Asynchronous approach in the plane: A deterministic polynomial algorithm[1]

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Deterministic asynchonous approach in the plane

Deterministically bring two mobile asynchronous agents initially separated within each other's range of vision/communication

Deterministic asynchonous approach in the plane

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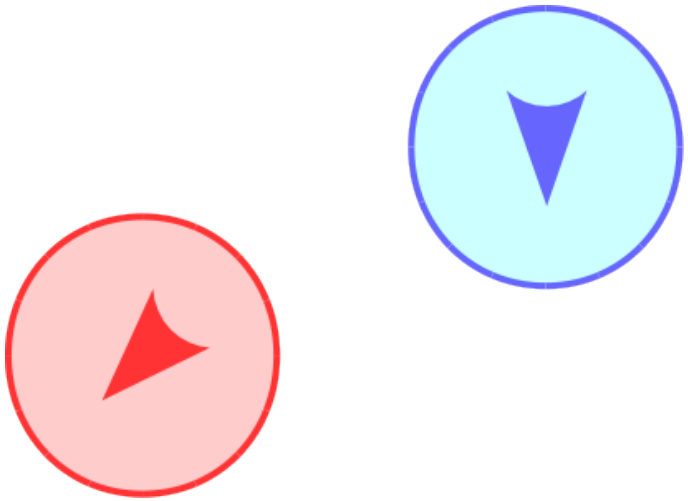

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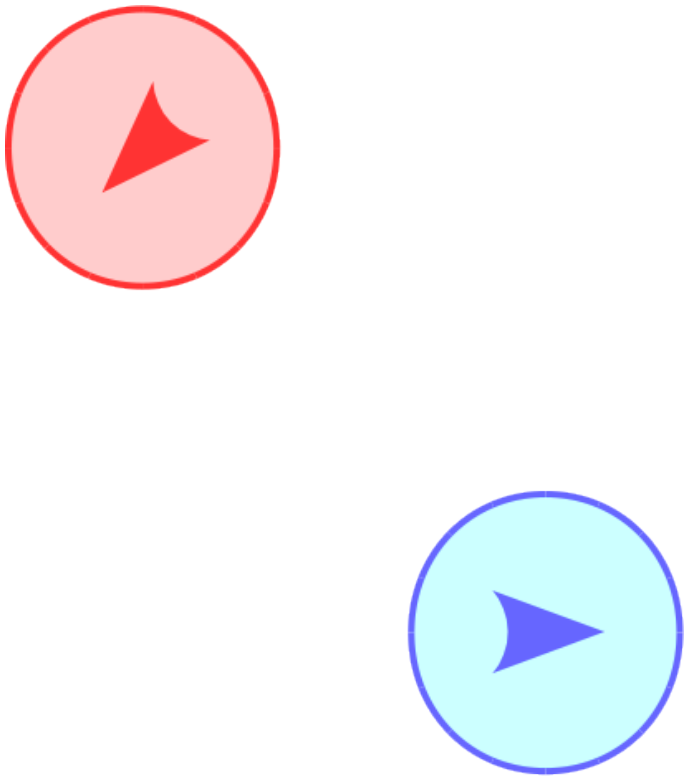

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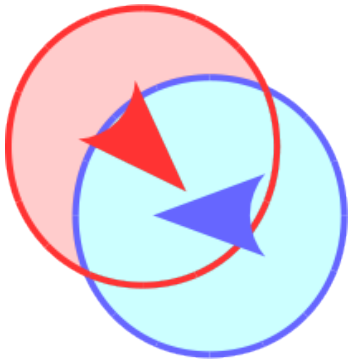

A first exponential solution

Czyzowicz, Pelc, and Labourel

Deterministic approach algorithm whose cost (total distance traveled) is exponential in D, the initial distance between the agents.

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Does a polynomial algorithm exist?

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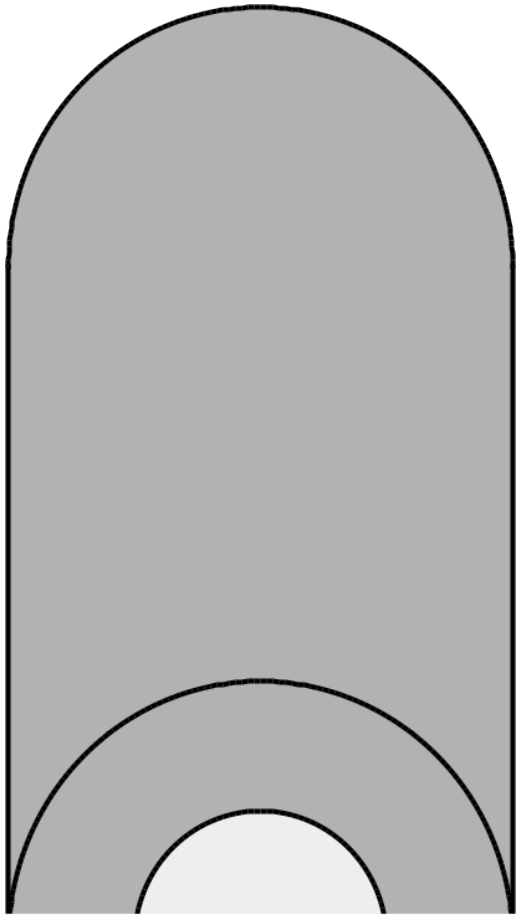
Does a polynomial algorithm exist?

Tunnels

Two routes r_1 and r_2 respectively from nodes v_1 and v_2 form a *tunnel* iff r_1 has a prefix p which ends at v_2 and r_2 has a prefix which is $\overline{p}$ *i.e.*, the reverse of p.

A first exponential solution



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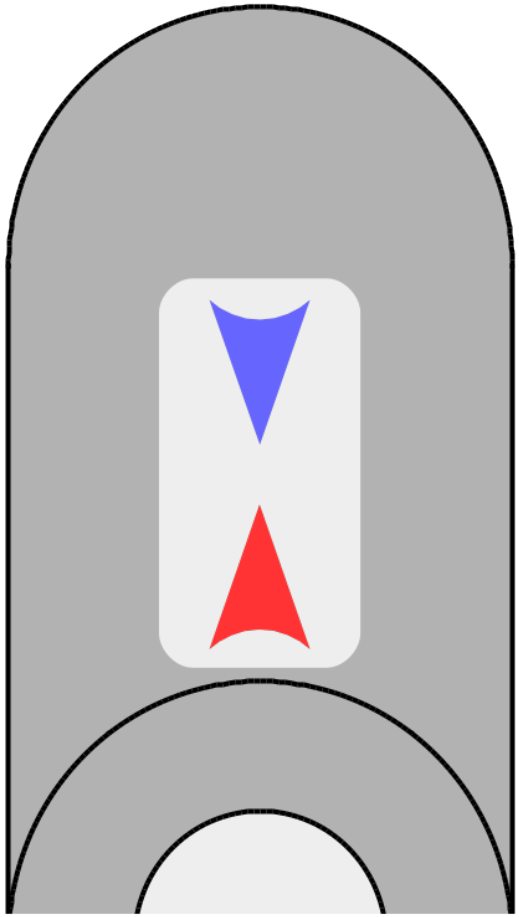

Polynomial algorithms thanks to simplifying assumptions

Bampas, Czyzowicz, Gasieniec, Ilcinkas, and Labourel

The agents know the coordinates of their initial location in a common coordinate system (some kind of GPS).
Nearly optimal solution.

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Dieudonné and Pelc

Each agent is assigned a constant speed which cannot change afterwards.

Reduction to rendez-vous in the infinite grid

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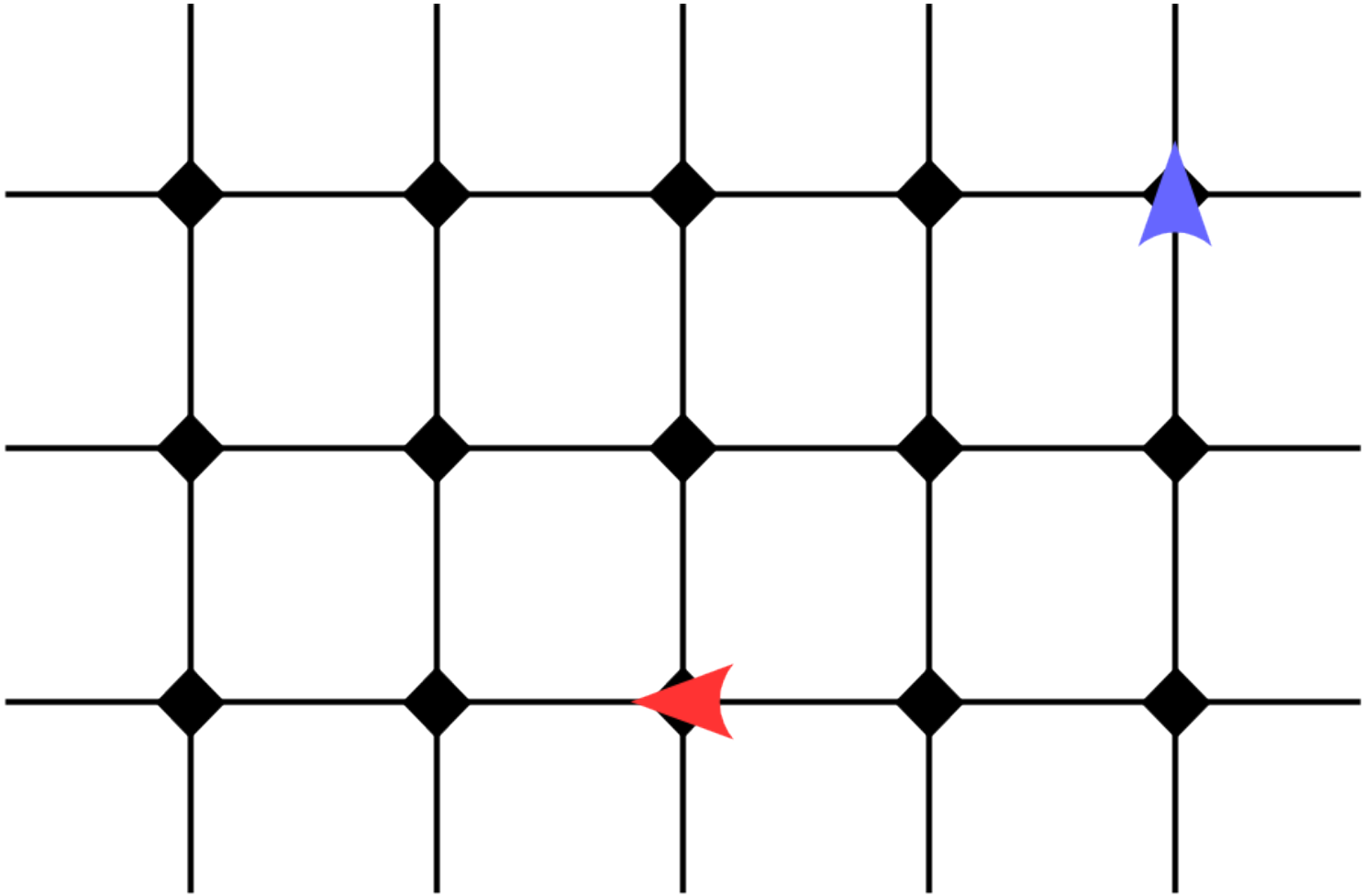

Precisions about the model

- Have to meet at a same point (either node or inside edge)

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- Compass

Our results

Deterministic algorithm whose cost (total number of edge traversals) is polynomial in the initial distance D and the length of the shorter label.

