UNIVERSIDAD DE BURGOS

Lecture 2

Multiprocessor architectures: distributed memory MIMD (multicomputers)

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v. 1.0

Introduction

- Loosely coupled hardware computers.
- There are different coupling levels within this category according to the hardware elements shared: storage, input/output...
- Since no shared memory is available, communication is obtained via message passing mechanisms.
  - Message: information exchange unit.
  - Packet: commutation unit.

Switching

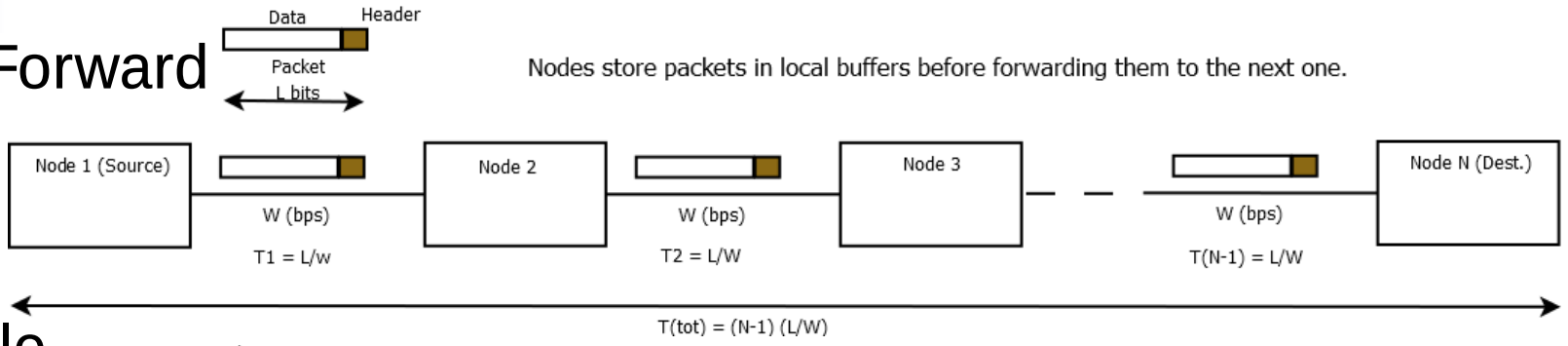
- Circuit switching: a permanent channel is stablished for the transmission of the whole message.
- Packet switching techniques (flow control):
  - Store and forward: $T=(L/W)(N-1)$
  - Wormhole: $T=(L/W) + (F/W)(N-2)$
  - Virtual cut through: $T = L/W + (P/W)(N-2)$

Packets: headed by destination and position within the message information.
Flit (flow control unit): have no such information except the head flit.
Phit: smallest possible information unit; number of data wires in the link.

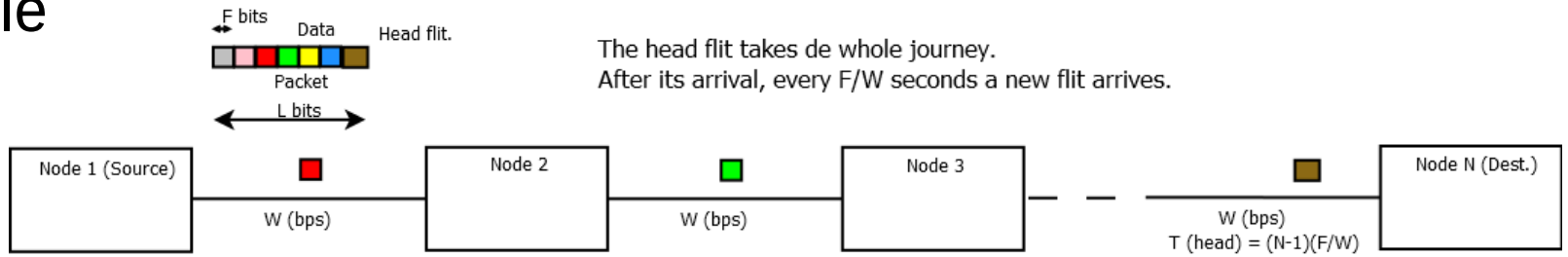
VCT pipeline is analogous to Wormhole but it requires storage space for full packets, just as S&F does.

Flow control techniques

Store & Forward

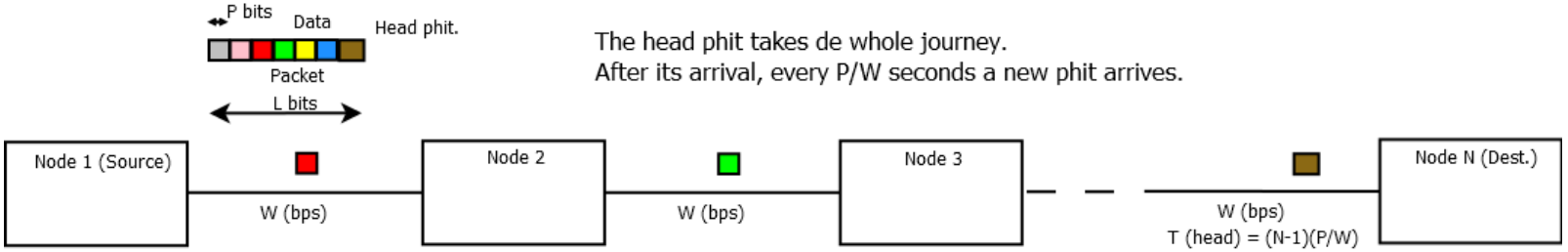


Wormhole



T (Tot) = (N-2)(F/W) + (L/W) = head flit to the sencond last node + 1 single hop for the whole packet.

Virtual cut through



T (Tot) = (N-2)(P/W) + (L/W) = head phit to the sencond last node + 1 single hop for the whole packet.

Packet switching

- Issues:
  - Flow control: when and how packets move. Involves:
    - Collision management (specially when buffering resources are scarce).
    - Routing: how to make packets find their way to destination.
  - Deadlock: packets end up in a closed loop -> network collapses.
  - Livelock: packets loops around the network for ever.
  - Starvation: a packet is never serviced and gets indefinitely stranded in a buffer.

Deadlock & starvation

Traffic deadlock

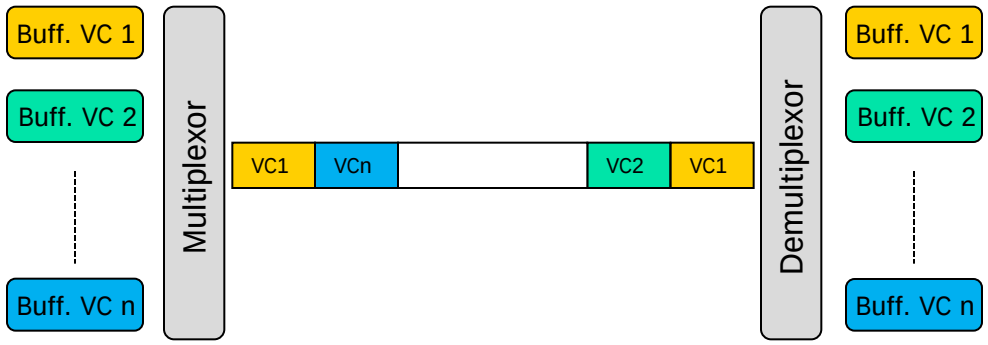
http://fedoraproject.org/wiki/FAD_SP_2013

Potential starvation situation

Cars coming from the streets in the lower half may not be able to enter the roundabout.

Packet switching

- Solutions:
  - Deadlock
    - Virtual channels to defer deadlock formation
    - Avoiding: certain algorithm – interconnect combinations are deadlock free.
    - Recovery: once the deadlock is produced, the system discards a packet. The sender is inform so it can re-try.
  - Collision management
    - Discard
    - Store
    - Forward -> livelock
    - Stall
  - Routing
    - Routing algorithms



Time multiplexed virtual channels

Multimedia content available

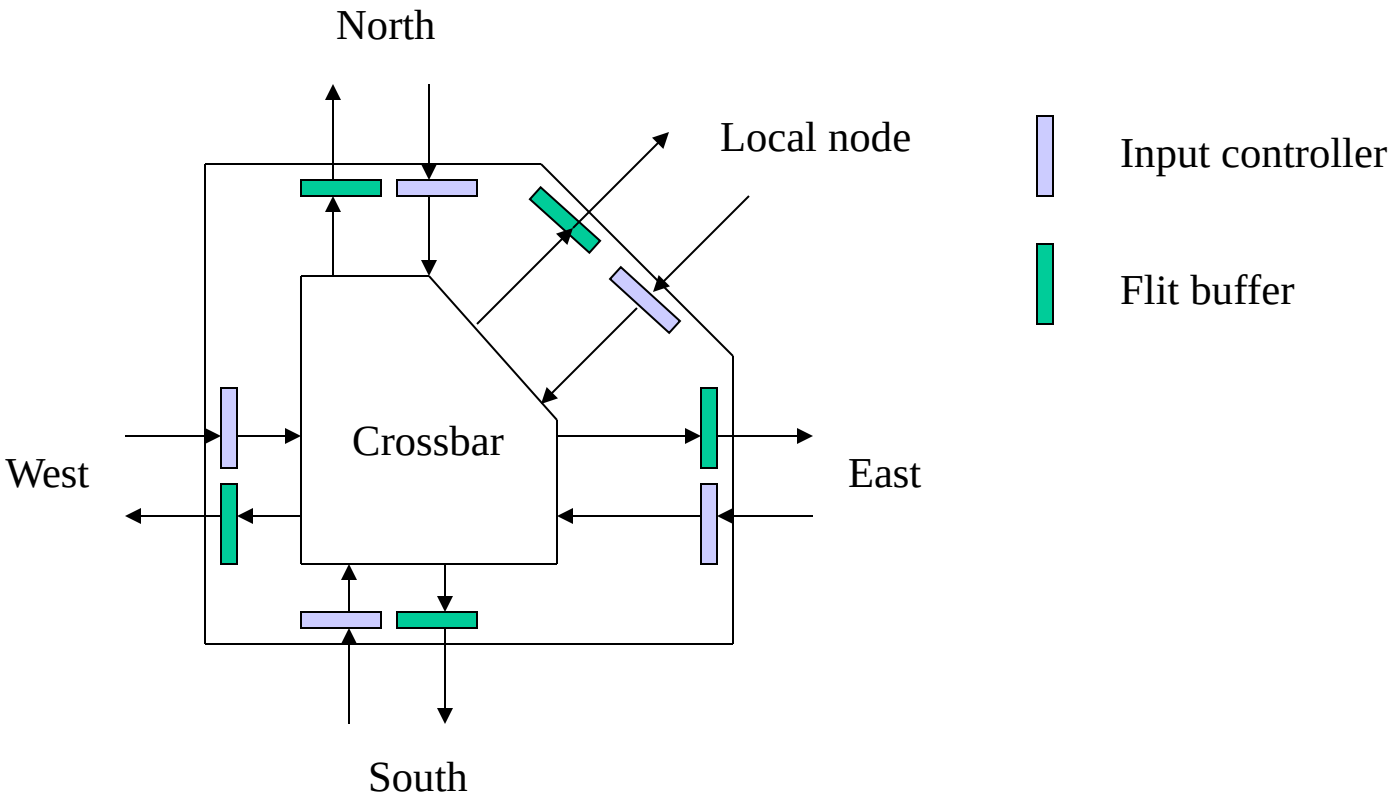
Routing algorithms

- Classification criteria:
  - Number of destinations: unicast, multicast
  - Decision making: centralized, source, distributed
  - Implementation technique: table look-up, finite state machine
  - Adaptivity: deterministic, adaptive
  - Number of alternative ways: partially adaptive, fully adaptive
  - Progressiveness: progressive, backtrack
  - Minimality: minimal (greedy), non minimal (nongreedy) -> livelock

Packet switching

Routing example

Sample router (Intel Paragon)



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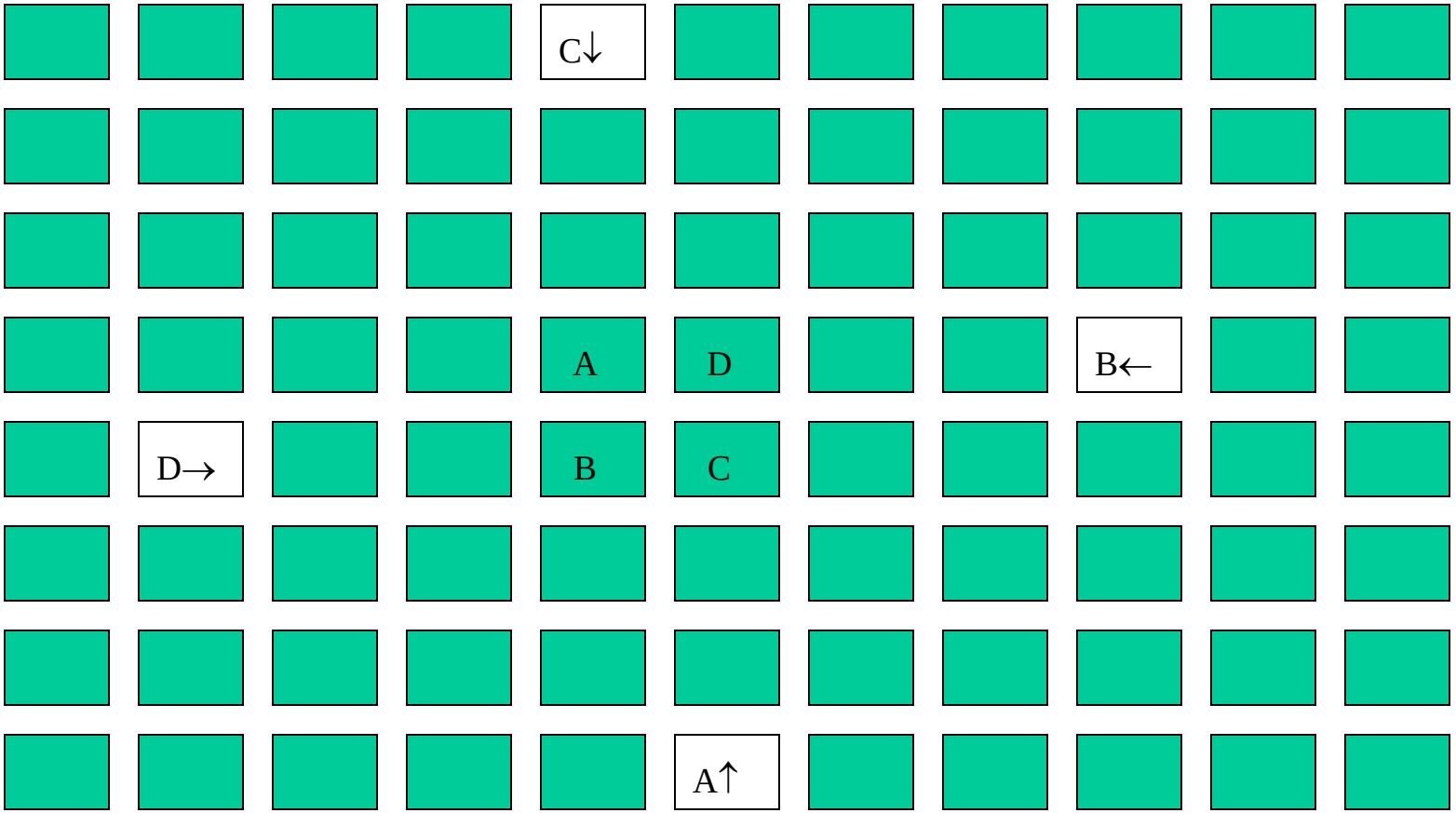
DEADLOCK FORMATION I



