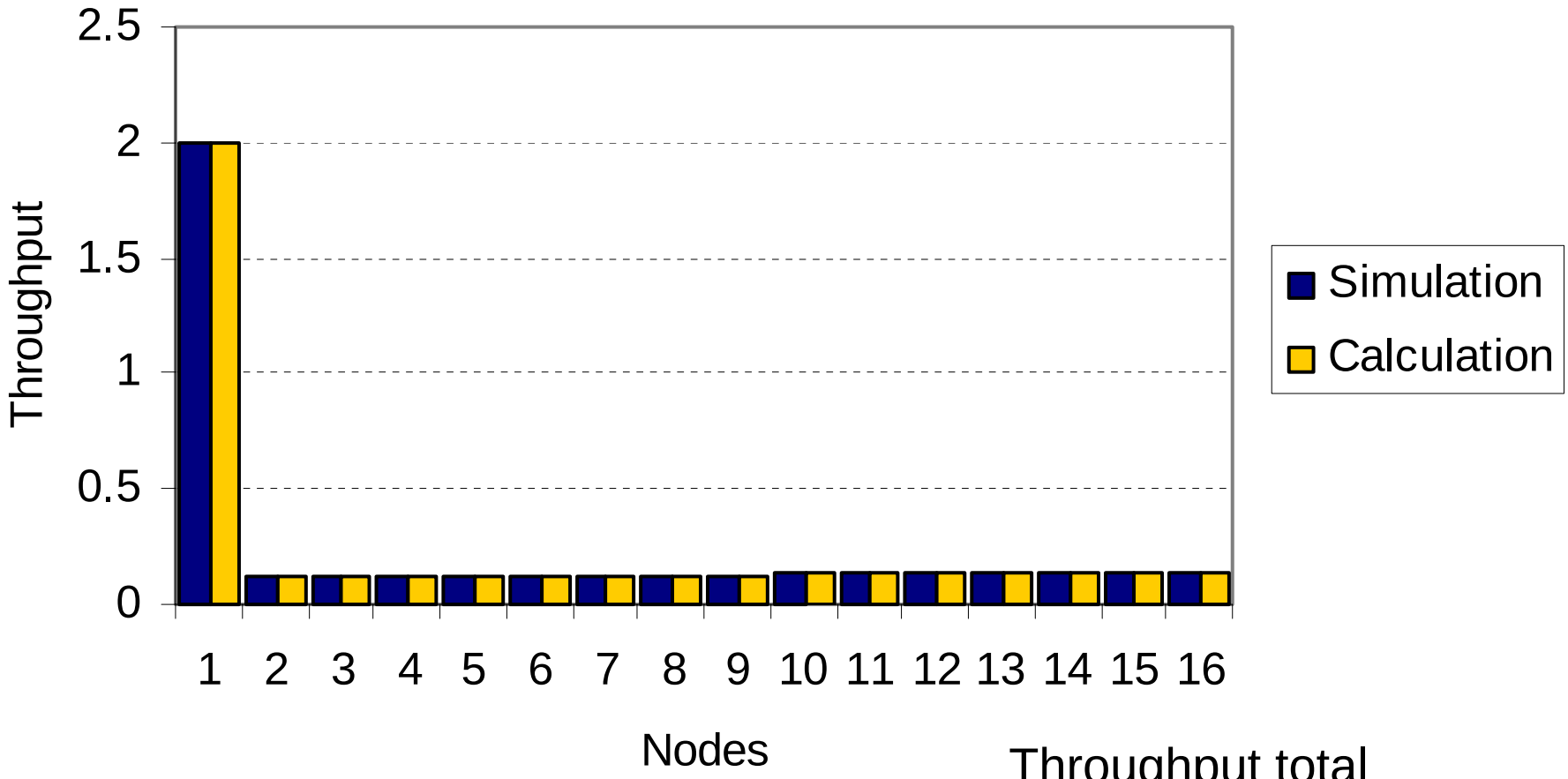
Dual ring

Uniform traffic
Saturated sources
16 nodes

Constant packets
8000 bits

Cyclic reservation protocol

Dual-Ring – Traffic scenario 4



Throughput total
Simulation : 3.98
Calculation : 3.99