Tackling the unknown distance

Simplifying assumption

Assume a synchronous setting

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First issue

Initial separating distance D unknown

Tackling the unknown distance

Simplifying assumption

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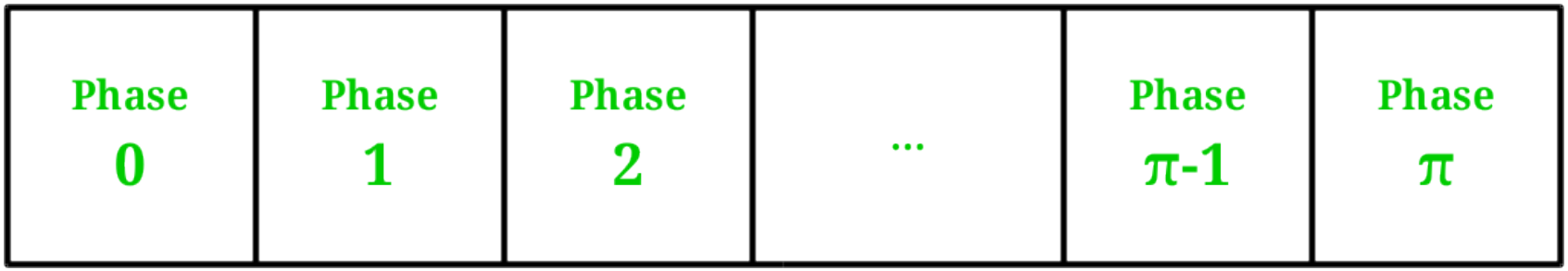
Solution: *phases*

Perform successive tests called phases:

During each test, the agents act as if the tested value were the good one.

Phase $i \rightarrow$ Tested value 2^i

Tackling the unknown distance



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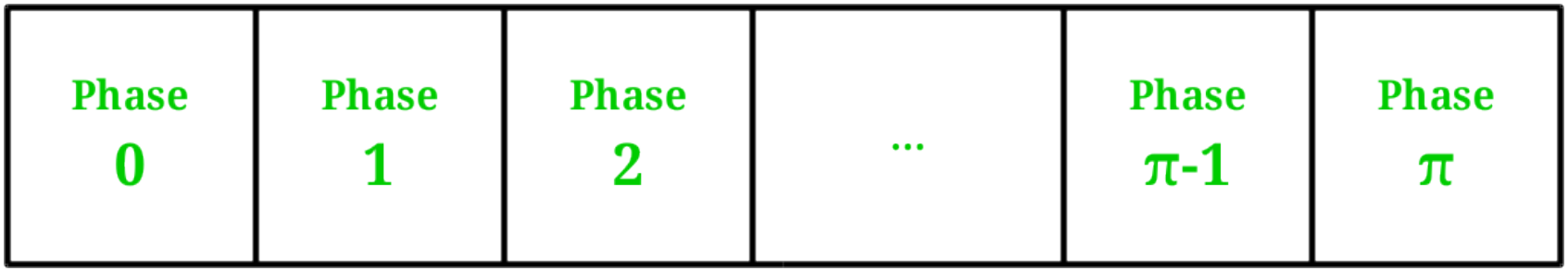

The good phase

Phase π with $2^{\pi-1} < D \leq 2^{\pi}$

Tackling the symmetry

Another issue

The grid is symmetric: if the agents keep performing the same actions they never meet

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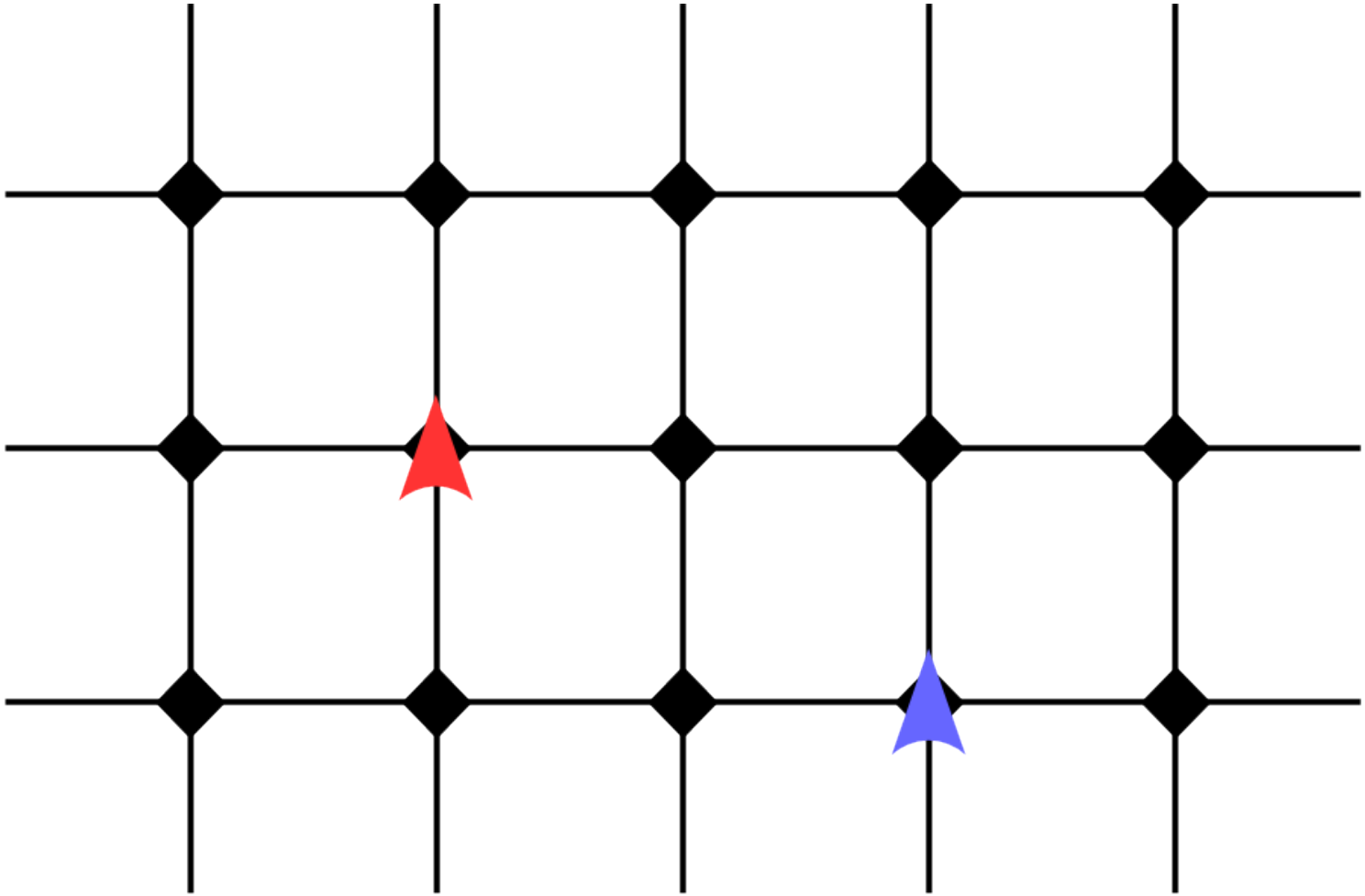

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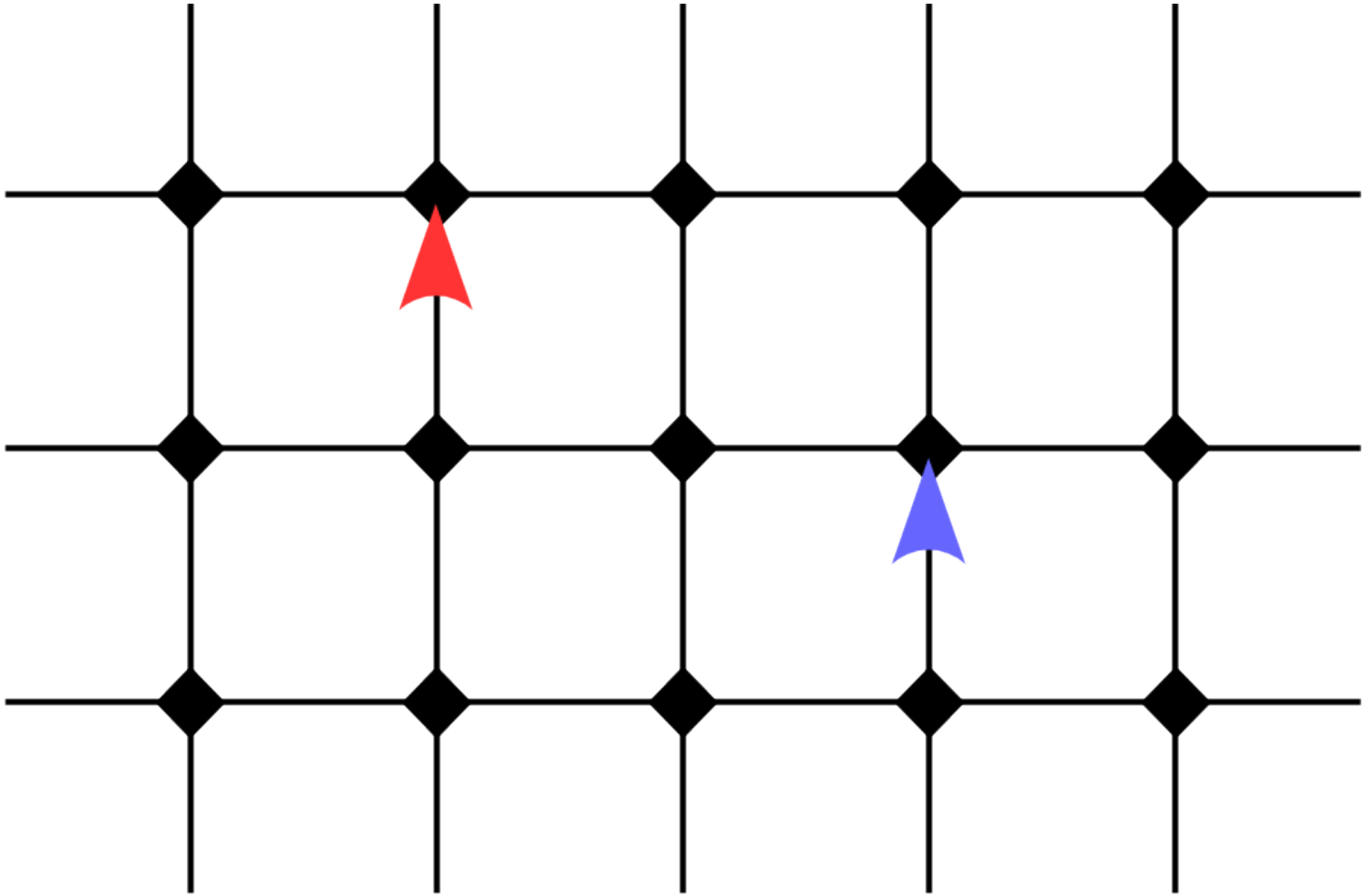