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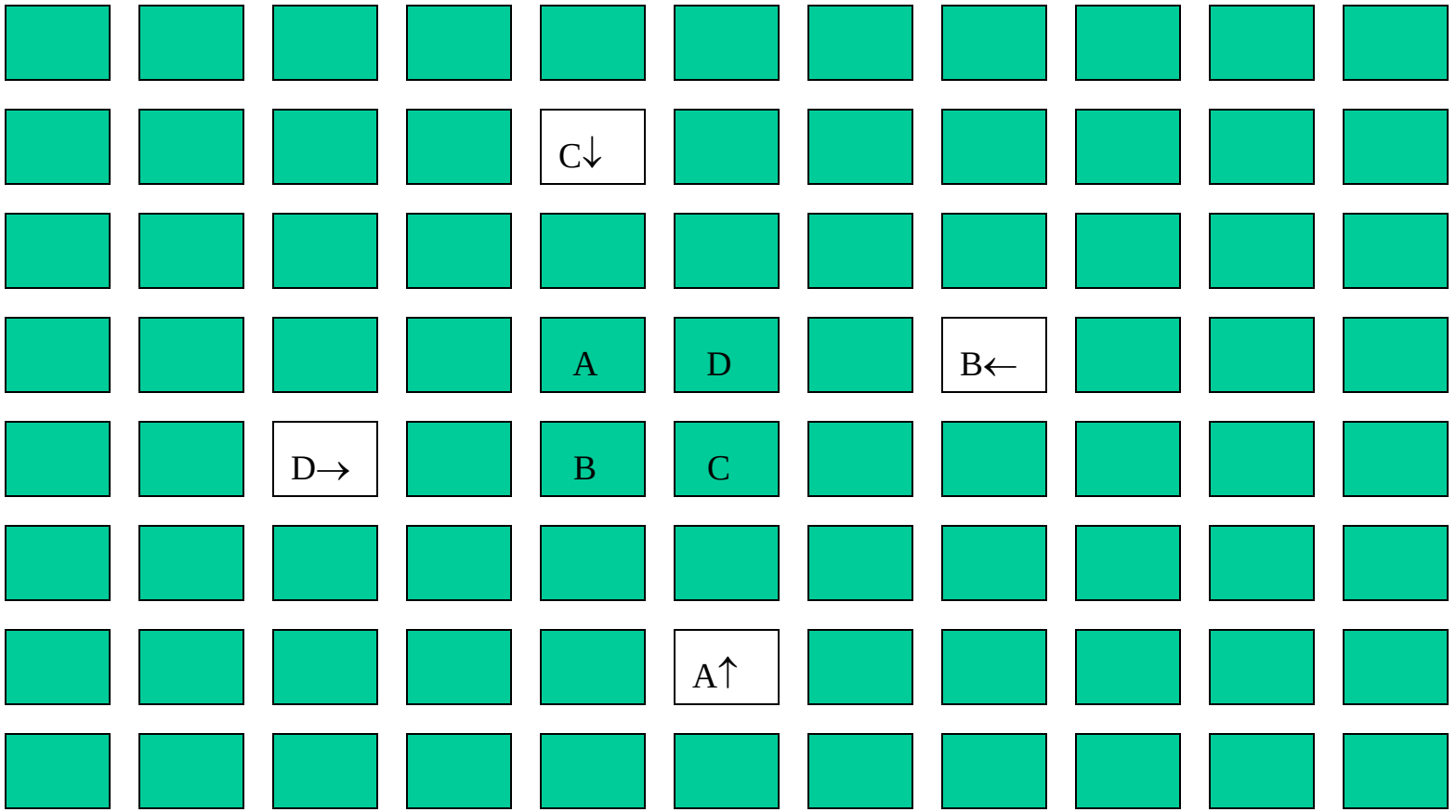
DEADLOCK FORMATION II



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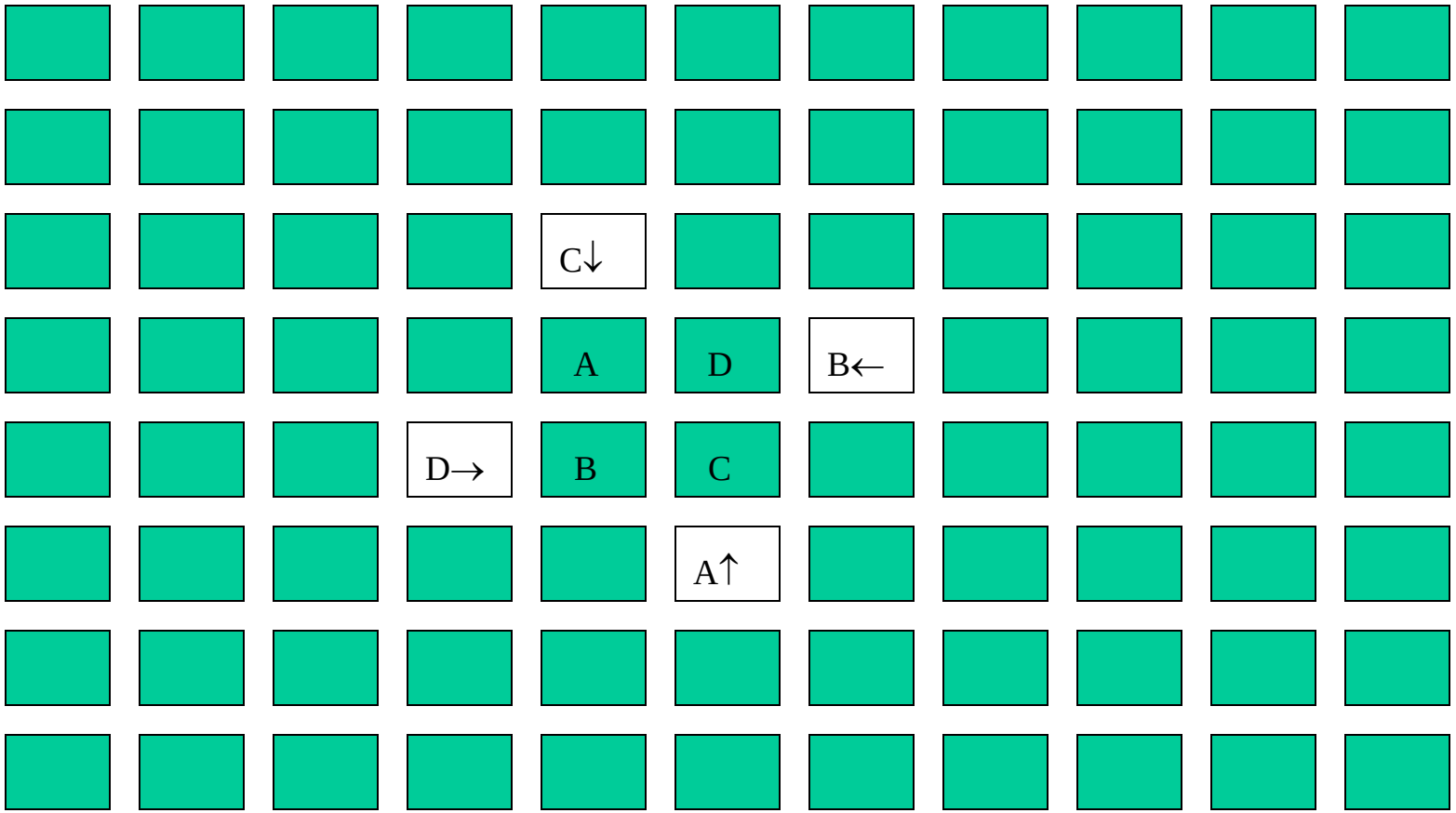
DEADLOCK FORMATION III



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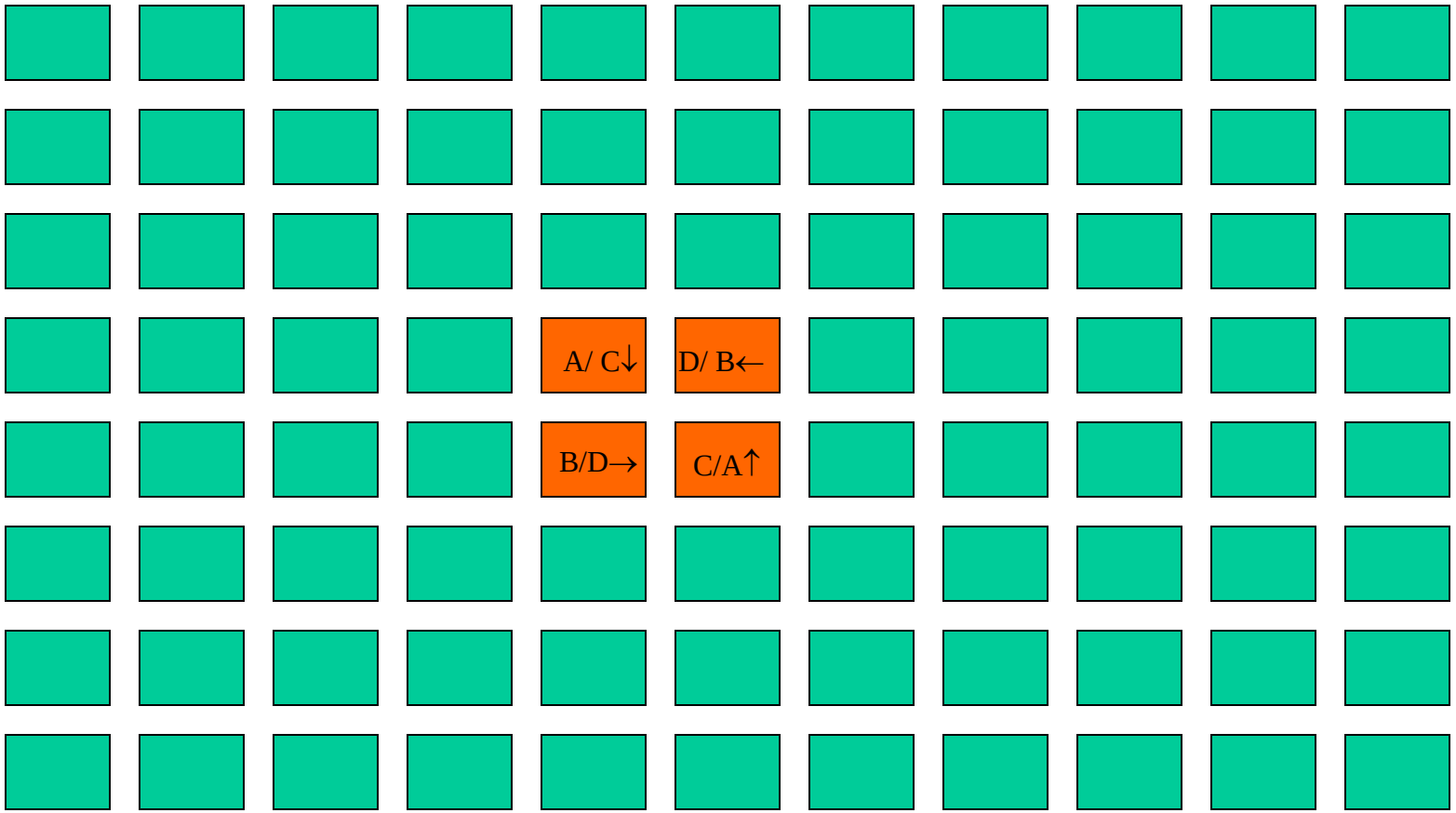
DEADLOCK FORMATION IV



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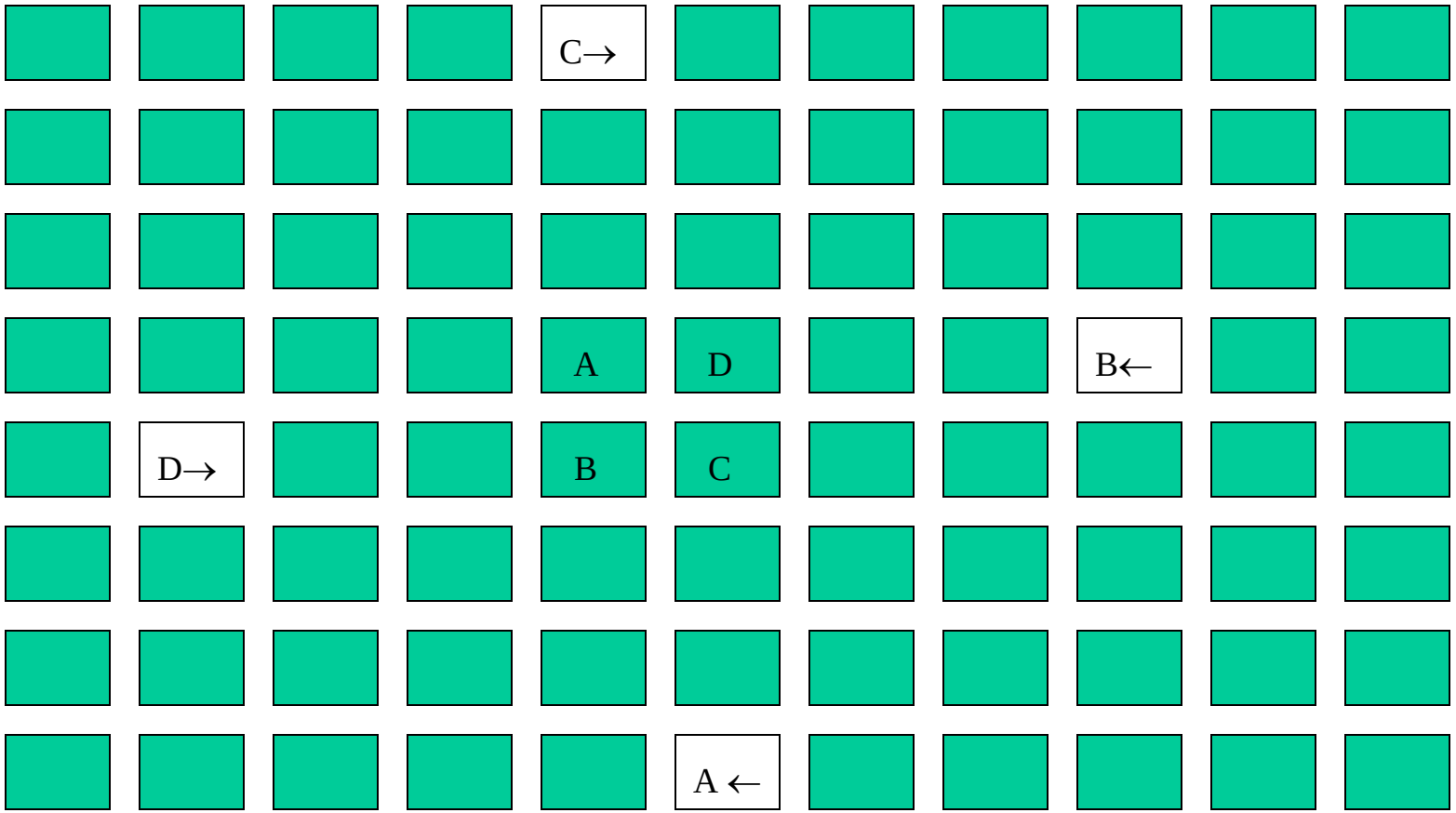
DOR ROUTING I



