1 Simulations

1.1 4x4 Crossbar

`Bestimmen und begründen Sie wie die Werte zustande kommen`

$$Avg = \sum_{n=0}^{N} \frac{\binom{N}{n}(N-n+1)! \cdot C_n}{\sum_{k=0}^{N}\binom{N}{k}(N-k+1)!} \tag{1}$$

- `avg Input Queue Length`
  - Generated Packets
    - size: $s = 512\,\mathrm{b}$
    - send interval: $t = 512\,\mathrm{ns}$
  - Connection to XBar
    - data rate: $1\,\mathrm{Gbps}$

$$r_{\text{gen}} = \frac{512\,\mathrm{b}}{512\,\mathrm{ns}} = 1\,\mathrm{Gbps} \tag{2}$$

$$C_n = 250\,\mathrm{Mbps} \cdot n \tag{3}$$

$$r_{\text{q fill,eff}} = \sum_{n=1}^{4} \frac{\binom{4}{n}(5-n)! \cdot C_n}{141} \tag{4}$$

$$= 347.5\,\mathrm{Mbps} \tag{5}$$

$$\Rightarrow l_{\text{q,avg}} = \frac{t_{\text{sim}} \cdot r_{\text{q fill, eff}}}{2 \cdot s} = 3394 \tag{6}$$

- `avg End-to-End Latency`
  - (no delays inside buffers, because the generated data rate, even for all 4 apps, is lower than a single data rate channels maximum throughput)
  - minimum
    - App → C → Inport → C → Outport → C → App
    - delay for packet: $t_{delay} = 512ns$ (per `DatarateChannel` C)

$$\Rightarrow t_{e2e,min} = 1.536\,\mu\mathrm{s} \tag{7}$$

  - maximum

    at end of simulation, inport buffer full, all in to one out

$$l_{inportq,max} = 7031 \tag{8}$$

$$r_{dequeue,min} = 250\,\mathrm{Mbps} \tag{9}$$

$$t_{\text{in queue, max}} = \frac{t_{q,inport} \cdot s}{r_{dequeue}} = 3.599\,\mathrm{ms} \tag{10}$$

$$\tag{11}$$

- on avg

$$t_{\text{e2e, avg}} = t_{\text{in queue, max}}/2 = 1.8\,\text{ms} \tag{12}$$

- `avg Arbiter Request Queue Length`
  - cases

$$C_n = n - 1 \qquad 1 \leq n \leq 4 = N \tag{13}$$

  - on avg (analogously to t_{e2e})

$$\Rightarrow l_{arbq,avg} = \sum_{n=1}^{4} \frac{\binom{4}{n}(5-n)! \cdot C_n}{141} = 0.39 \tag{14}$$

- `avg Arbiter Request Queue Time`
  - cases

$$C_n = 512\,\text{ns} * n \tag{15}$$

  - on avg

$$\Rightarrow t_{arbq,avg} = \sum_{n=1}^{4} \frac{\binom{4}{n}(5-n)! \cdot C_n}{141} \tag{16}$$

$$= \tag{17}$$

- `avg Output Buffer Queue Length`
  - Generated Packets
    - size: $s = 512\,\text{b}$
    - send interval: $t = \text{uniform}(1\,\mu\text{s}, 10\,\mu\text{s}) = 5.5\,\mu\text{s}$
  - Connection to and in XBar
    - data rate: 1 Gbps

$$r_{\text{generated}} = \frac{512\,\text{b}}{5.5\,\mu\text{s}} = 93\,\text{Mbps} \tag{18}$$

$$\Rightarrow l_{\text{q,avg}} = 0 \tag{19}$$

- `avg Throughput`

  input and output buffers always empty

$$r_{cross} = 4 * r_{\text{gen}} \tag{20}$$

$$= 372\,\text{Mbps} \tag{21}$$

1.2 Throughput vs. Ports

- with ourr formula 0.6, 0.44, 0.347518, 0.286498, 0.243324, 0.211277, 0.186604, 0.167047, 0.151176, 0.138045,

  ¿ 0.127005, 0.117594, 0.109478, 0.102407, 0.0961928, 0.0906881, 0.0857783, 0.0813722, 0.077396,

  ¿ 0.0737899, 0.0705046, 0.067499, 0.0647391, 0.0621958, 0.0598446, 0.0576646, 0.0556378, 0.0537485,

  ¿ 0.0519832, 0.0503302, 0.048779

1.3 Throughput vs. Injection Rate

- not in saturation until delay $\leq 832\,\mathrm{ns}$
- saturation pont $r_{sat} = \frac{512\,\mathrm{b}}{832\,\mathrm{ns}} = 615\,\mathrm{Mbps}$
- The main reason will be the arbiter. It can only process packets at about 600 Mbps on avg., therefore bottlenecking the rest of the system

1.4 Throughput vs. Bandwidth

- Network in aturation until Bandwith $> 1600\,\mathrm{Mbps}$
- throughput at saturation point $r_{sat} = 1\,\mathrm{Gbps}$
- If the Arbiter can only work at 62% of the bandwidth, we reach this saturation point if 62% of the bandwidth is 1 Gbps, therefore the required bandwith is 1613 Gbps

2 Optimizations