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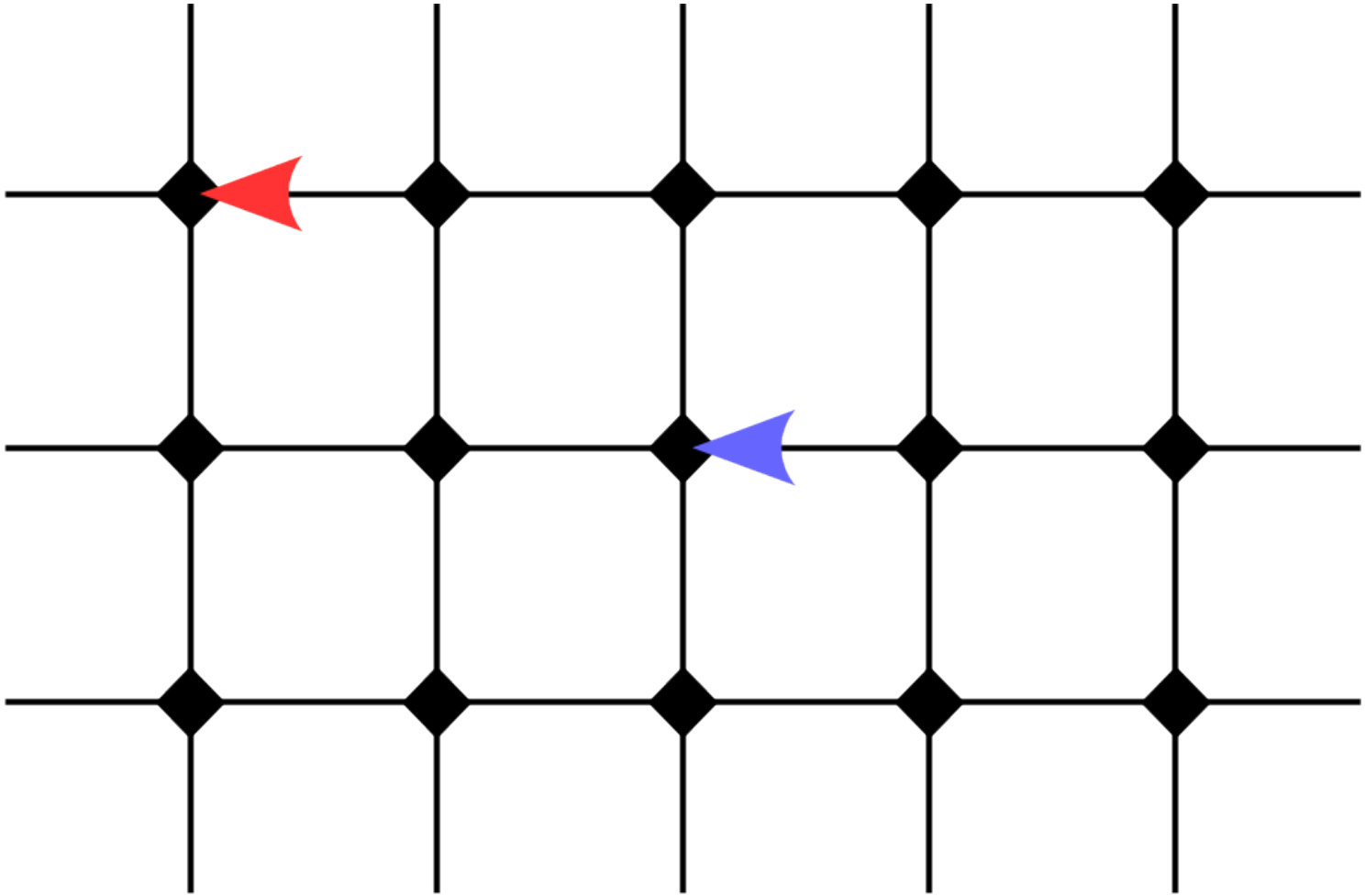

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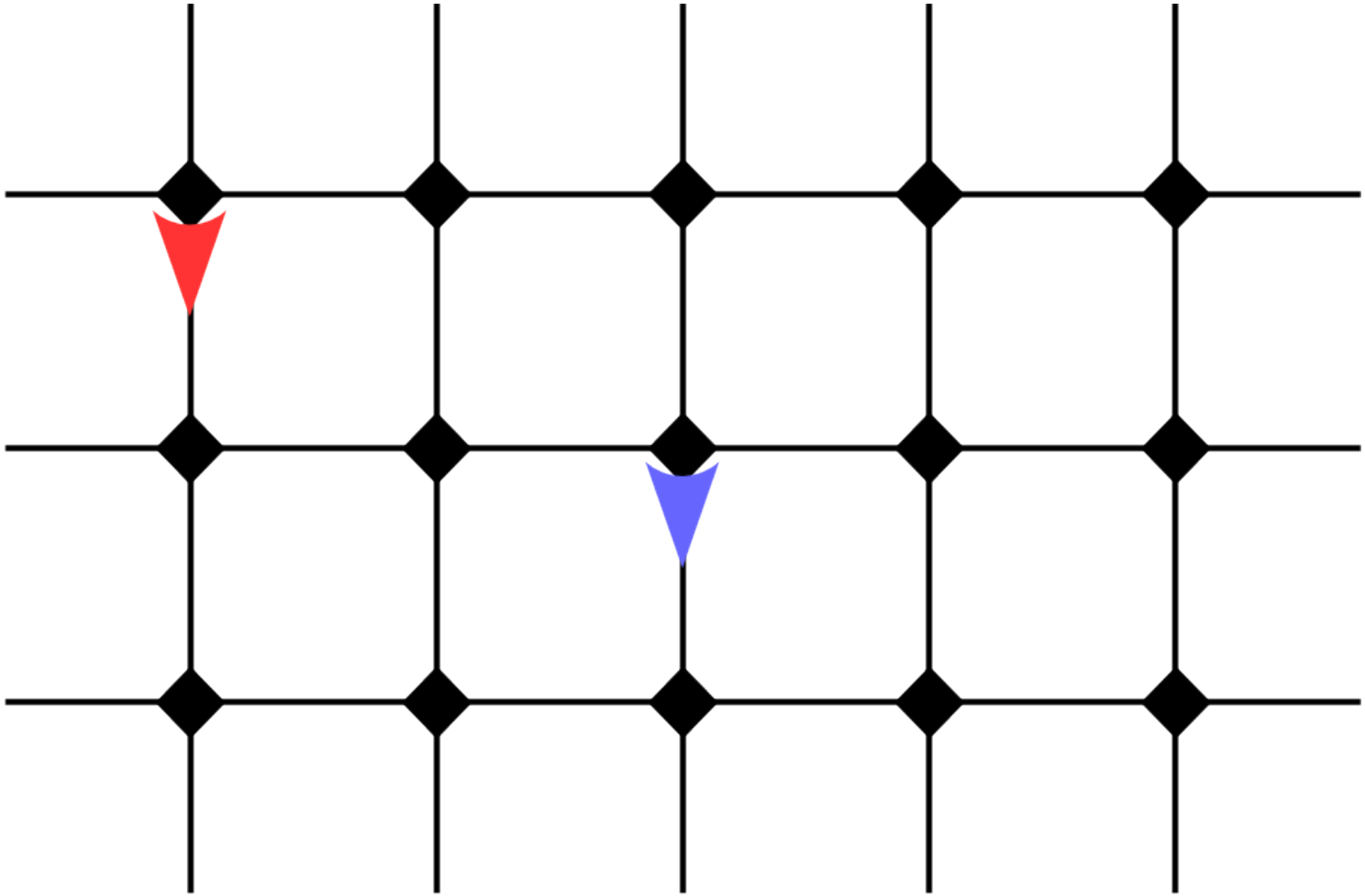

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Roughly speaking: each agent reads a binary sequence obtained from its label until they read different bits.

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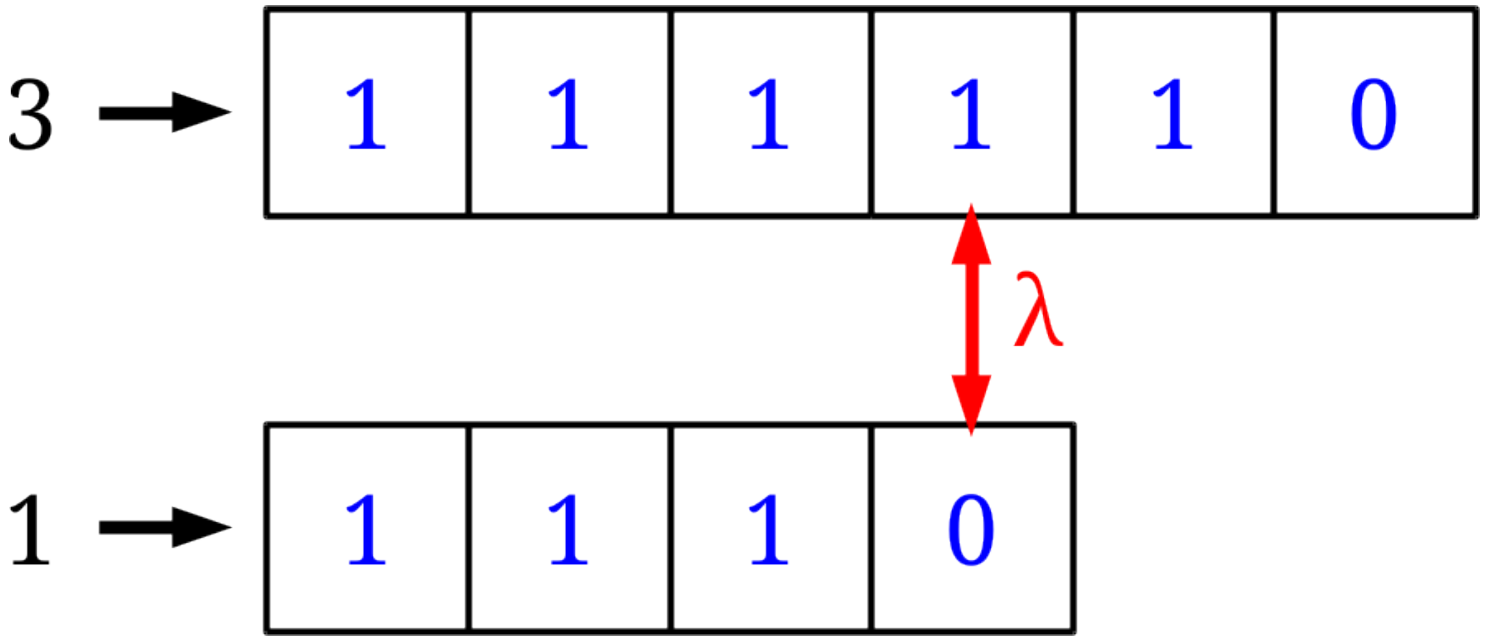

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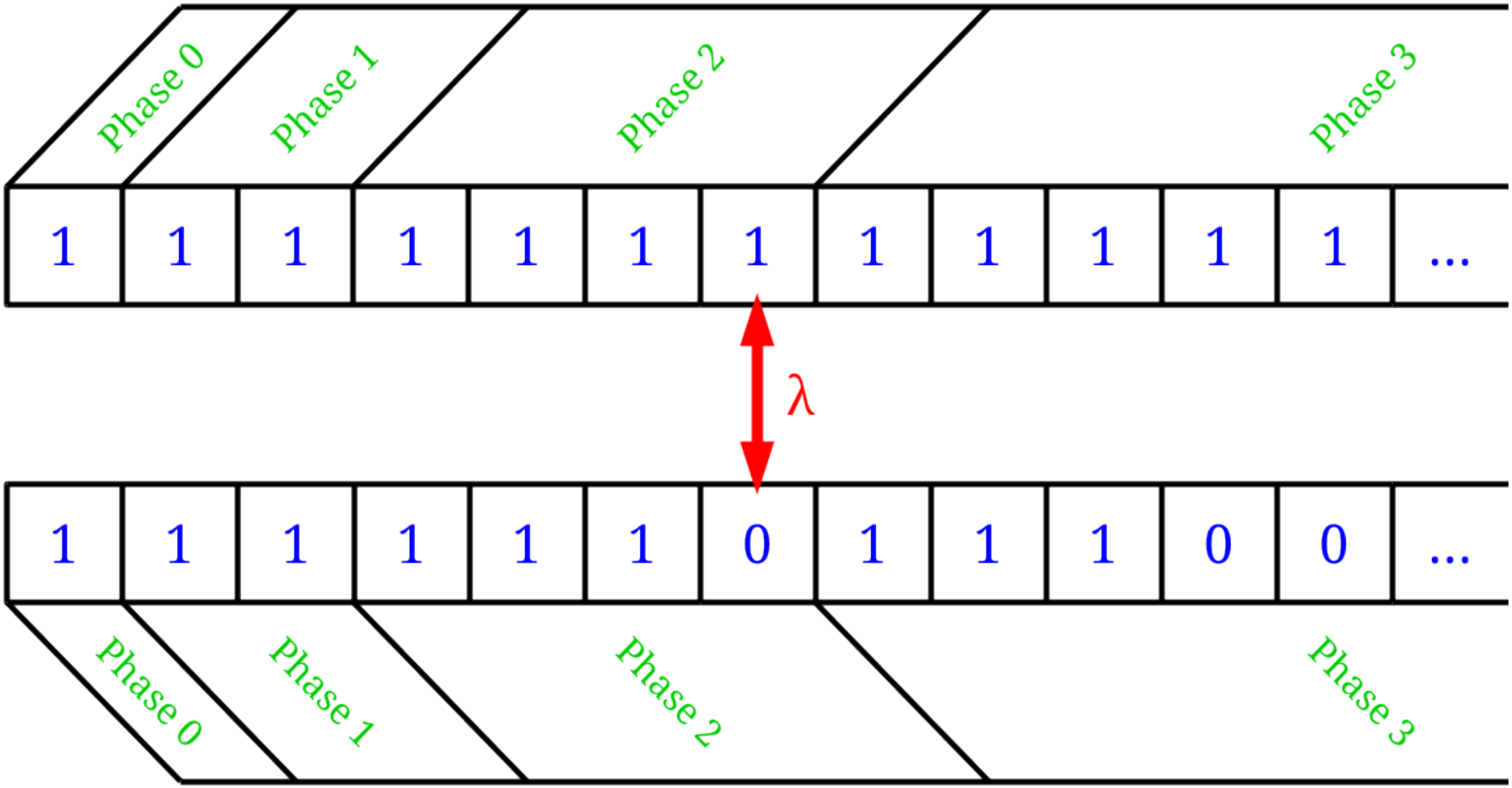