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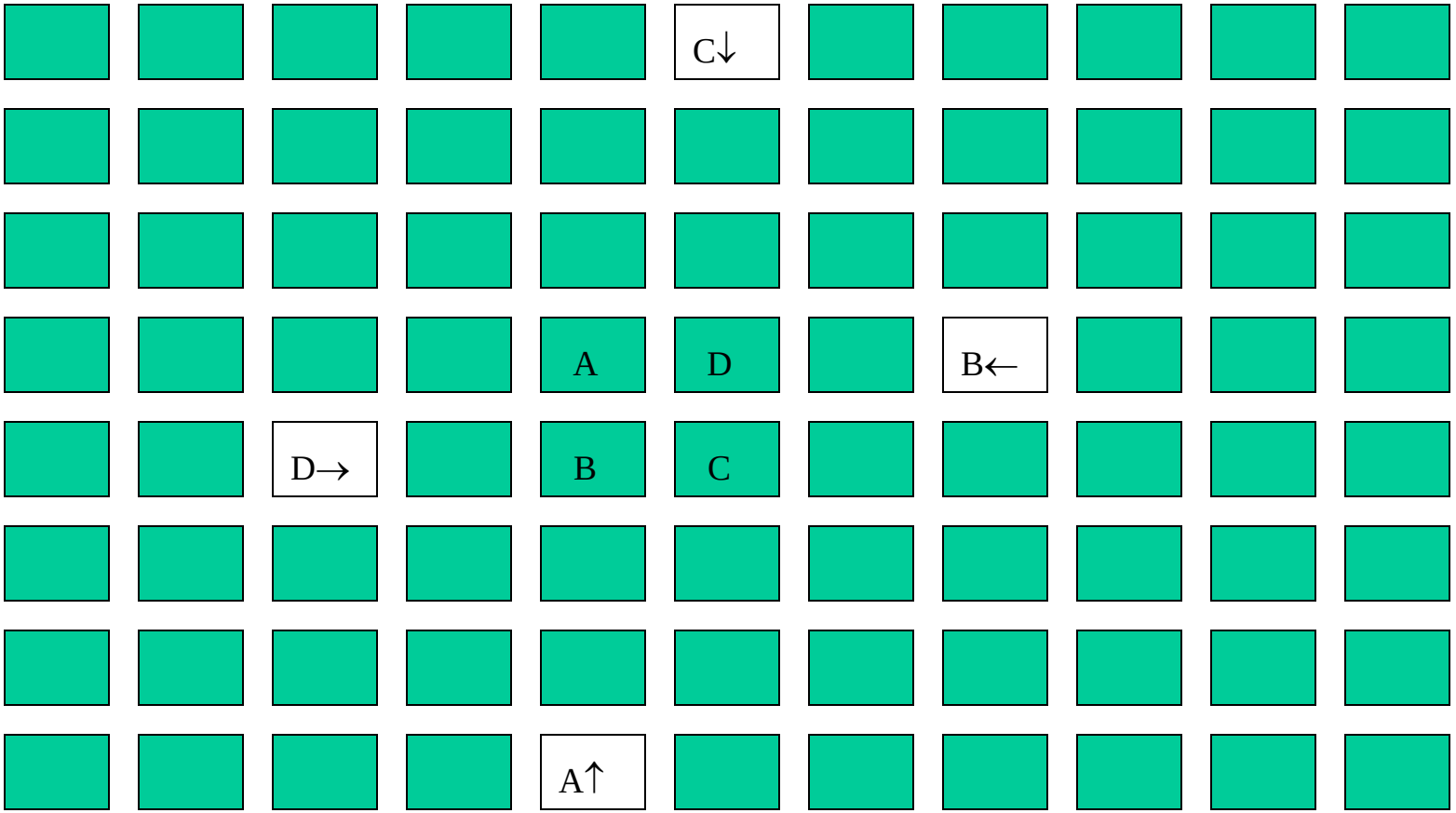

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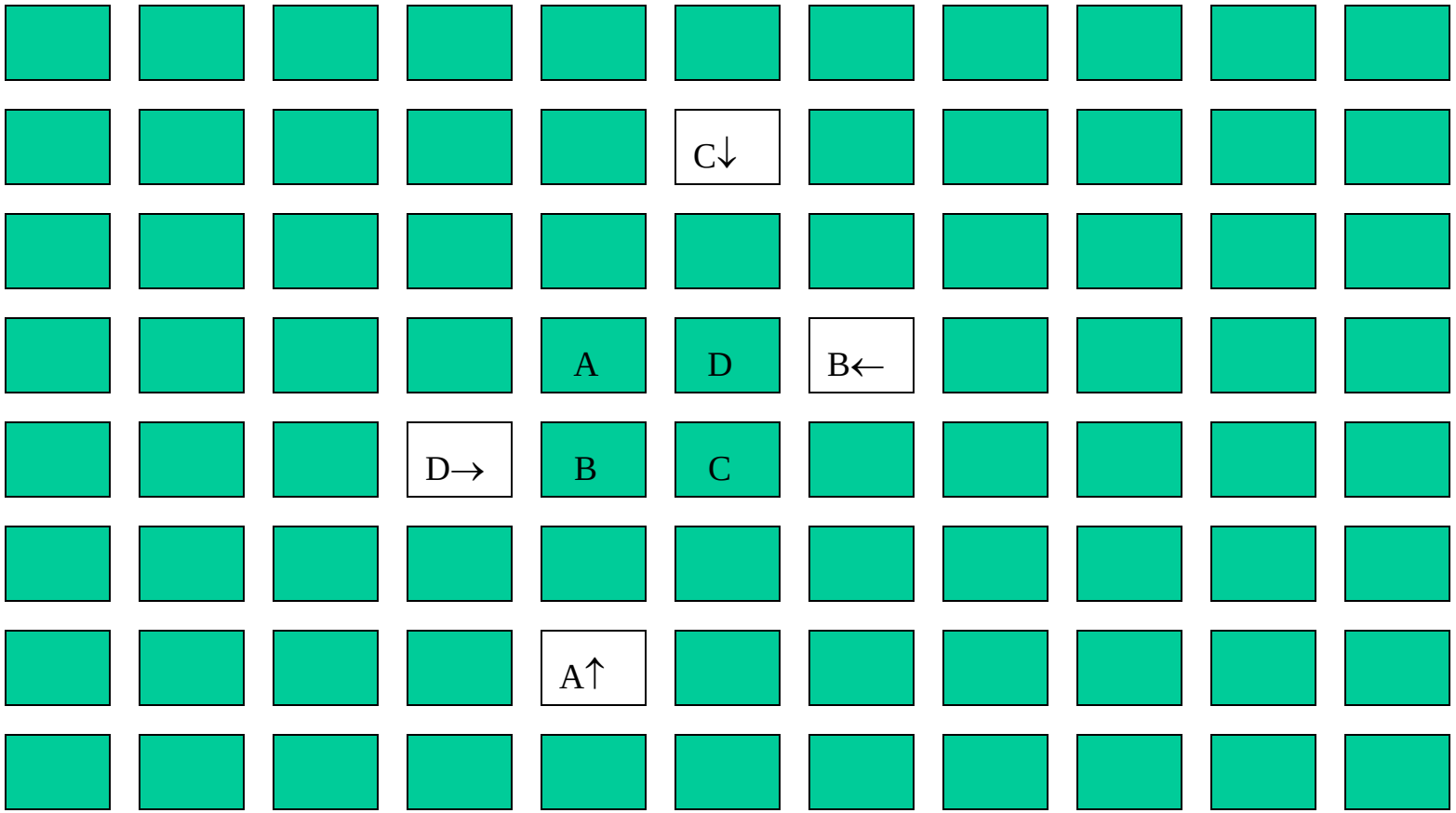

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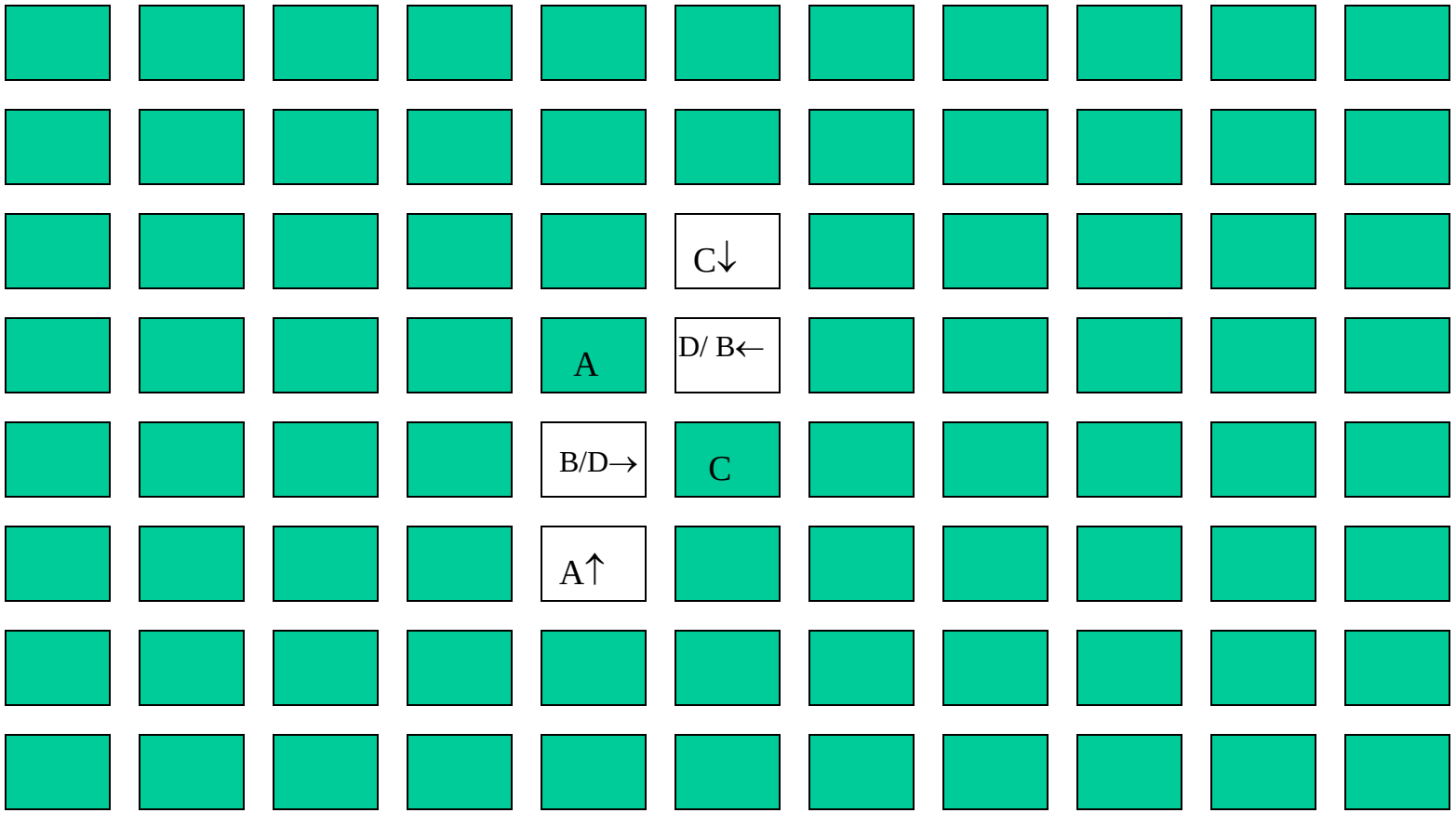

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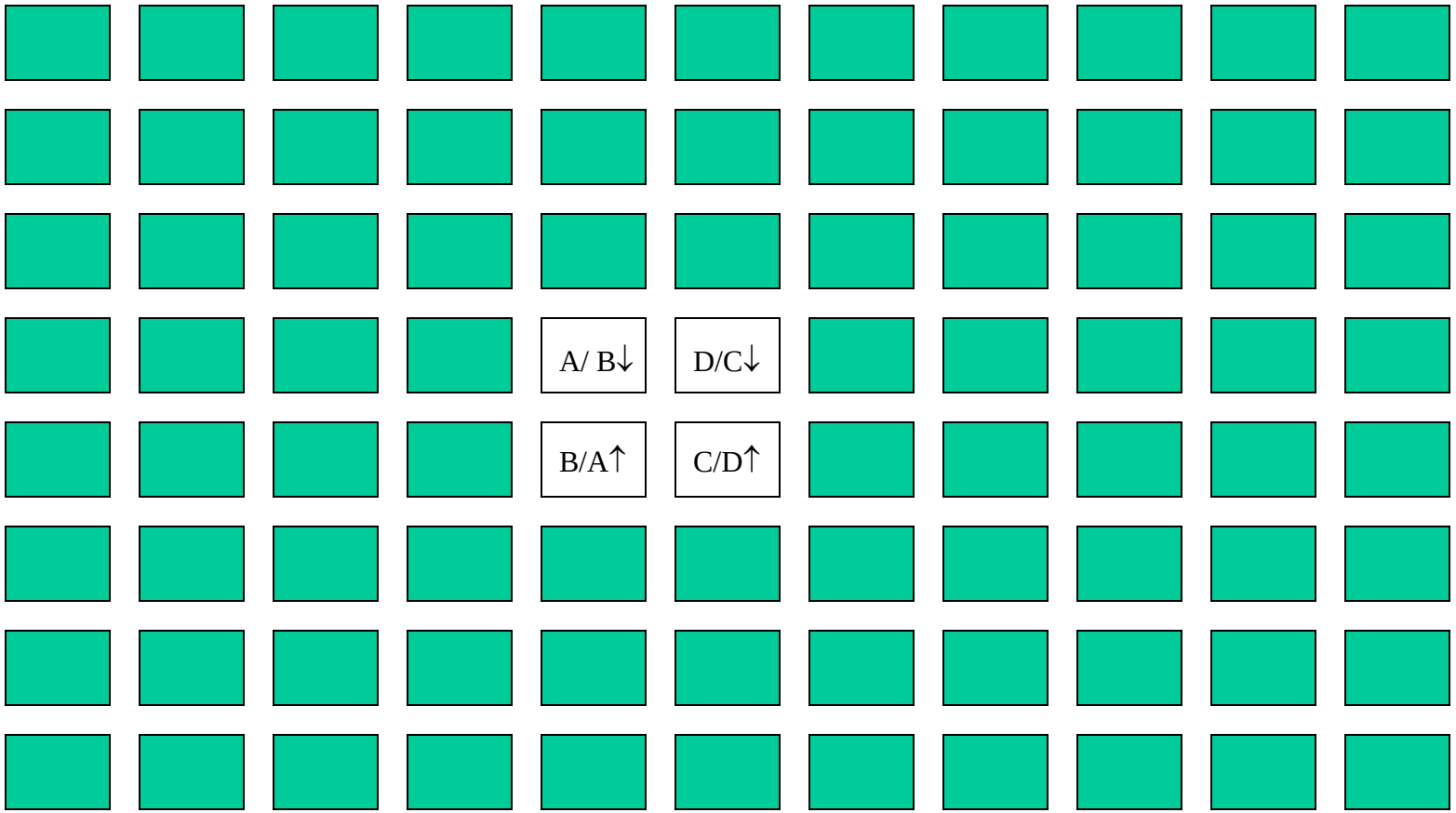
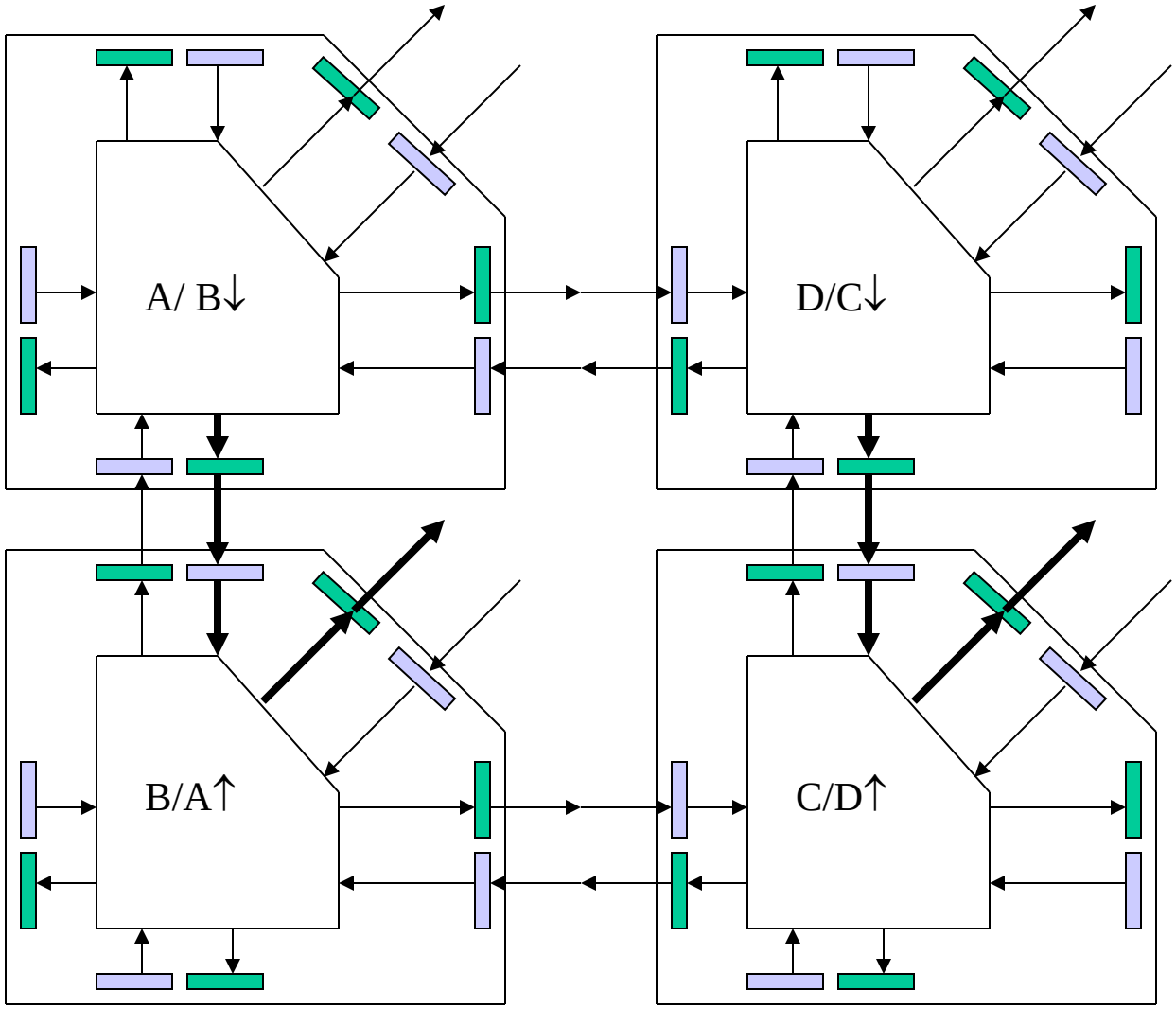


