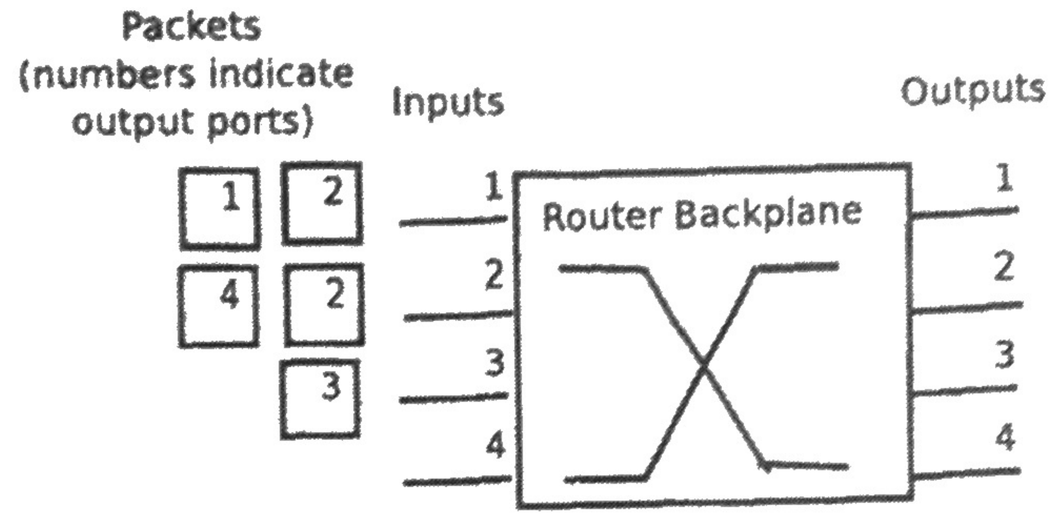
**9. [8 points]:** Consider the router backplane below, with packets arriving as shown. The number on each packet designates its intended output port. Suppose that each input and output port have a rate of 1 Gigabit per second.




**A.** Suppose the router has a ***bus backplane*** with throughput of 5 Gigabits per second. What is the total maximum throughput that the router can achieve? Why?

**B.** The example shows an example of *head-of-line blocking*. Explain why, and explain how virtual output queueing can fix the problem.

**C.** Now suppose the router has a *crossbar switch backplane* with a throughput of 10 Gigabits per second (a "speedup" of 2) and virtual output queueing. Given the packet arrival pattern shown in the figure, give a sequence of matchings of input ports to output ports that results in 100% utilization (to save time, simple notation like "Round 1: $1 \rightarrow 2$" is sufficient to indicate that you match input one to output two in round one). Your solution should have two rounds.

**(Answer legibly in the space below.)**

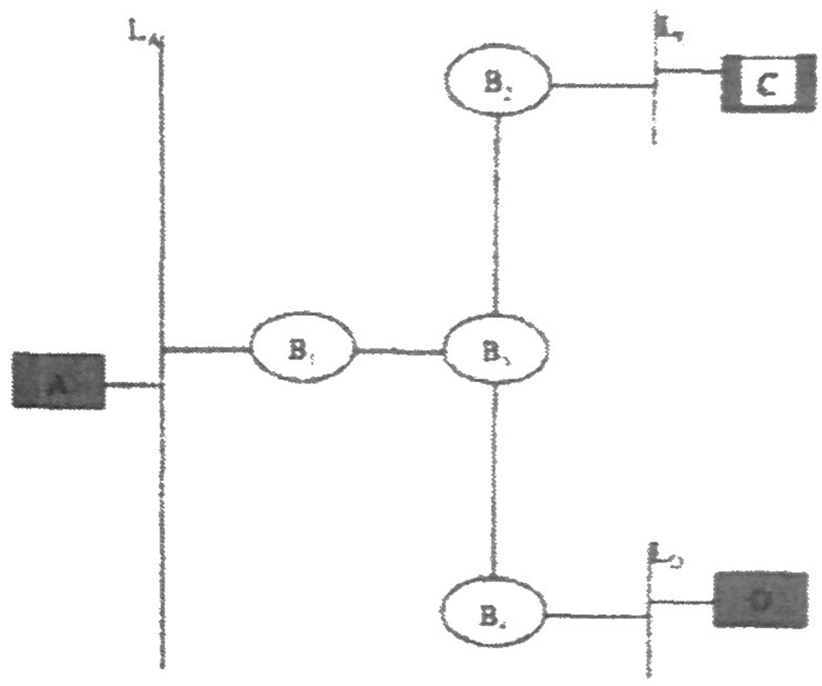
A. 4 Gbps. Only one input-output pair can use the bus at any time; only four inputs.

B. There are two packets for output 2 at the heads of queues. One of those results in either 1 or 4 being blocked, even though there could be a match to the output. (e.g., $1 \rightarrow 1$, $2 \rightarrow 2$, $3 \rightarrow 3$)

C. Rnd 1: $1 \rightarrow 1$, $2 \rightarrow 2$, $3 \rightarrow 3$
Rnd 2: $1 \rightarrow 2$, $2 \rightarrow 4$. [many possible correct answers]

**Name:**

**12. [12 points]:** Consider the bridge topology shown the figure below. Assuming that all of the forwarding tables are initially empty, write out the forwarding tables at each of the four bridges $B_1$ through $B_4$ at the conclusion of the following transmissions:




1. A sends to D
2. D sends to A
3. C sends to A

In the forwarding table at each node, identify the port by the unique LAN segment ($L_A$, $L_C$, or $L_D$) reachable using that port, unless there isn't one, in which case use the identifier of the neighboring bridge to identify the port.

**After A sends to D:**

| $B_1$ | | $B_2$ | | $B_3$ | | $B_4$ | |
|---|---|---|---|---|---|---|---|
| Destination | Port | Destination | Port | Destination | Port | Destination | Port |
| A | $L_A$ | A | $B_3$ | A | $B_1$ | A | $B_3$ |
| C | — | C | — | C | — | C | — |
| D | — | D | — | D | — | D | — |

**After D sends to A:**

| $B_1$ | | $B_2$ | | $B_3$ | | $B_4$ | |
|---|---|---|---|---|---|---|---|
| Destination | Port | Destination | Port | Destination | Port | Destination | Port |
| A | $L_A$ | A | $B_3$ | A | $B_1$ | A | $B_3$ |
| C | — | C | — | C | — | C | — |
| D | $B_3$ | D | — | D | $B_4$ | D | $L_D$ |

**After C sends to A:**

| $B_1$ | | $B_2$ | | $B_3$ | | $B_4$ | |
|---|---|---|---|---|---|---|---|
| Destination | Port | Destination | Port | Destination | Port | Destination | Port |
| A | $L_A$ | A | $B_3$ | A | $B_1$ | A | $B_3$ |
| C | $B_3$ | C | $L_C$ | C | $B_2$ | C | — |
| D | $B_3$ | D | — | D | $B_4$ | D | $L_D$ |

**Name:**