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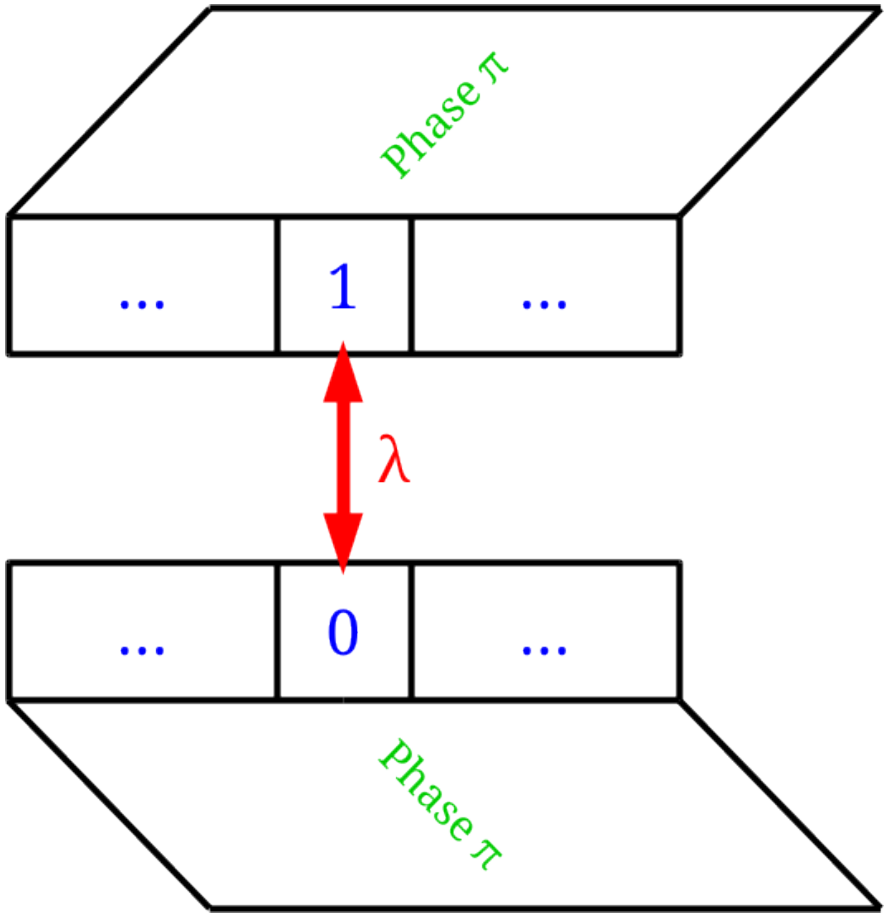
The good phase (update)

Phase π with $2^{\pi-1} < max\{D, \lambda\} \leq 2^{\pi}$

Focus and notations



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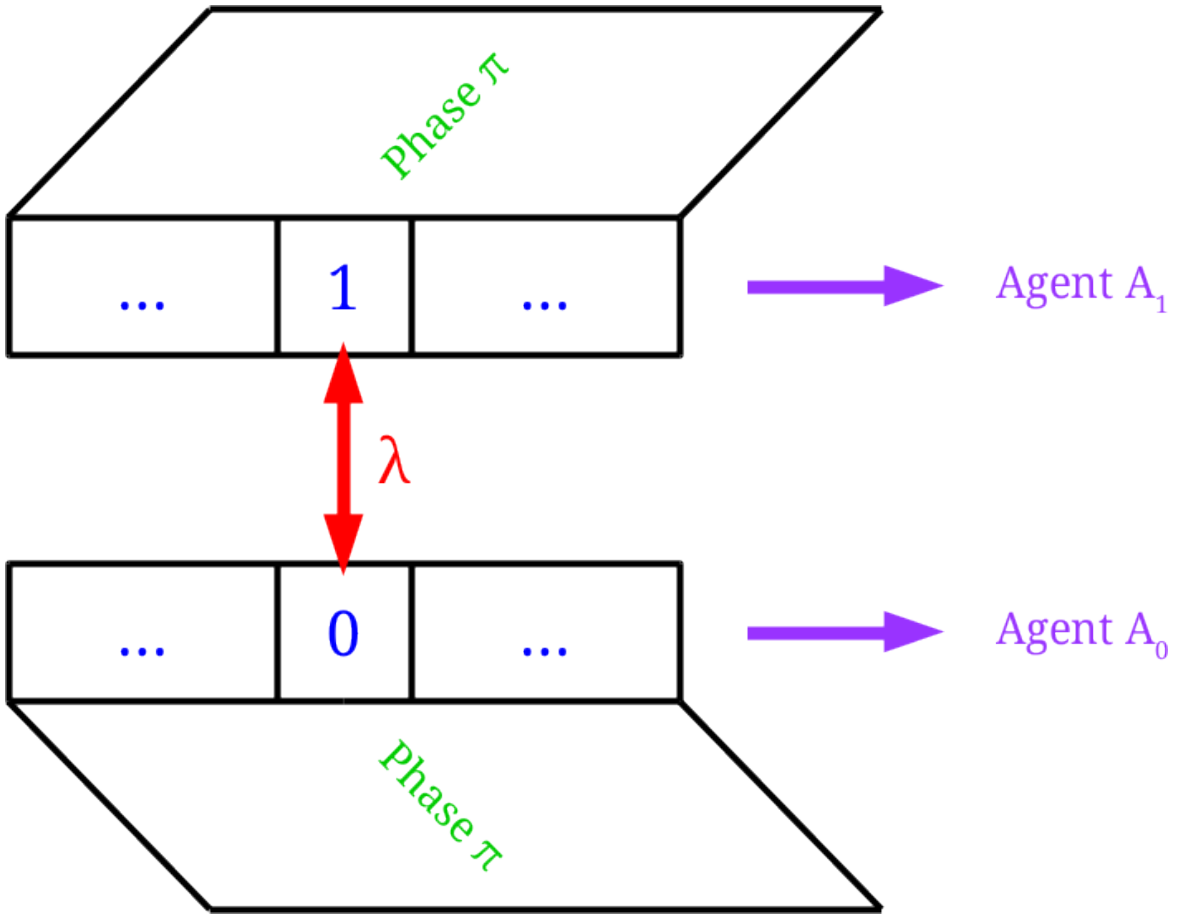

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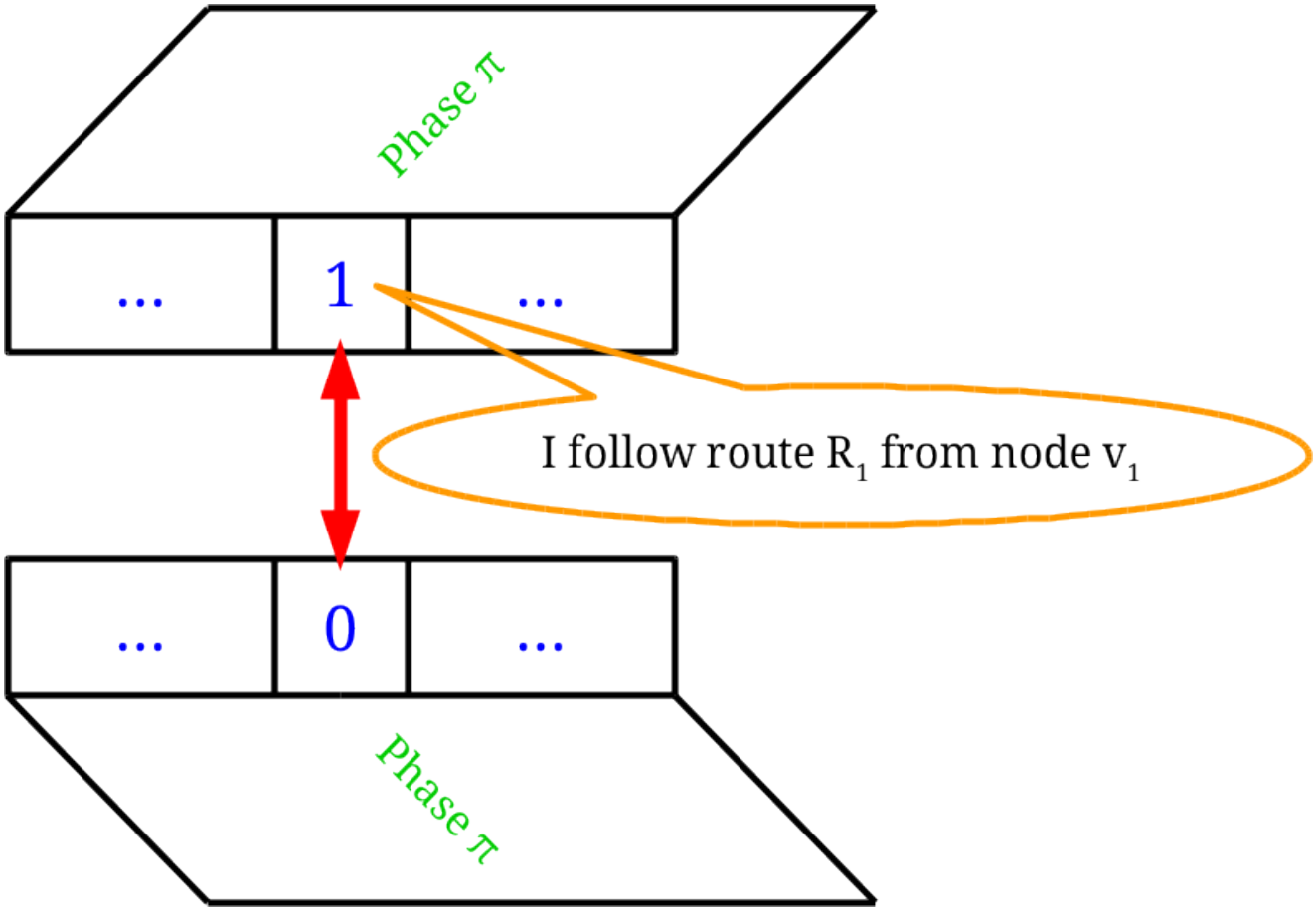