DOR ROUTING V



DOR ROUTING VI

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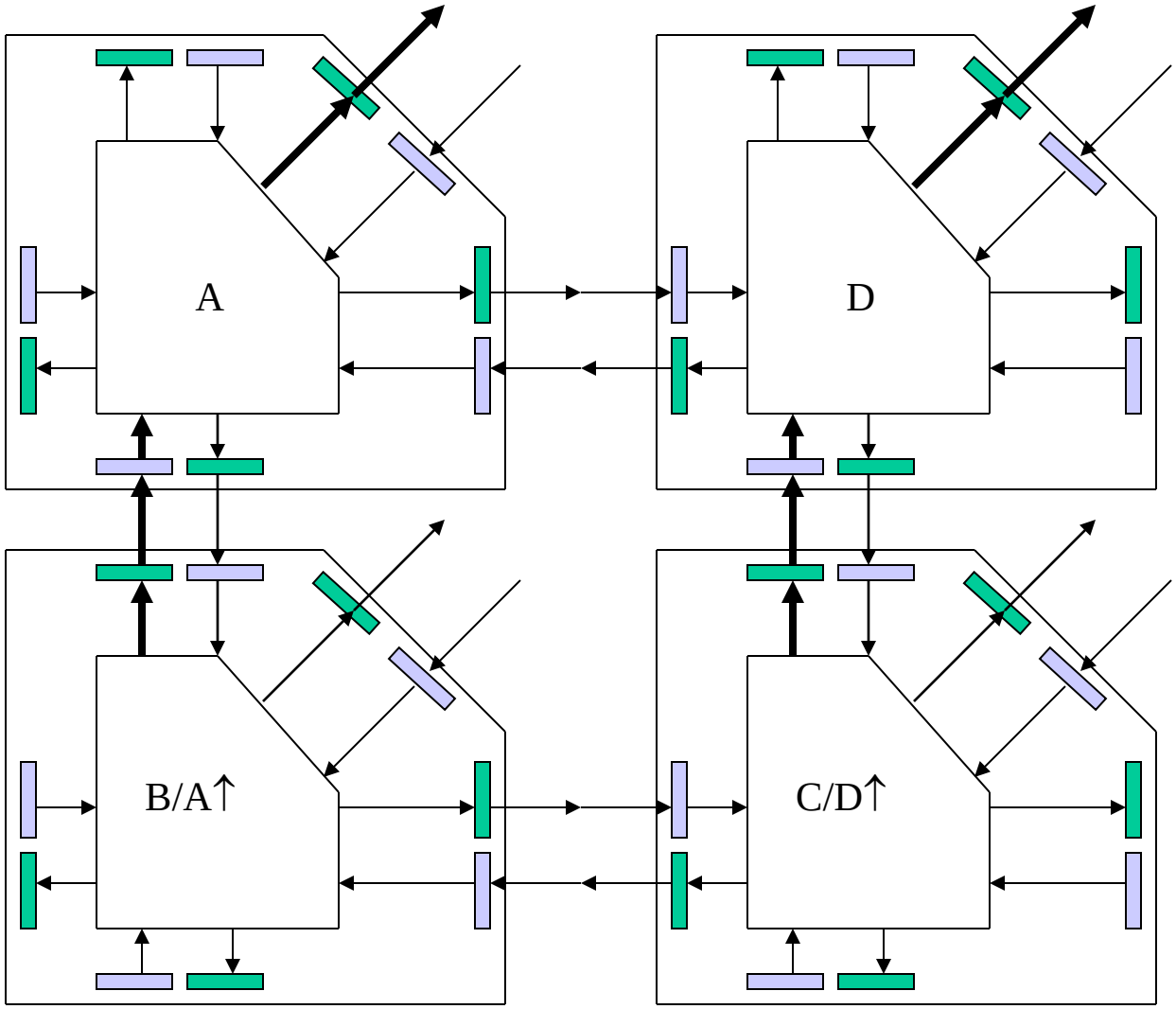

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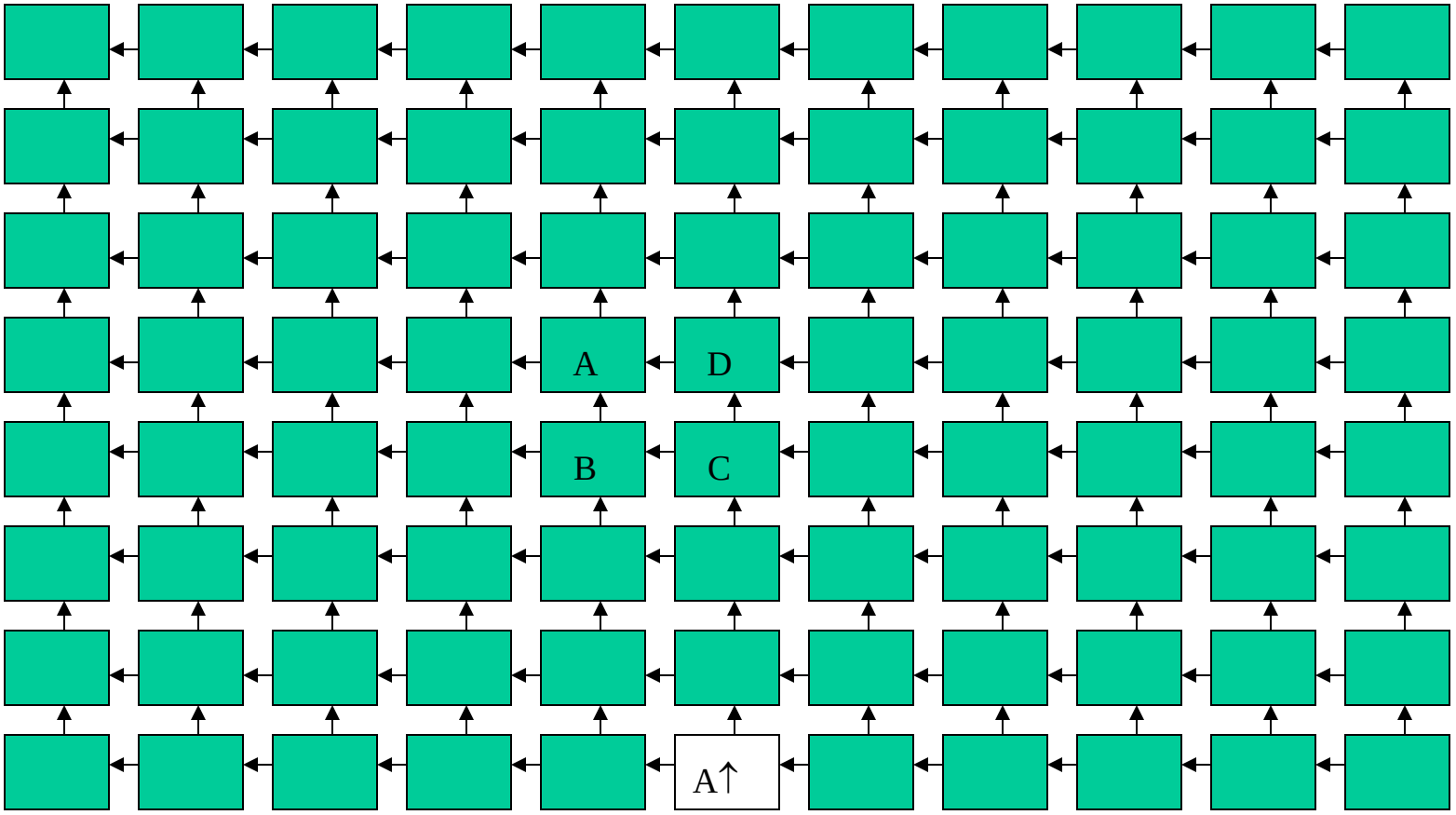
VIRTUAL NETWORKS I (northwest)



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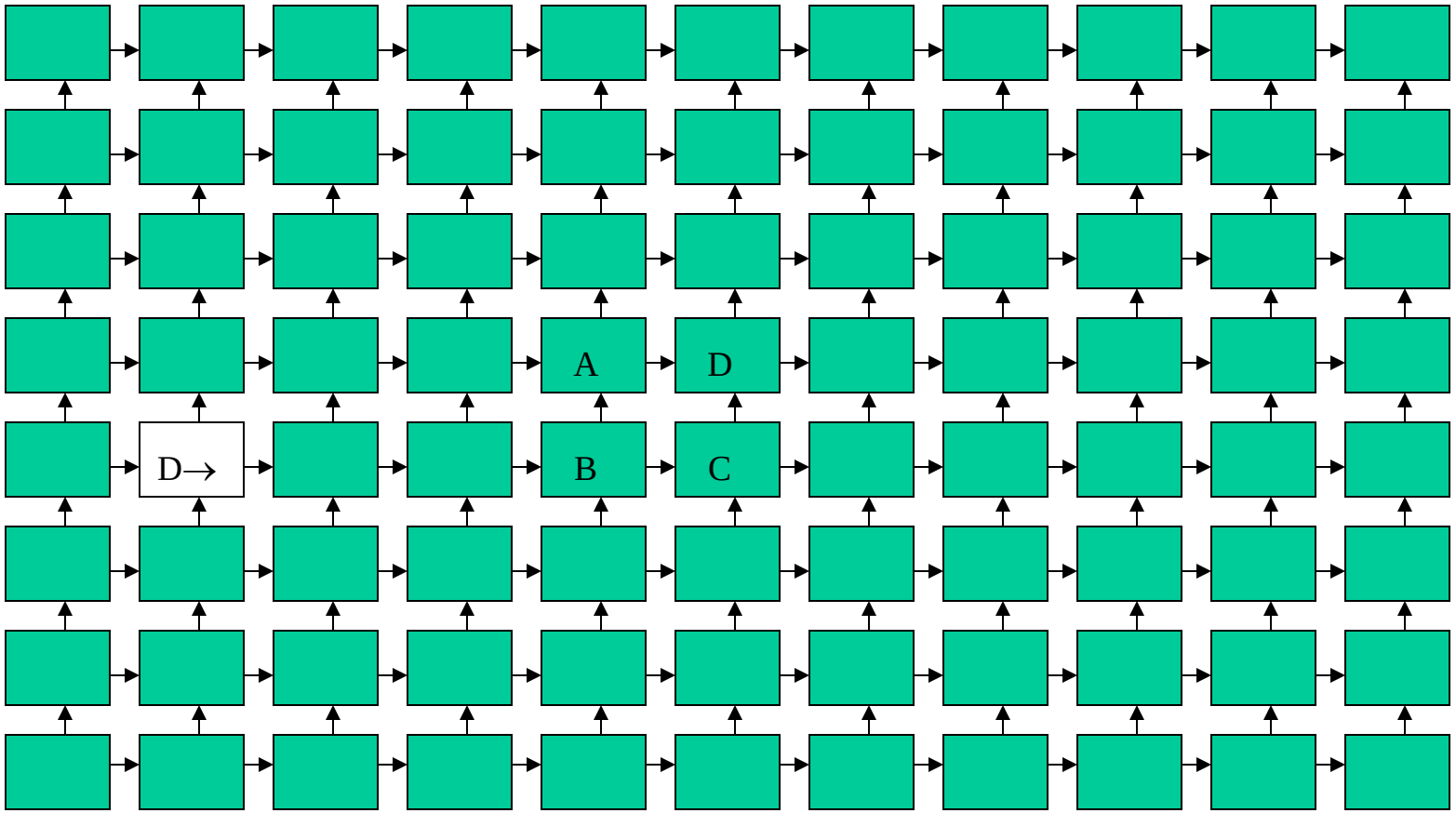
VIRTUAL NETWORKS I (northeast)



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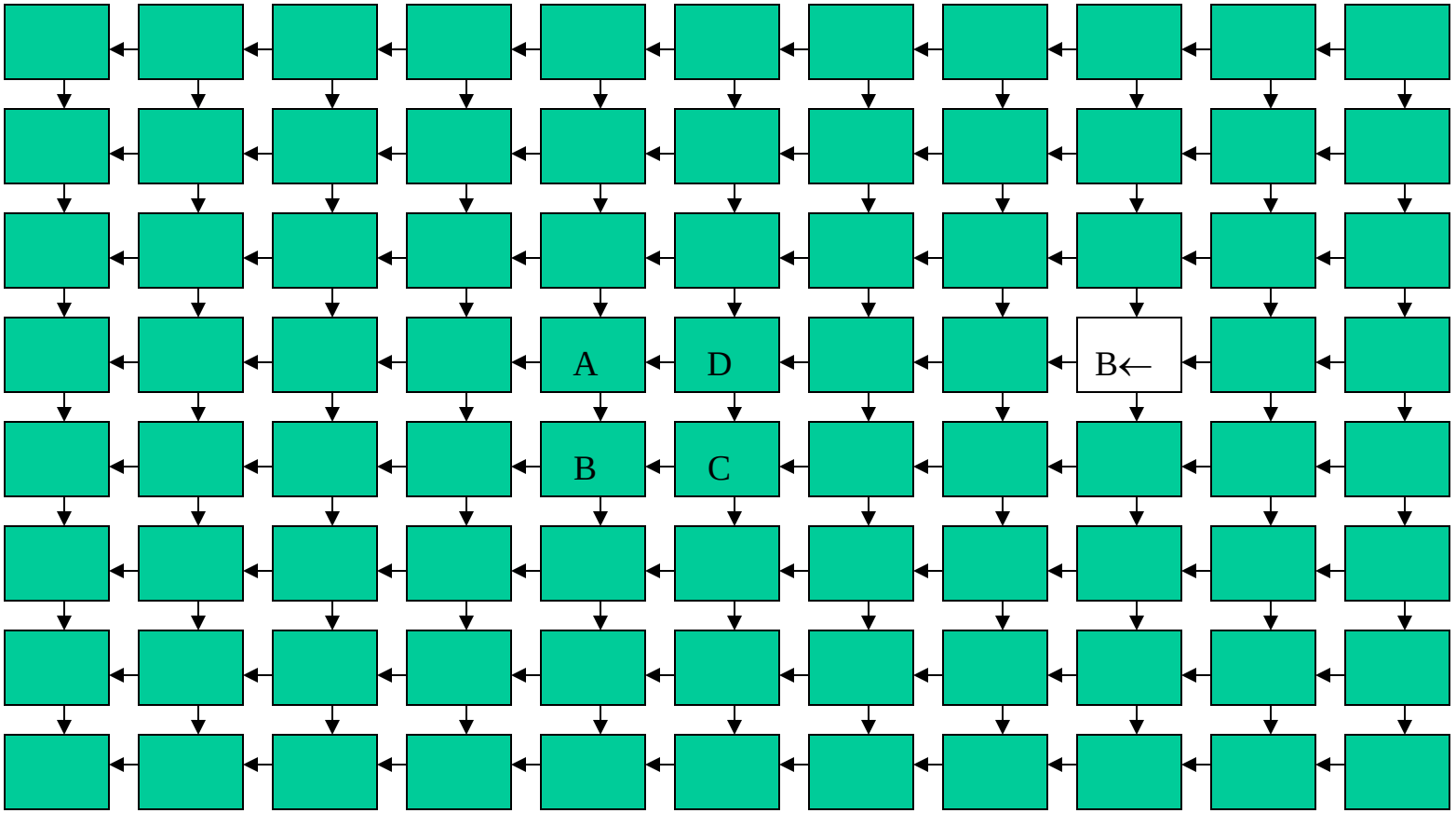
VIRTUAL NETWORKS I (southwest)



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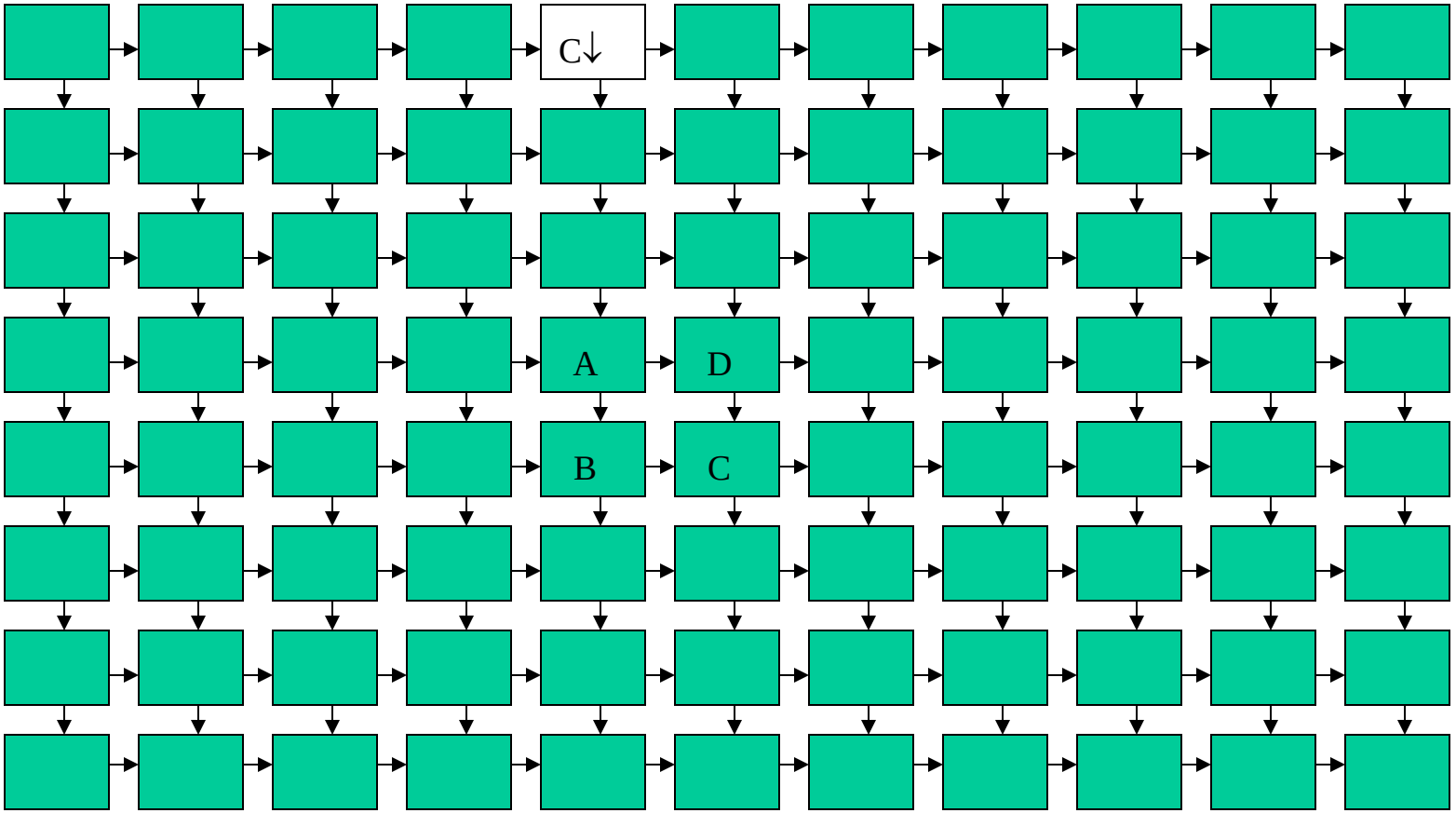
VIRTUAL NETWORKS I (southeast)



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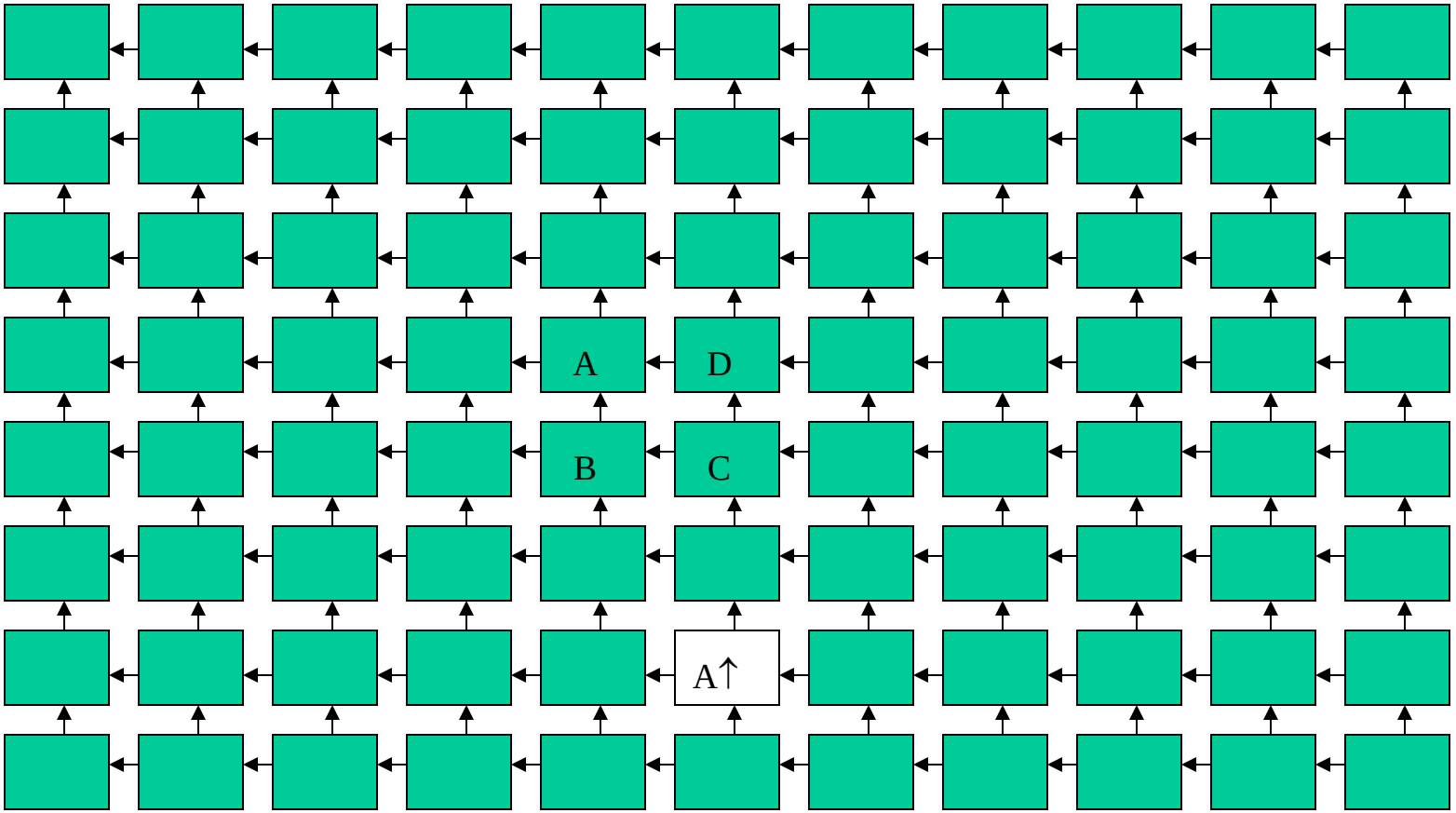

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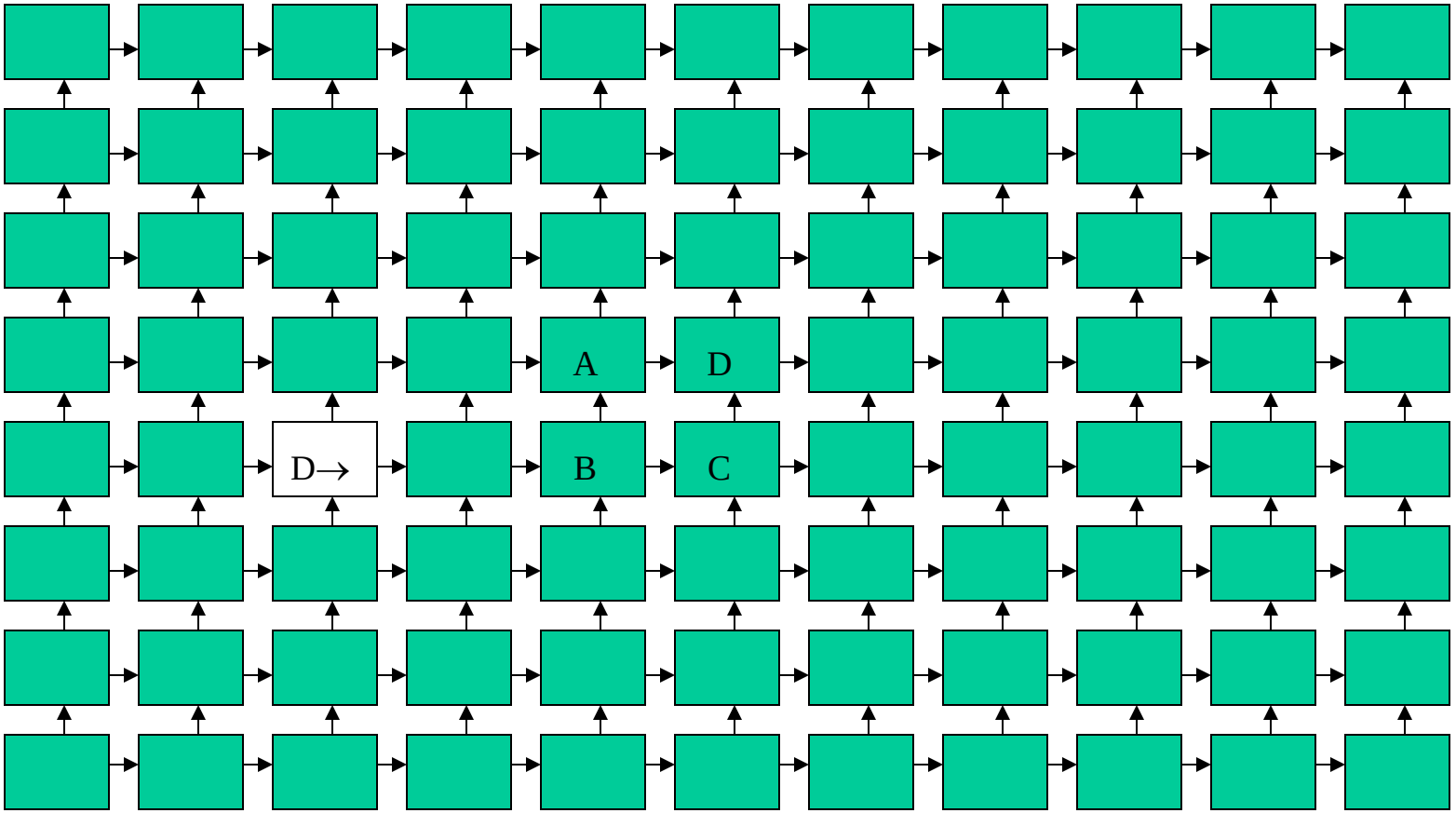

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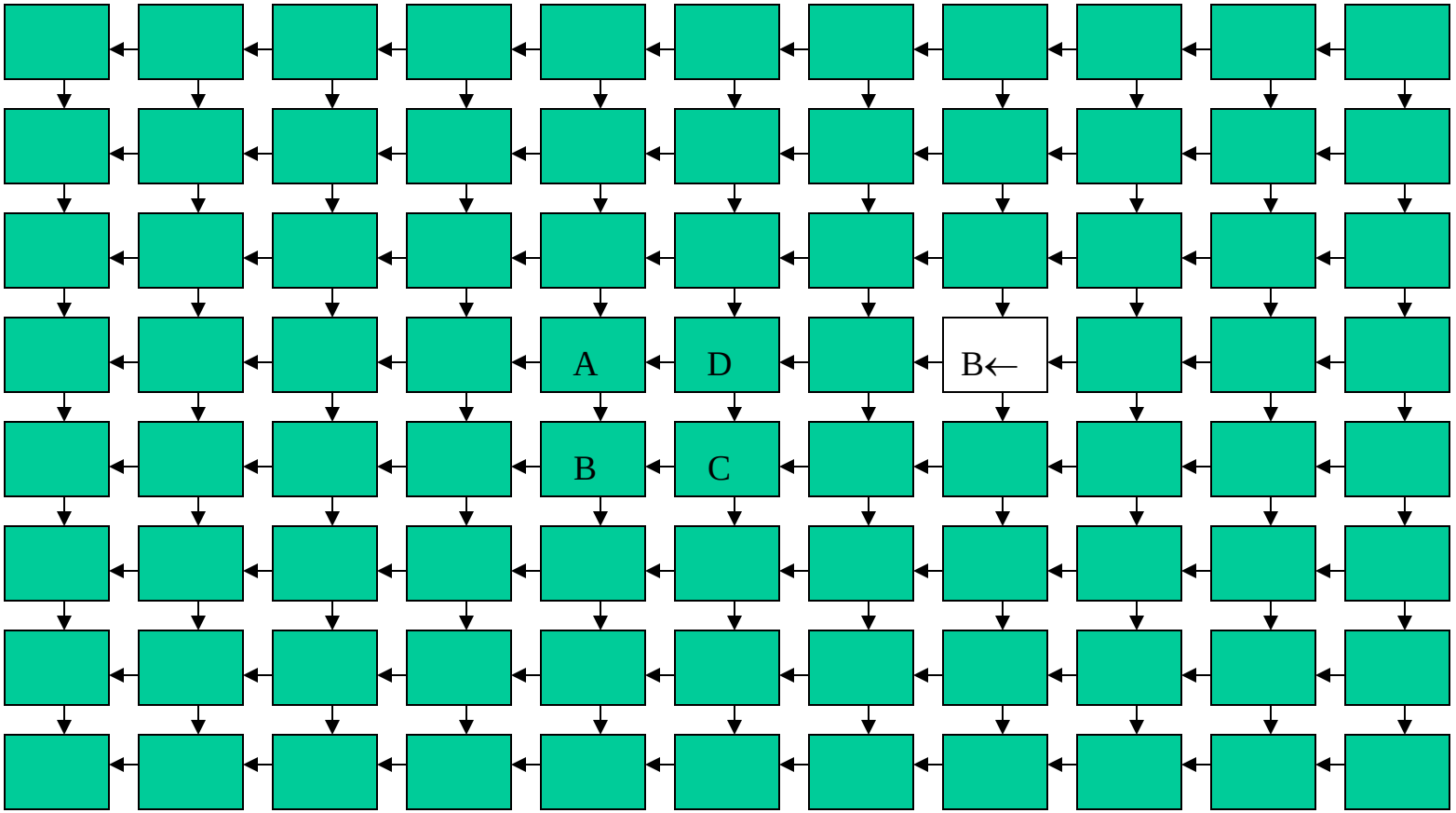