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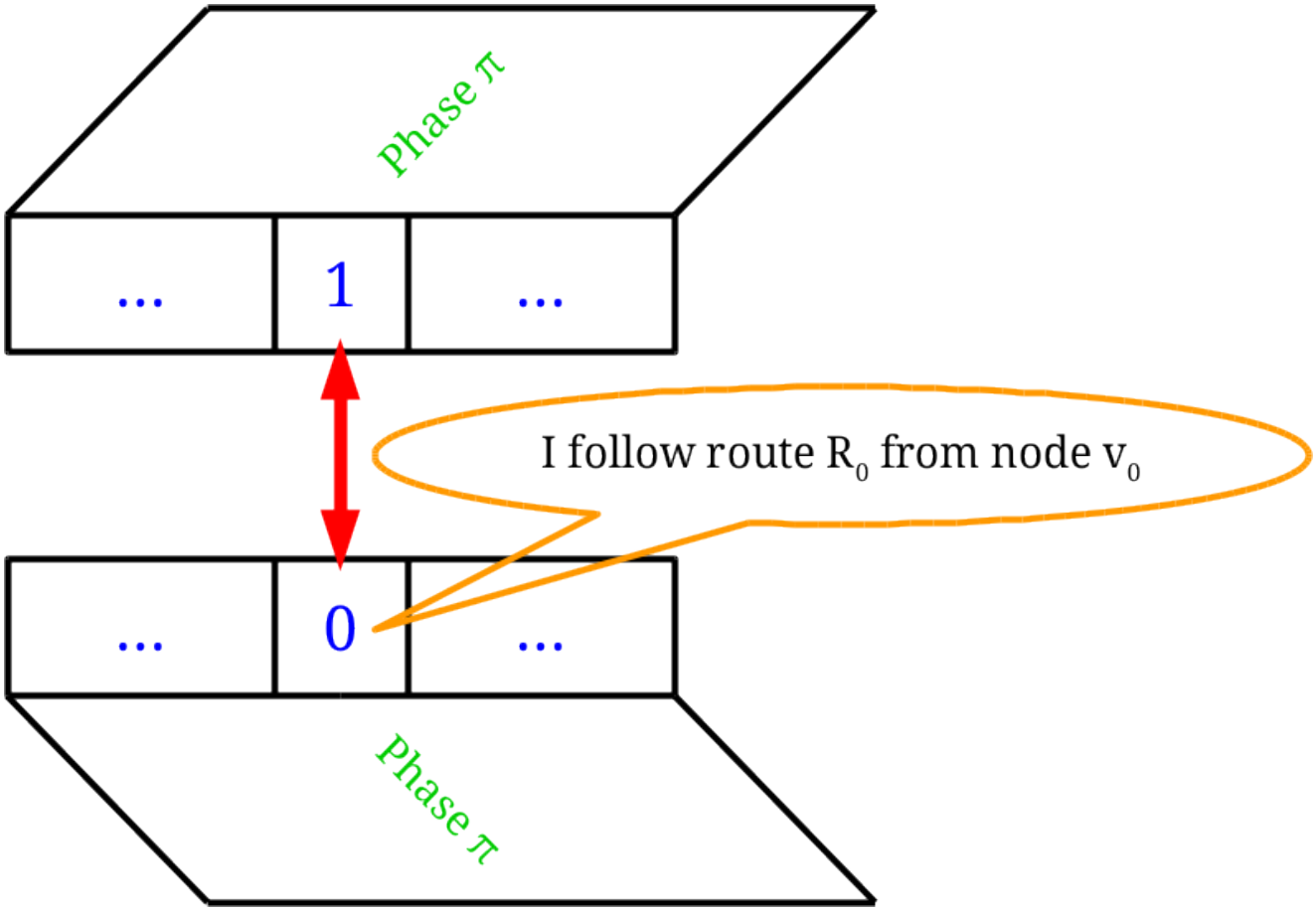

Removing the synchronous setting assumption

Actual contribution

So far, well known techniques.

From now on, we get into our actual contribution.

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The ahead agent *pushes* the other one:

Either they meet or the later agent makes some progress.

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Synchronisation mechanisms

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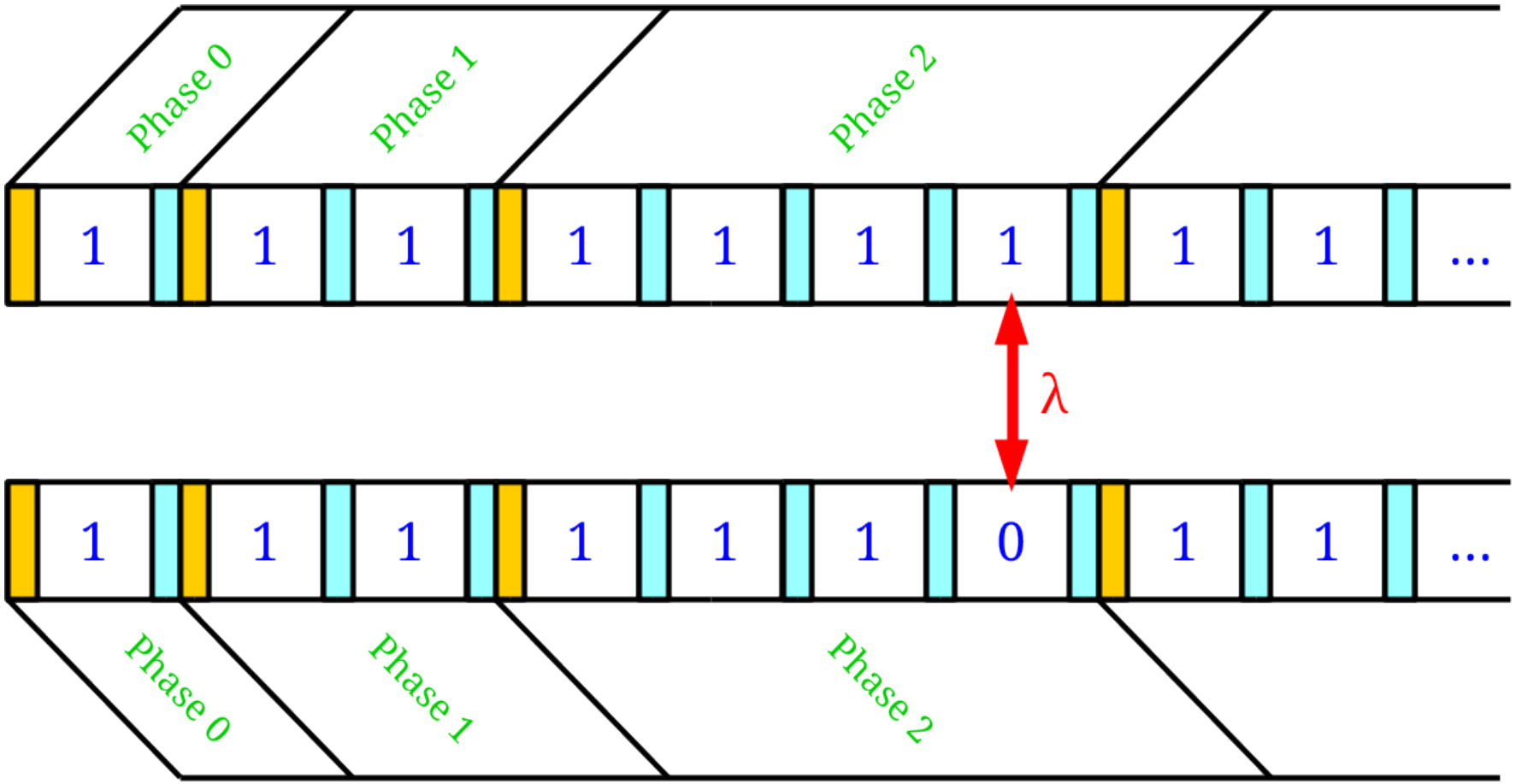
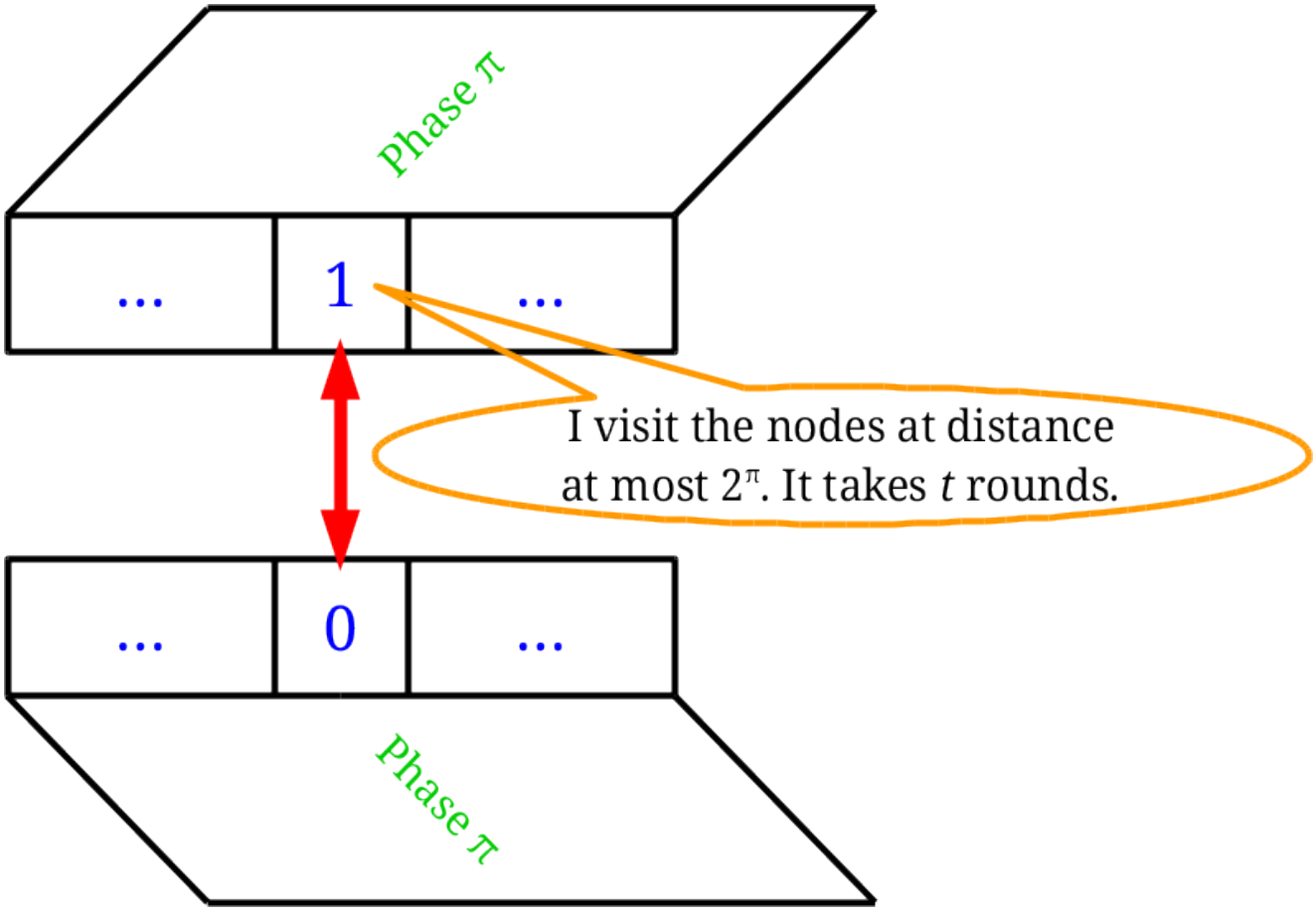
Two kinds:

- First one: between bit readings, pushes the latest bit reading
- Second one: between phases, pushes the previous phases

Removing the synchronous setting assumption



Naïve attempt (1)