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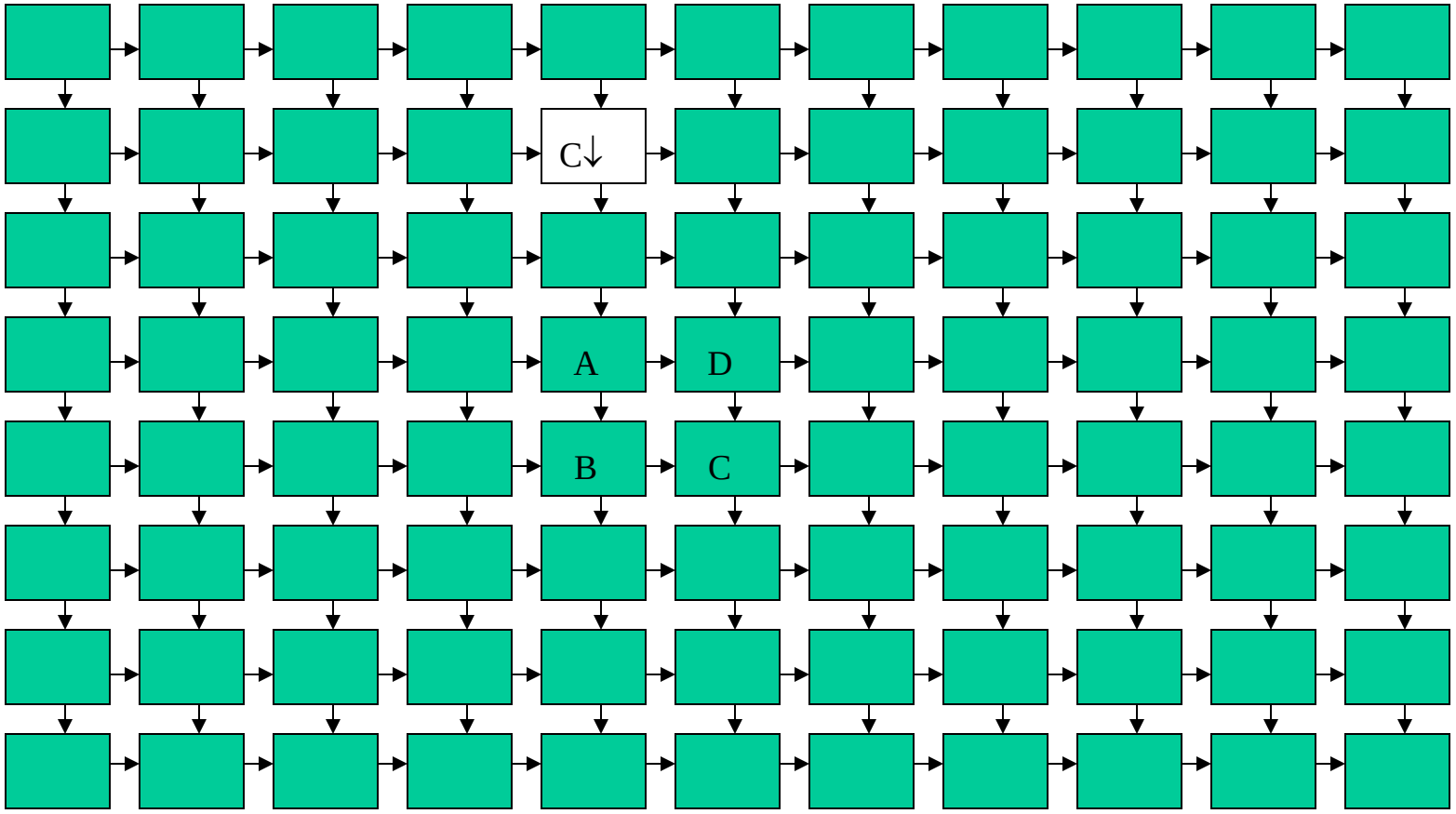

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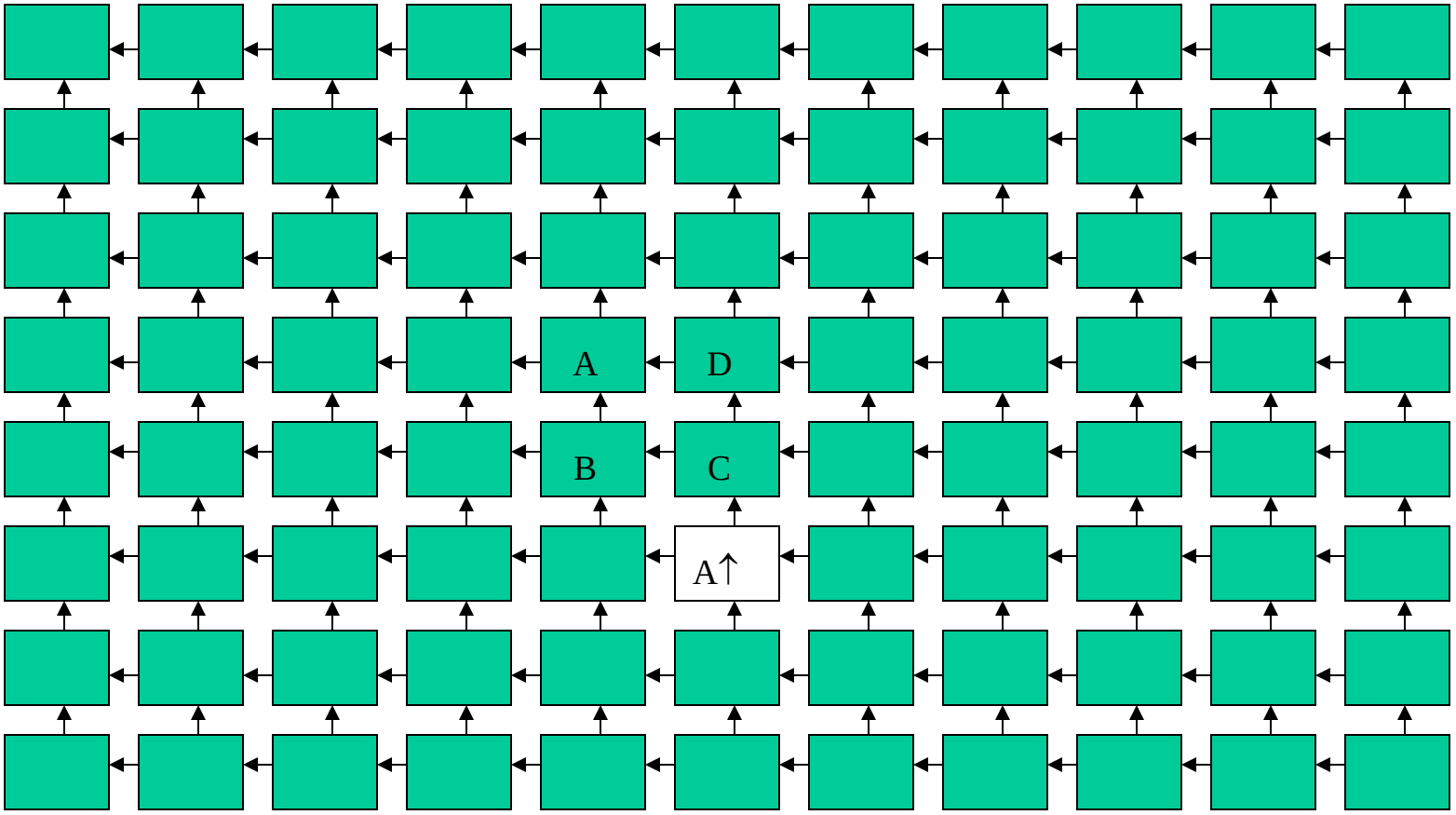
VIRTUAL NETWORKS III (northwest)



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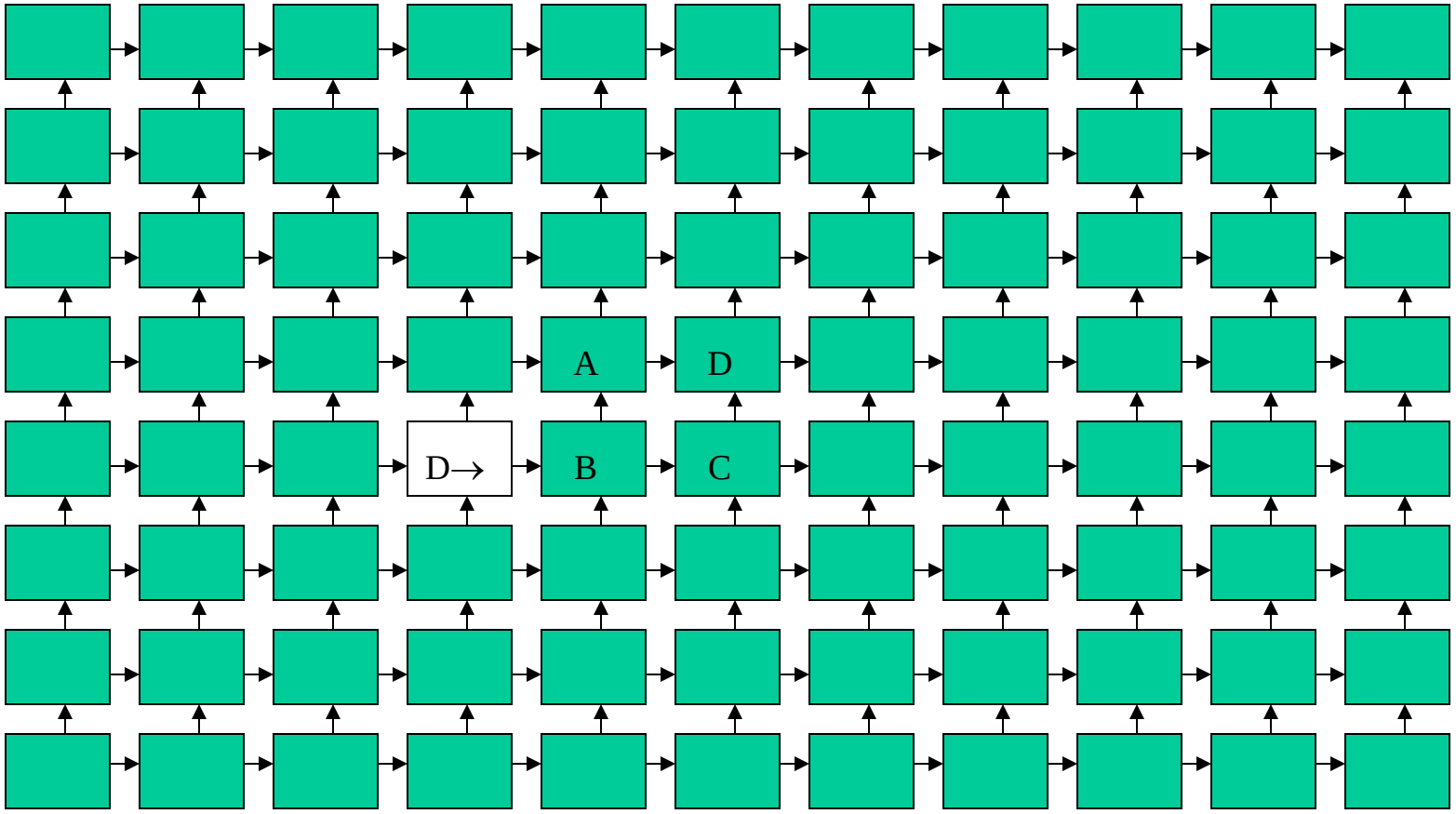

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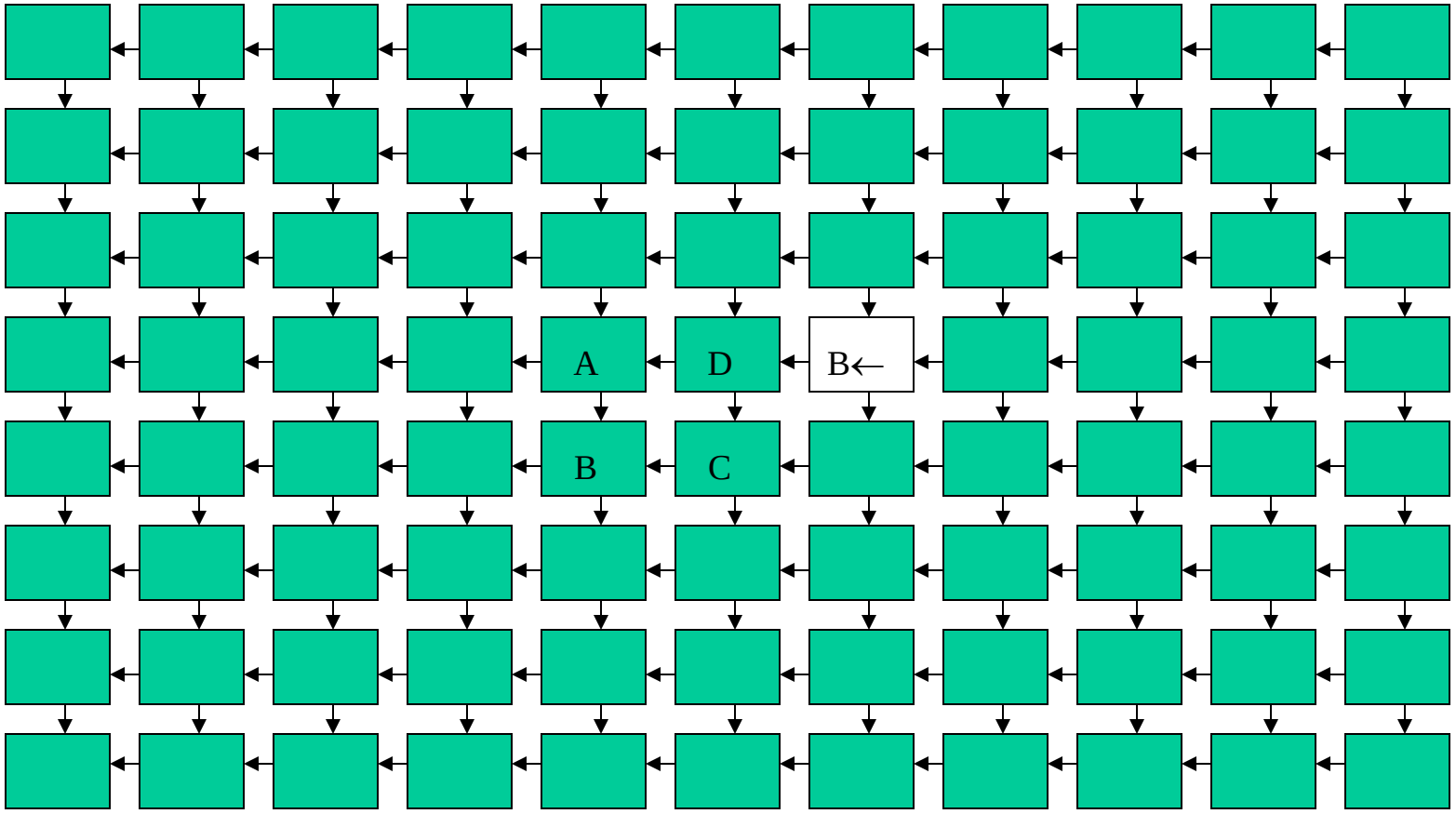

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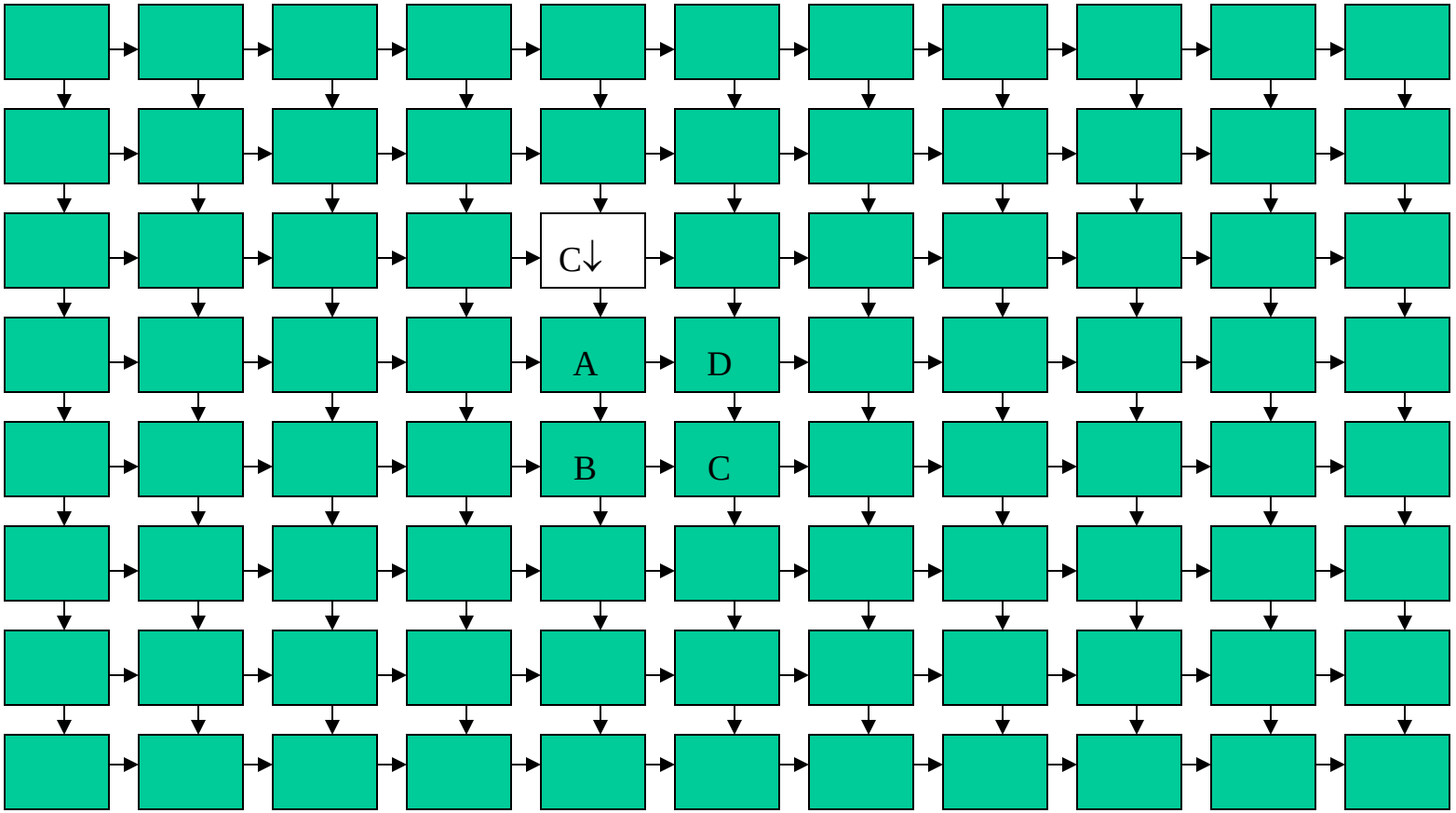

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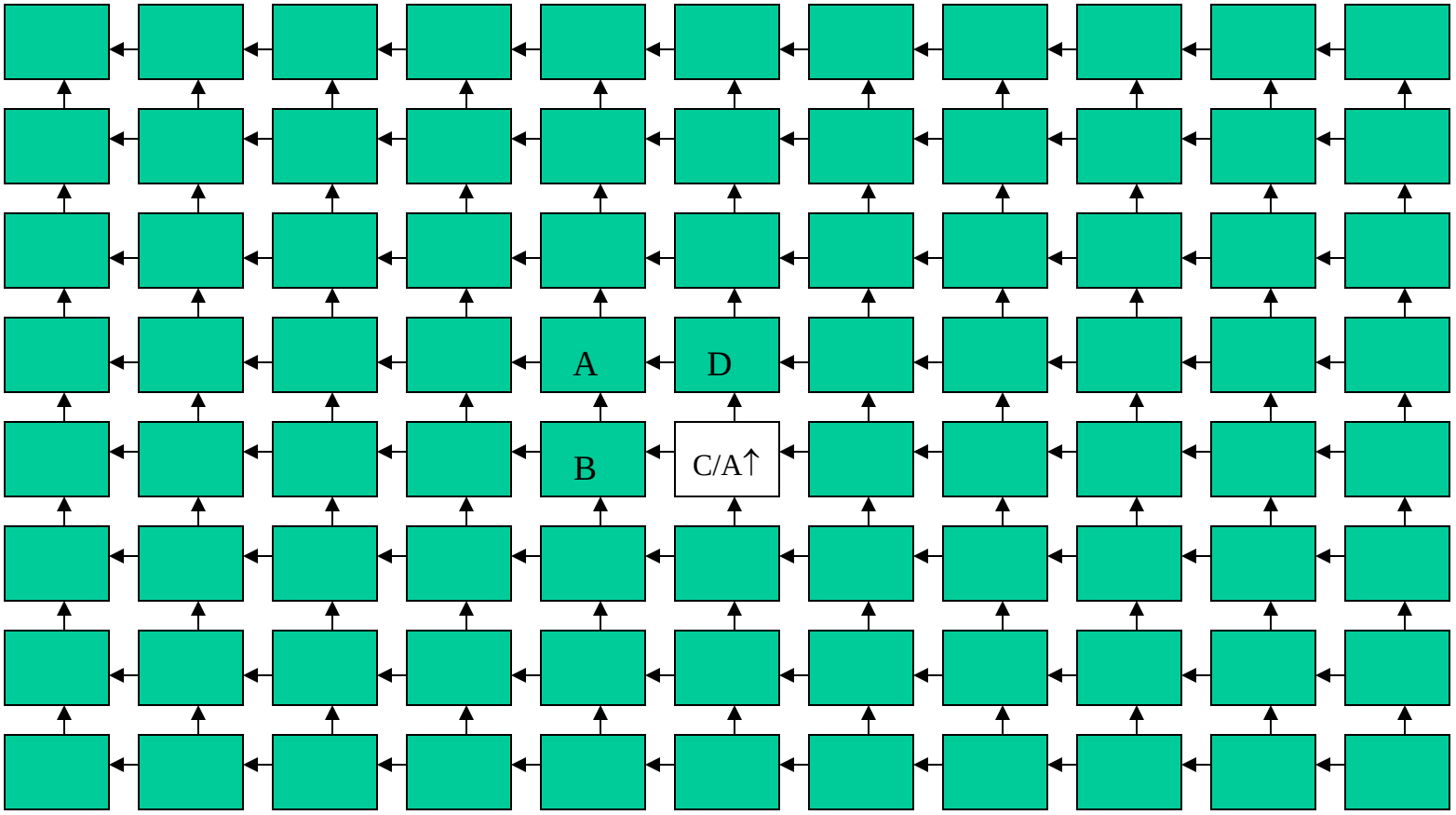
VIRTUAL NETWORKS IV (northwest)



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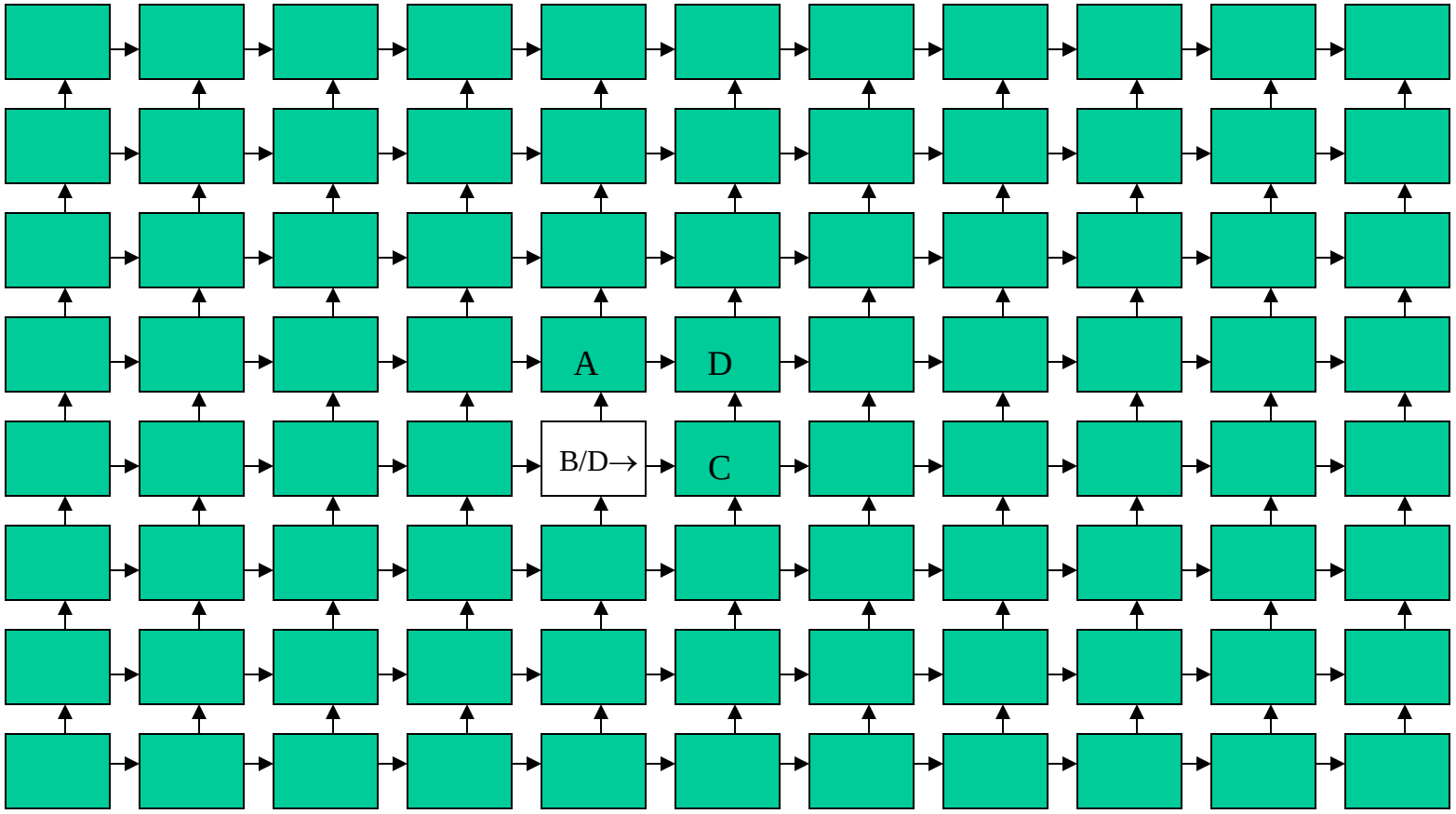
VIRTUAL NETWORKS IV (northeast)



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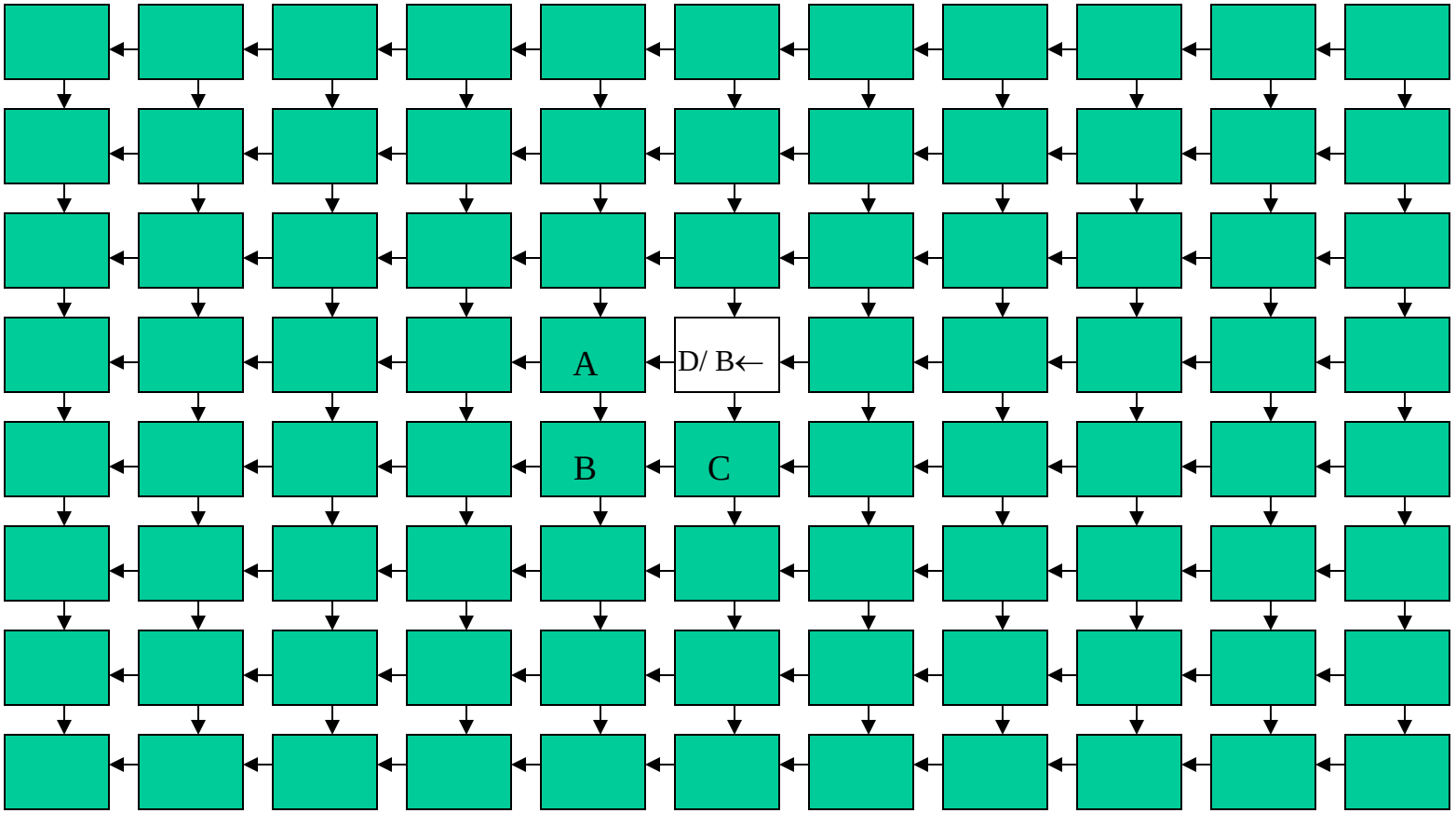

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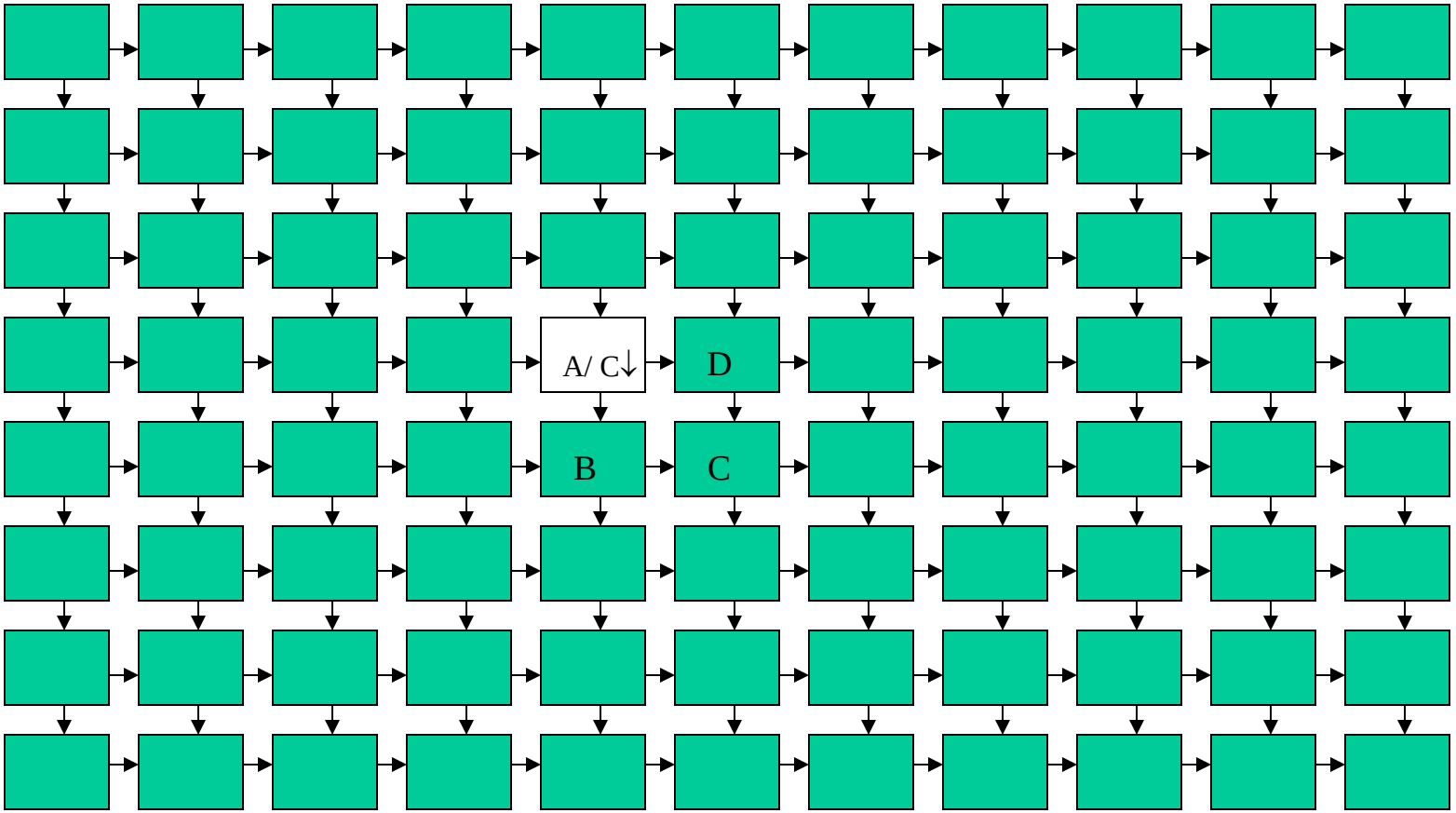