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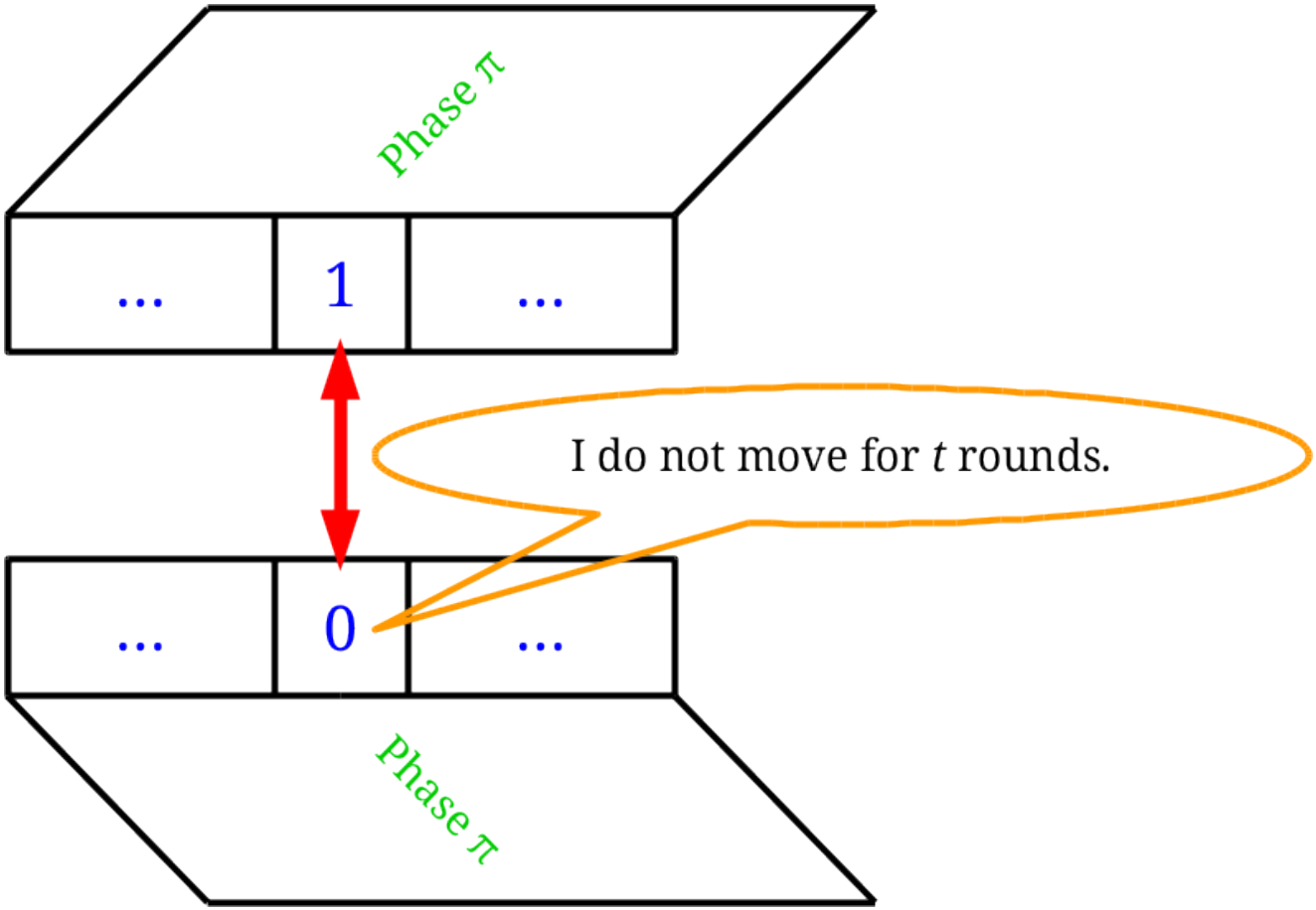

Naïve attempt (1)

Waiting does not work!

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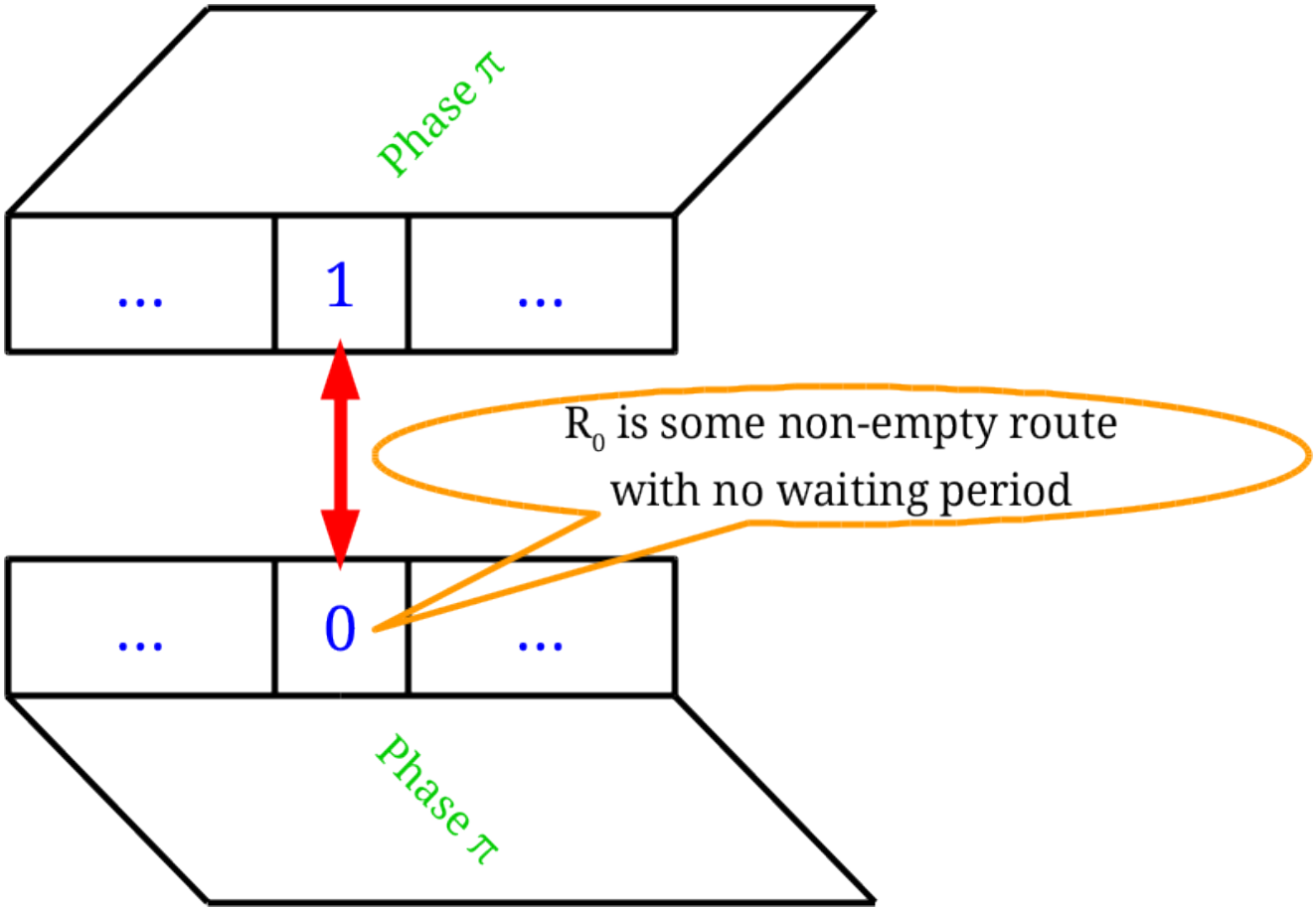

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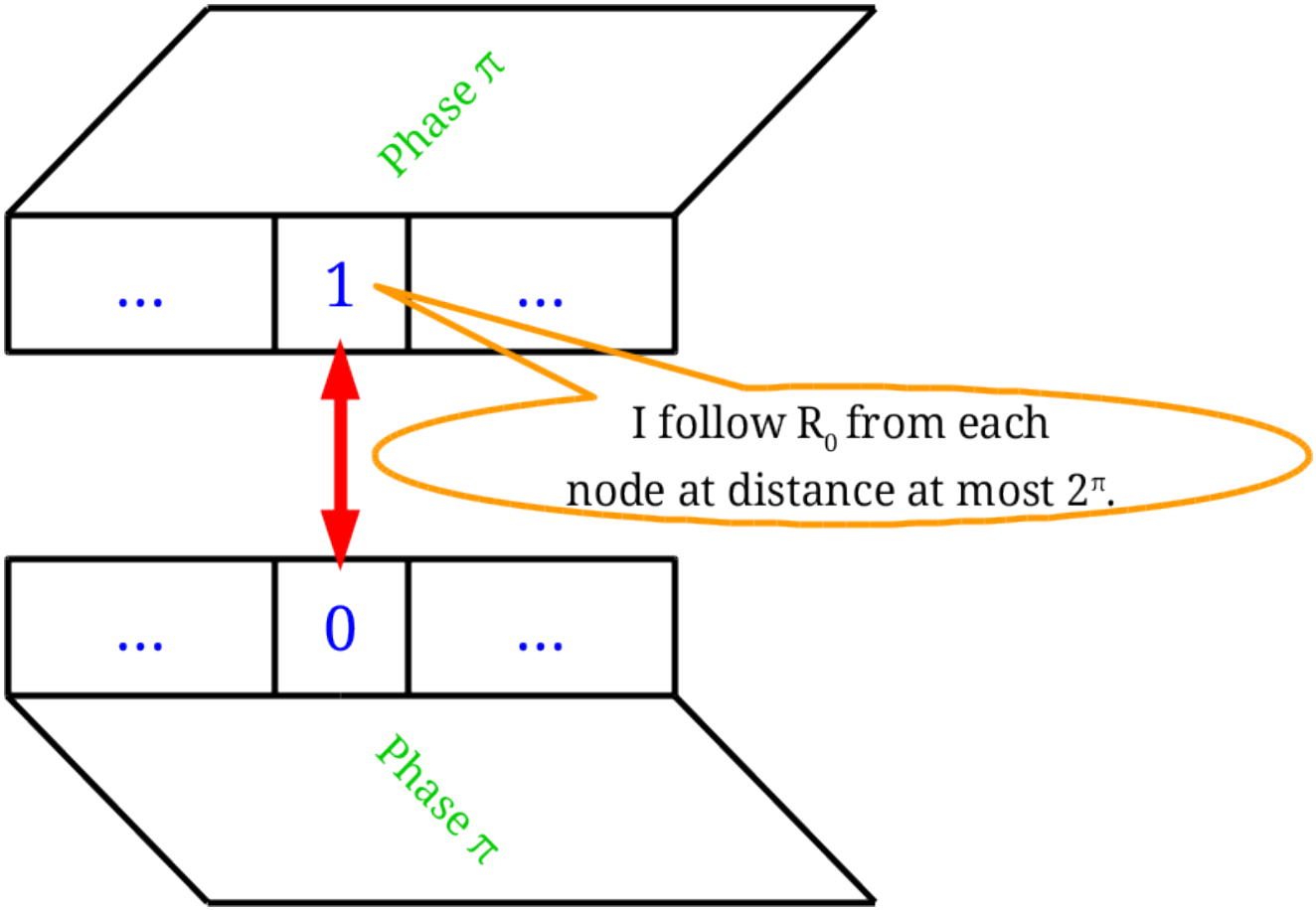

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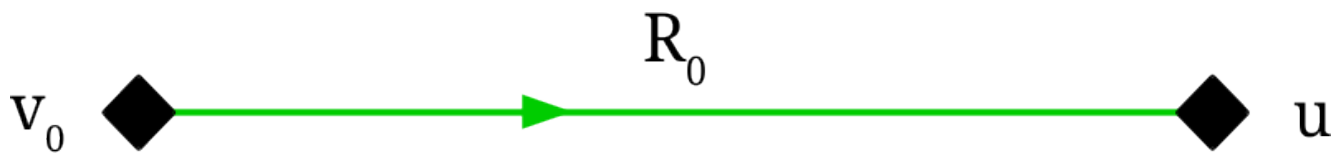

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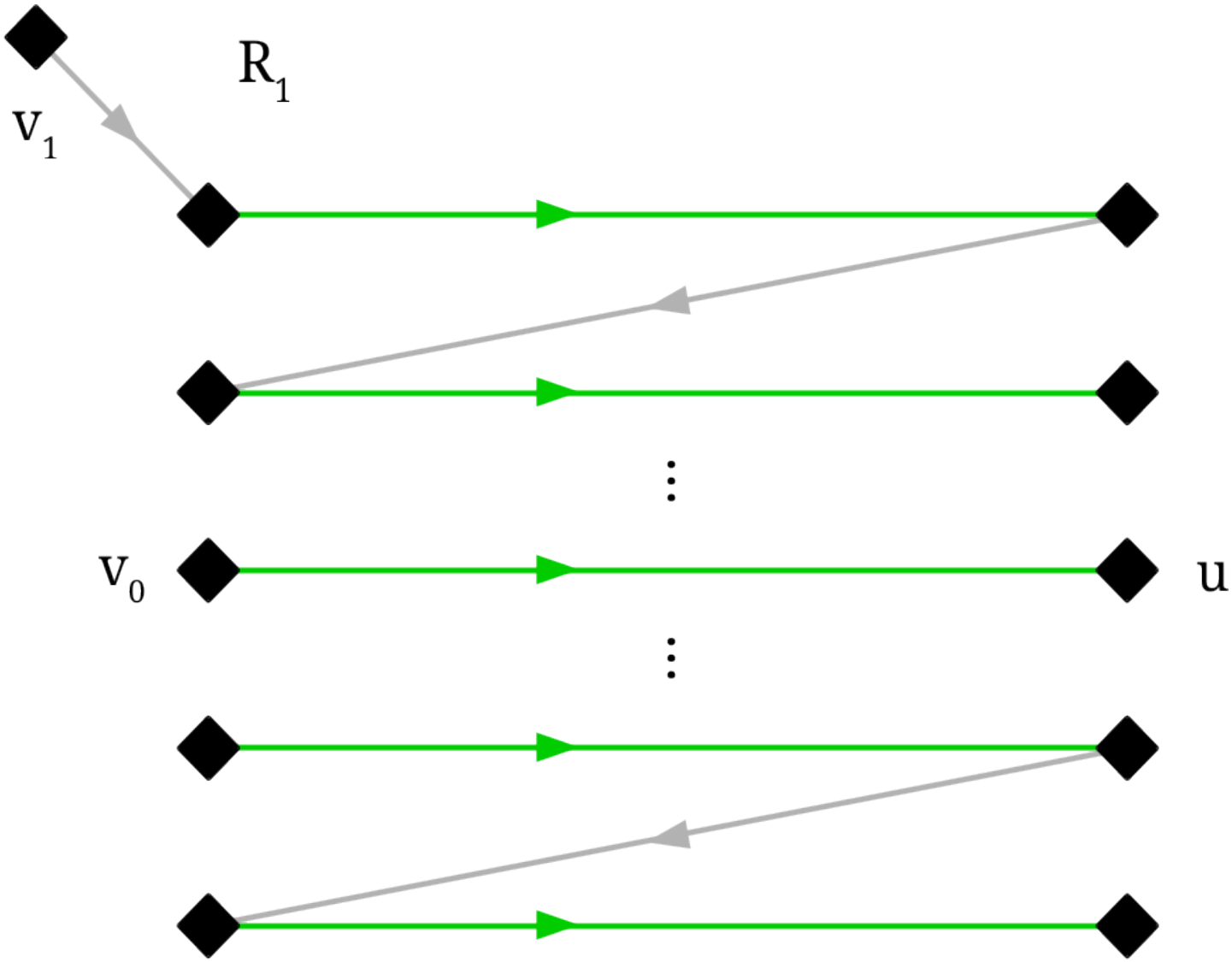
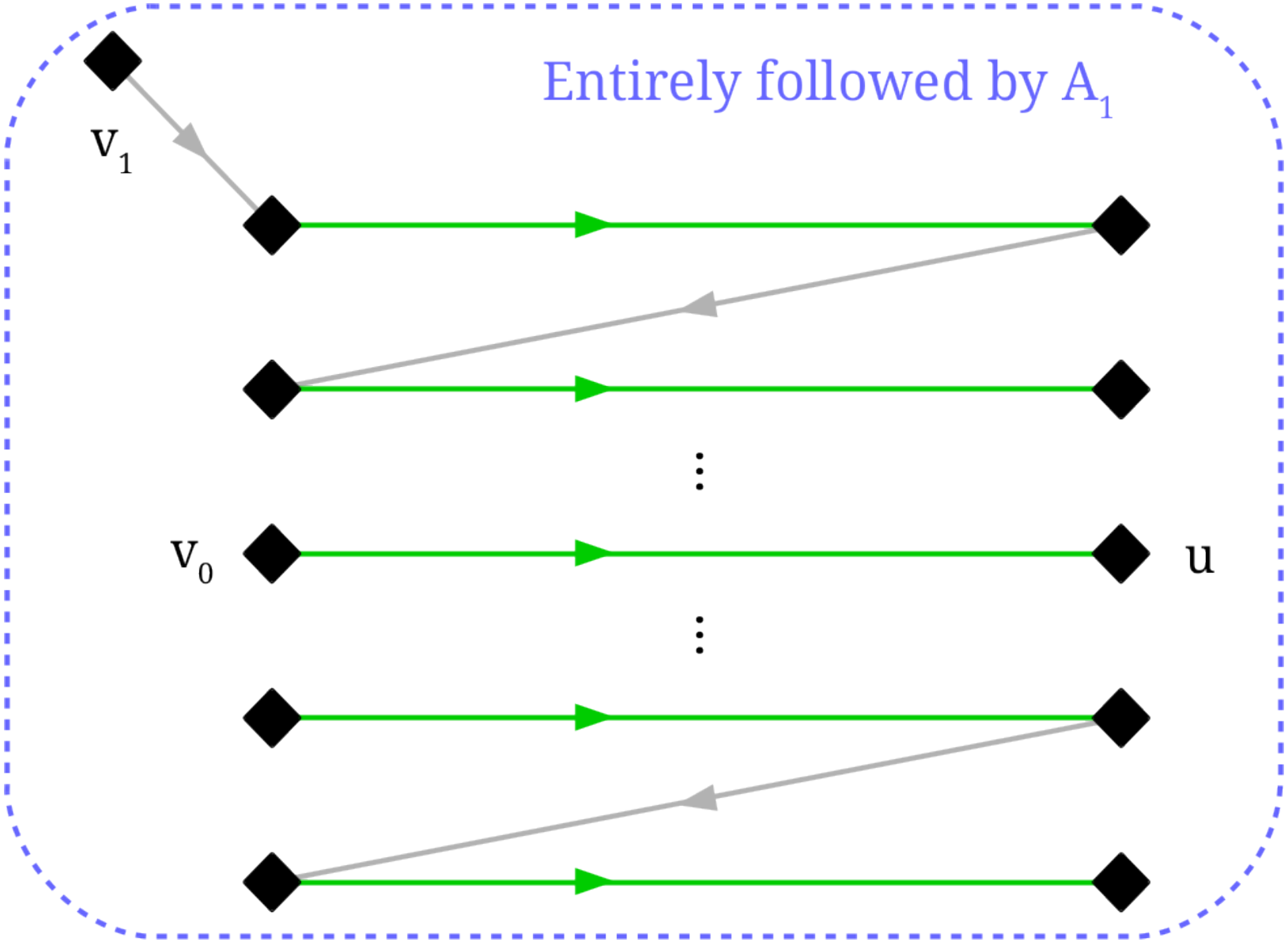


Small break (1)



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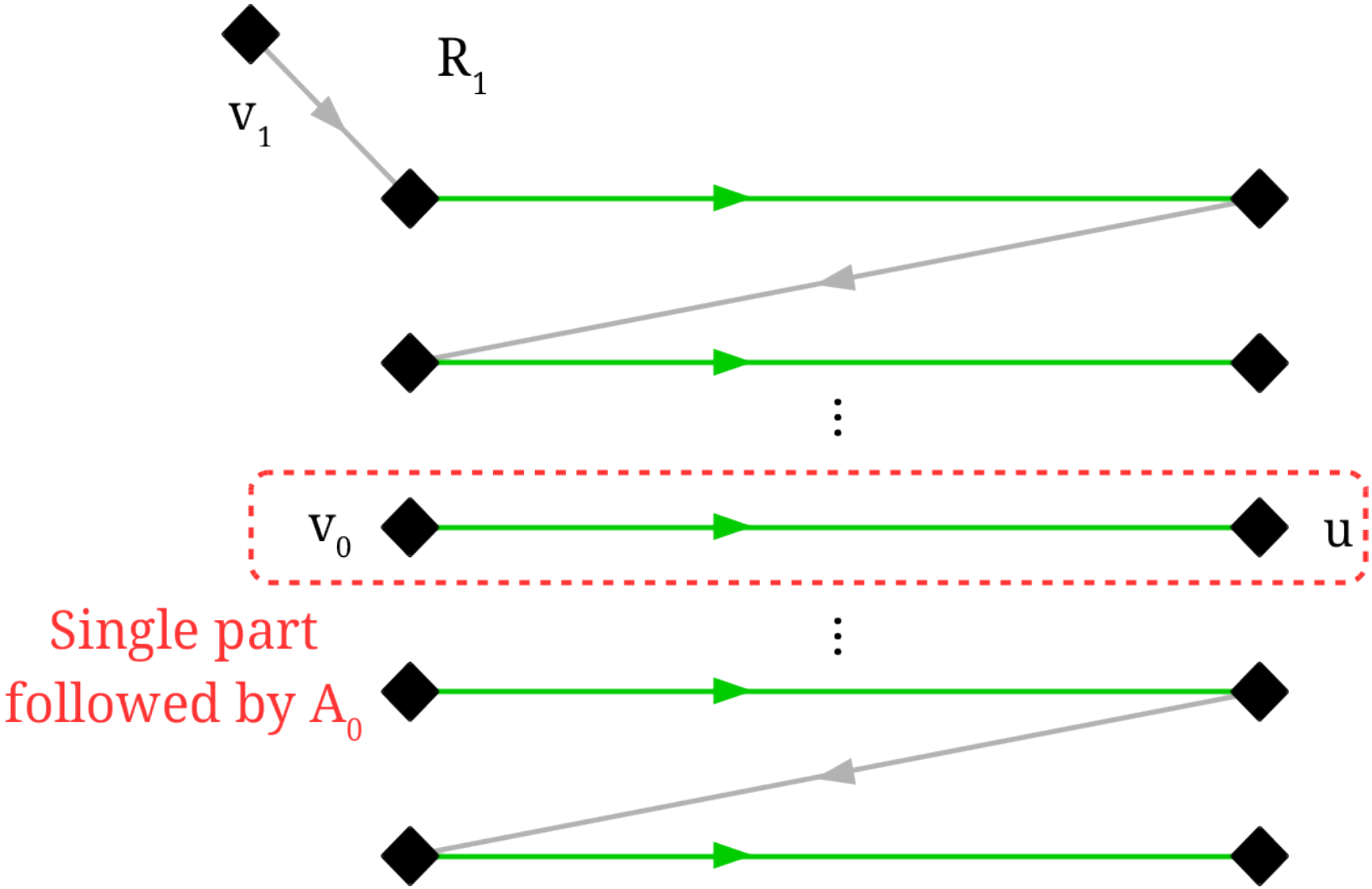

Naïve attempt (2)

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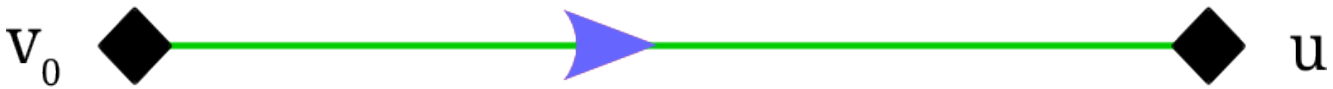