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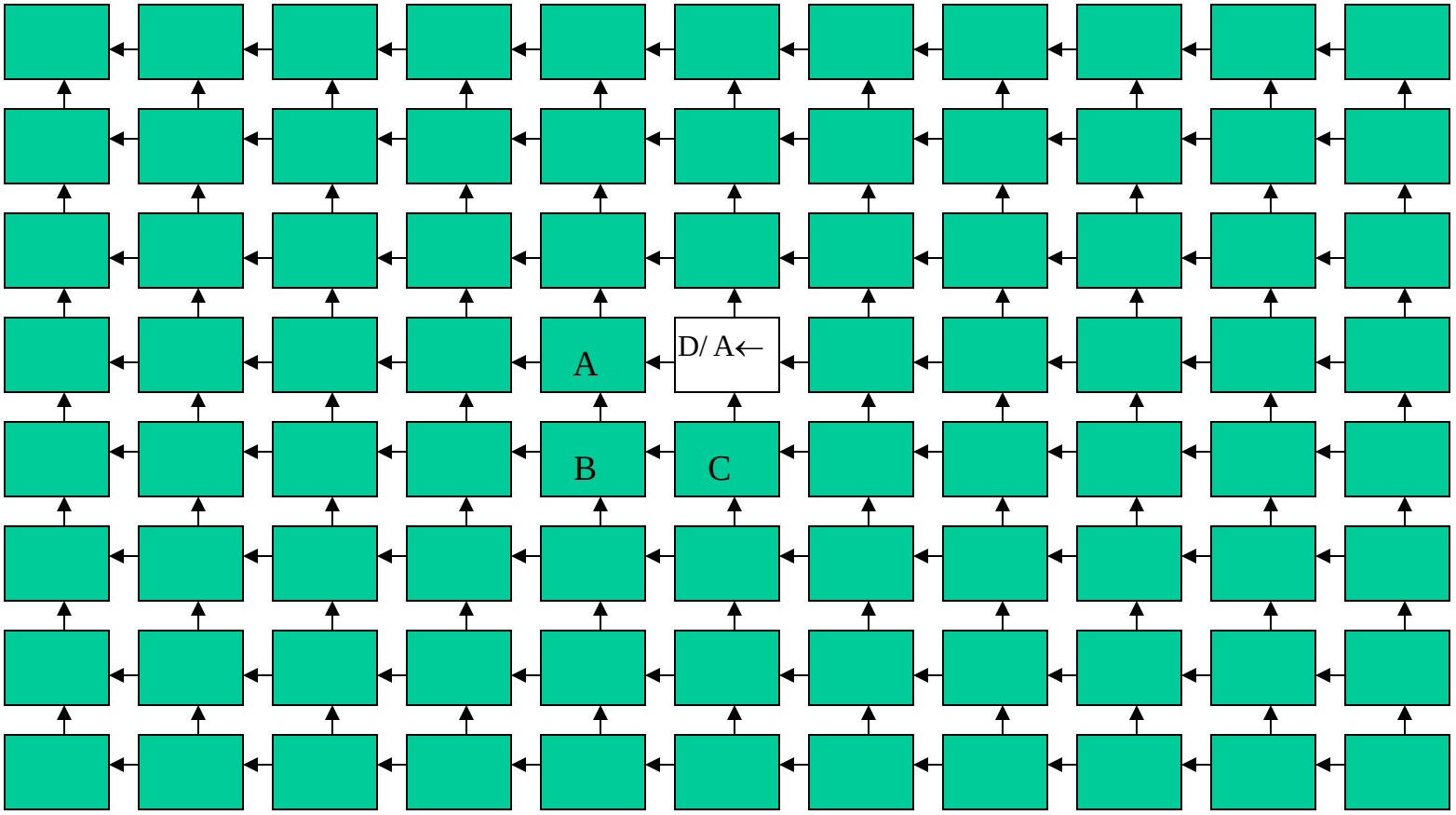
VIRTUAL NETWORKS V (northwest)



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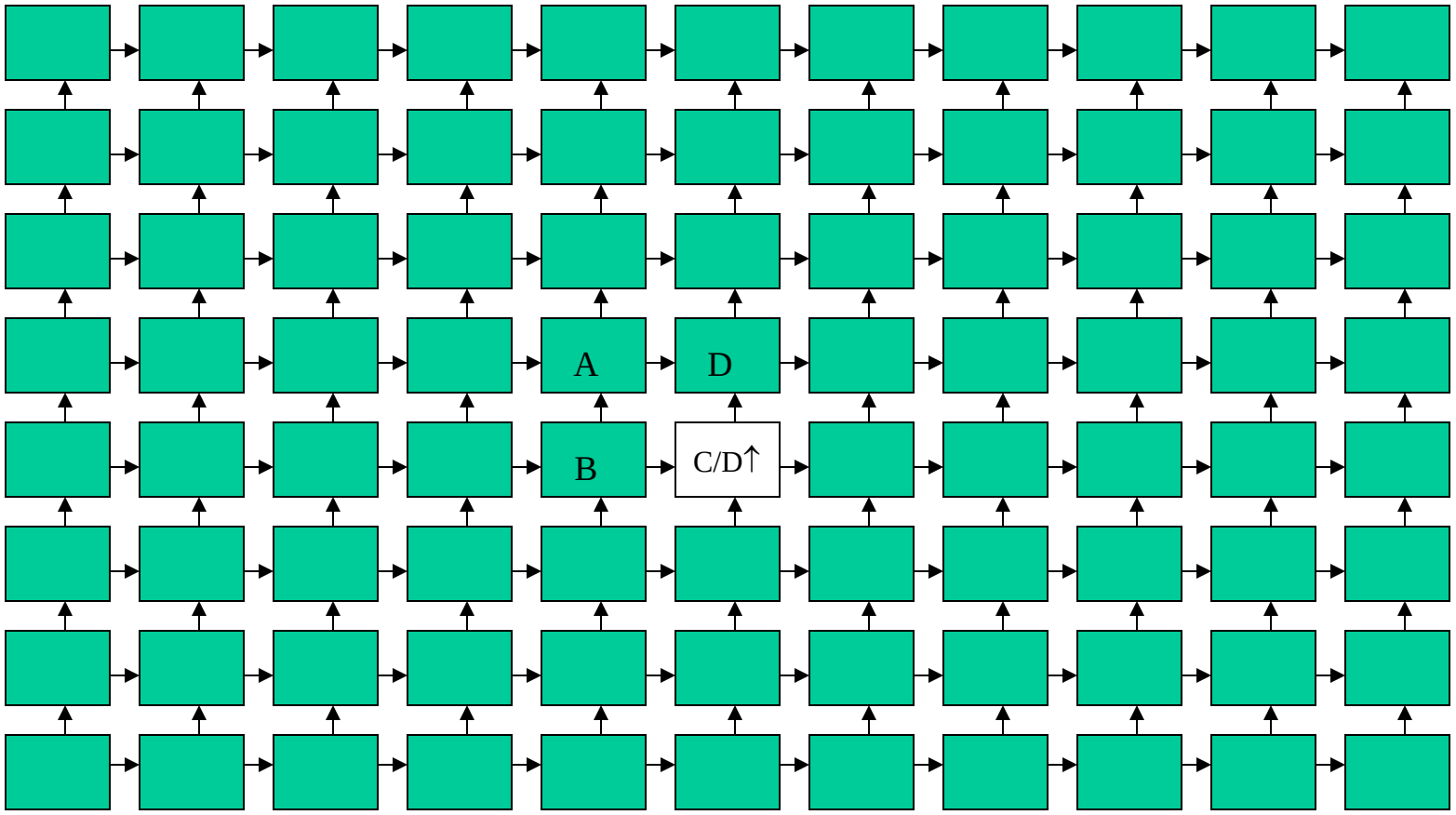

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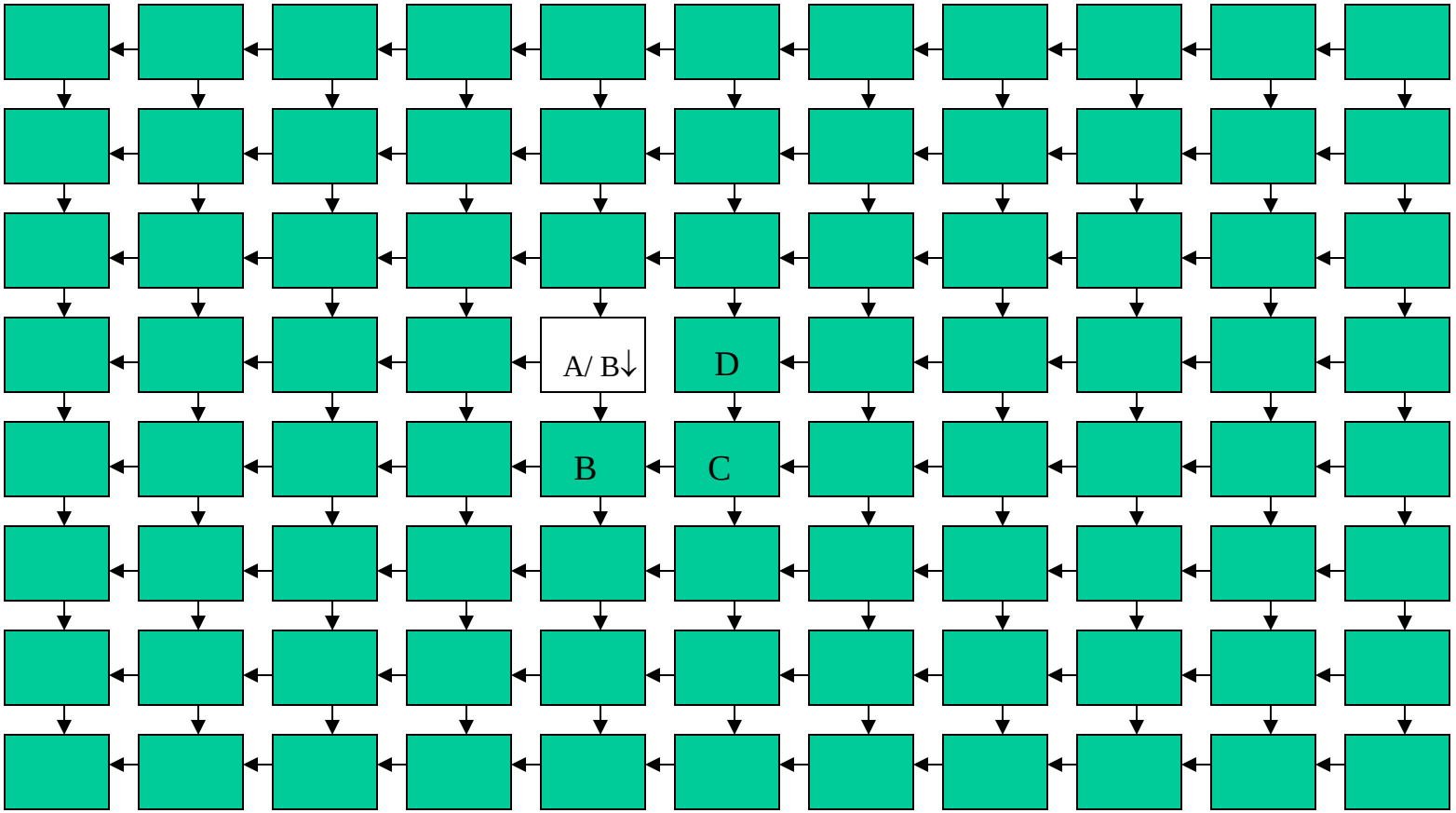

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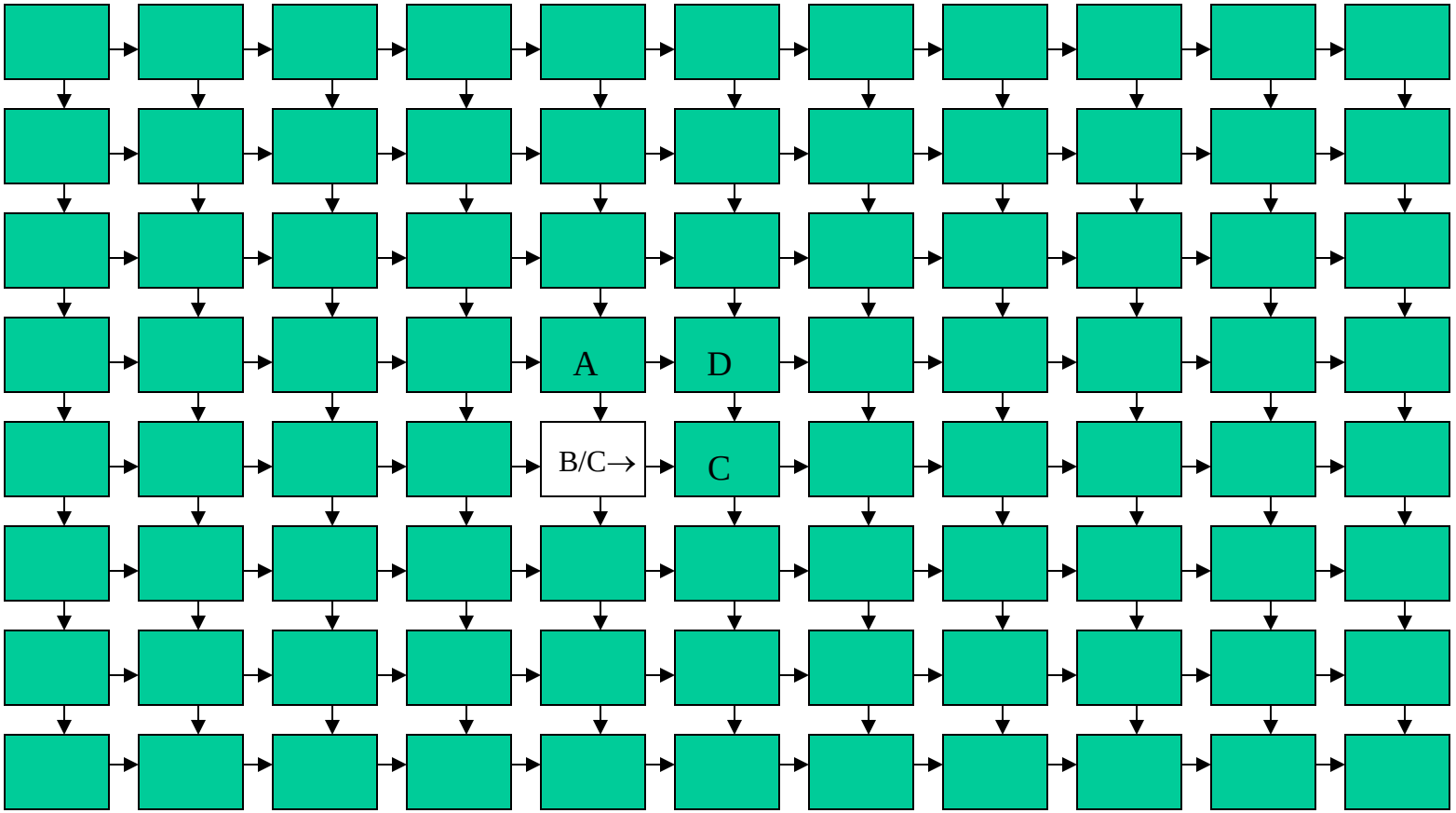

Routing algorithm example

- Topology: mesh.
- Type of algorithm: unicast, progressive, centralized, minimal.
- According to its implementation it may be:
  - Deterministic o adaptive.
  - Table look-up or finite state machine.
- Compatible with DOR.
- Consists of subtracting the coordinates of the source node from those of the destination one.
- The route for a packet to travel from node (2,8) to node (12, 6), comprises 12 – 2 = 10 hops in x^+ direction and 6 – 8 = 2 hops in y^-direction.