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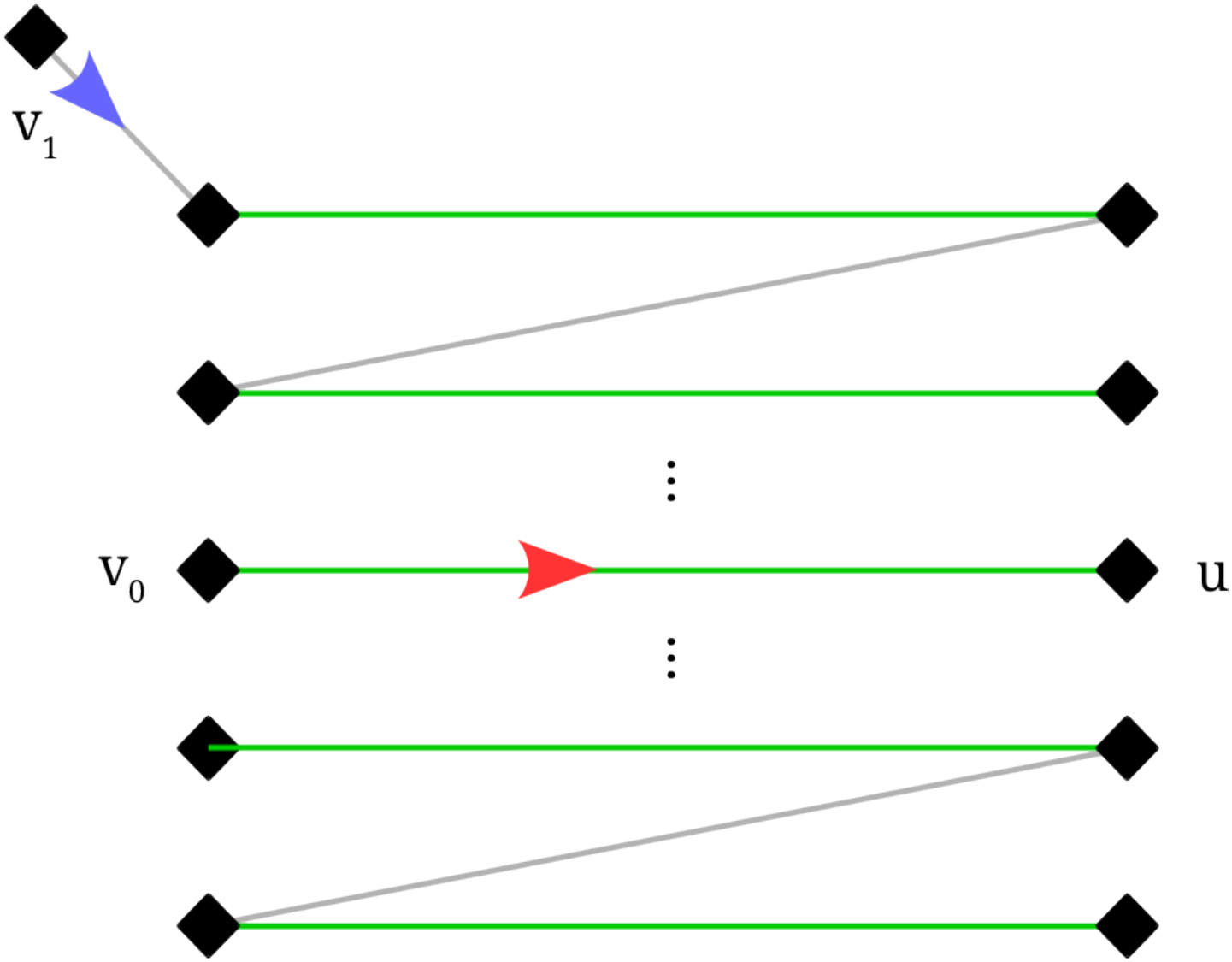

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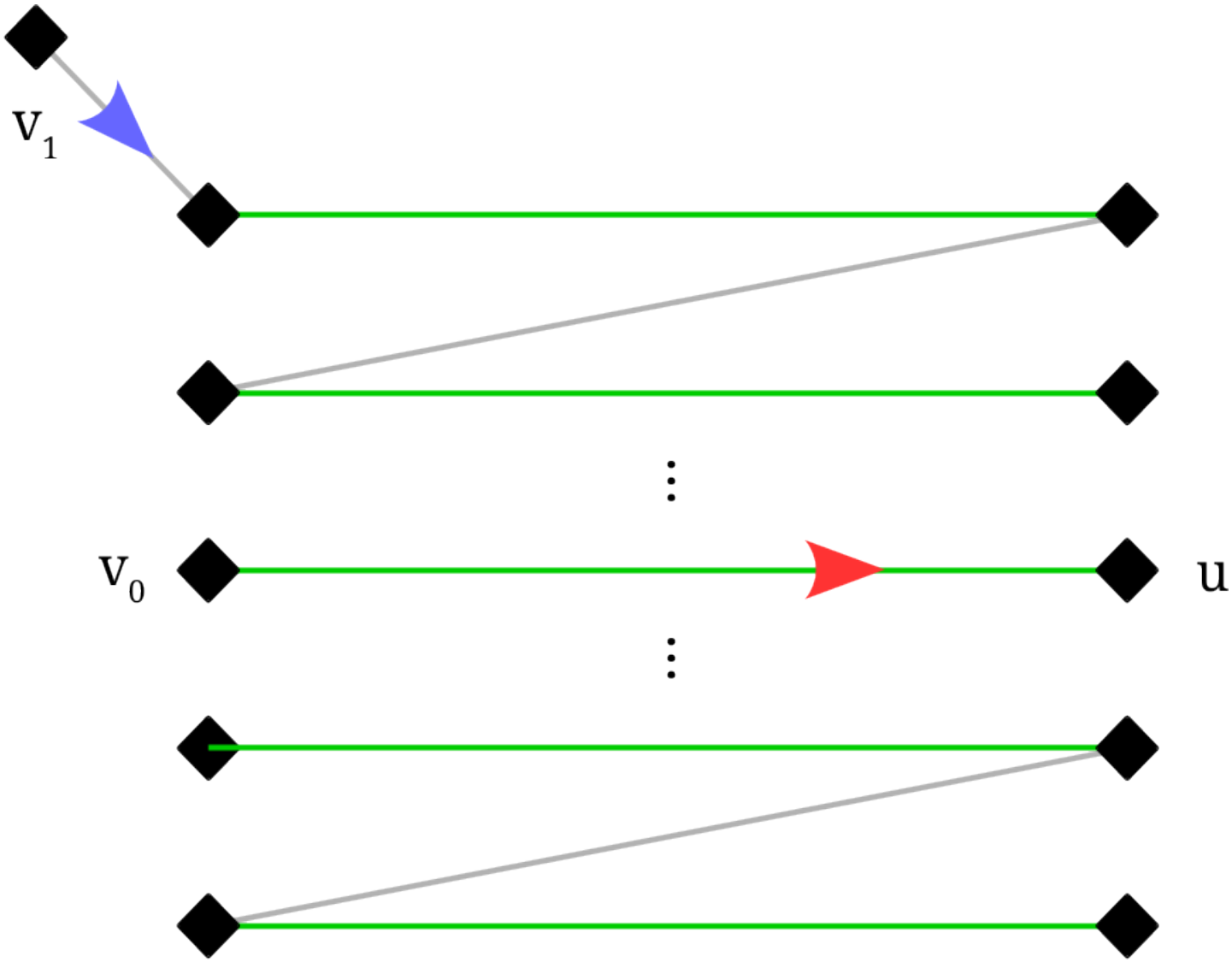

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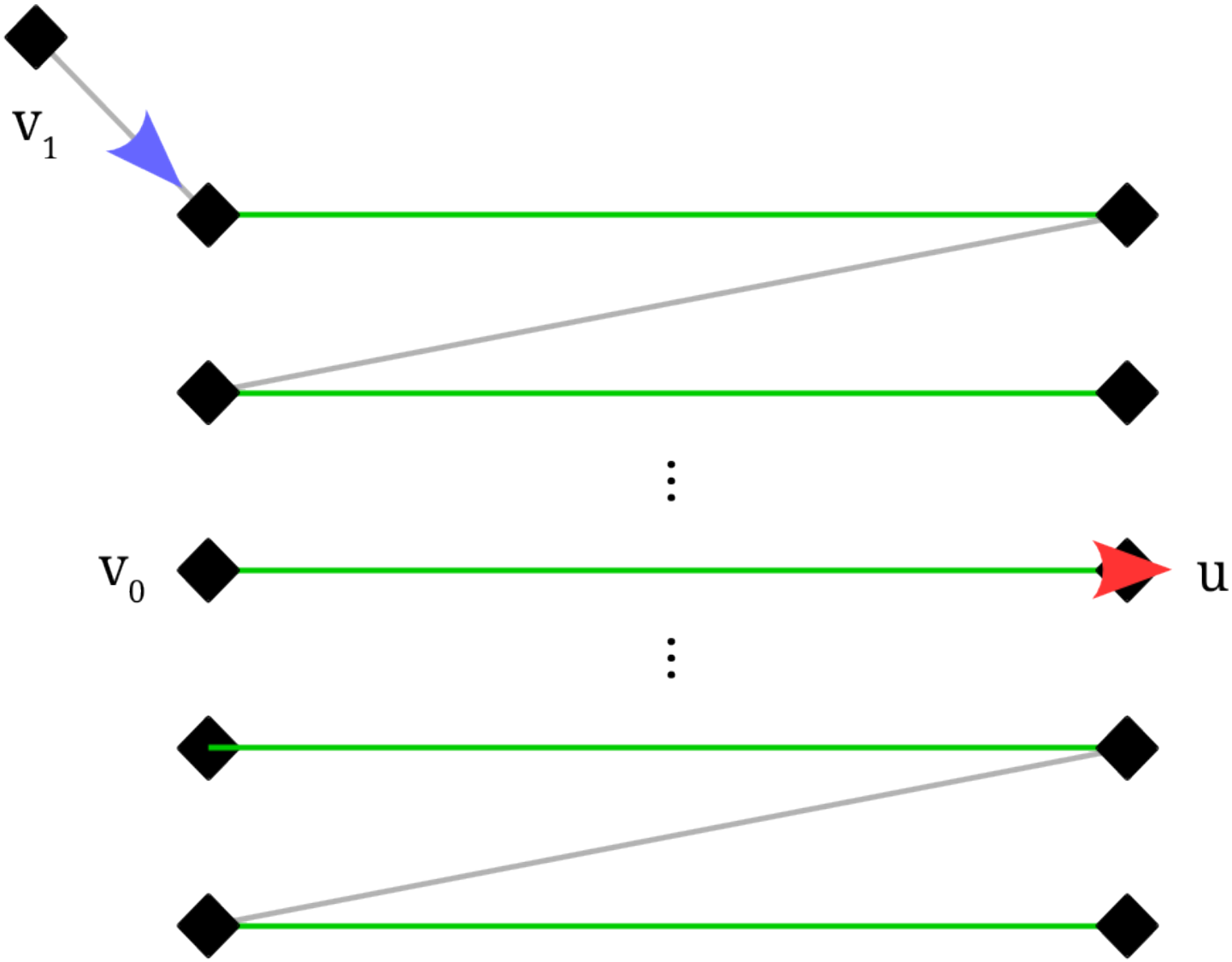
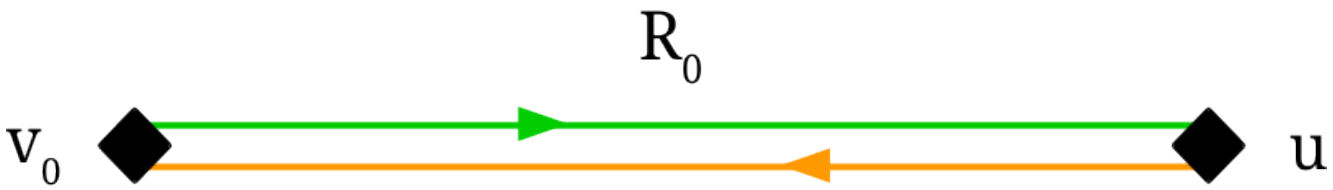


First improvement based on tunnels

Let us use reverse routes and tunnels.

First improvement based on tunnels



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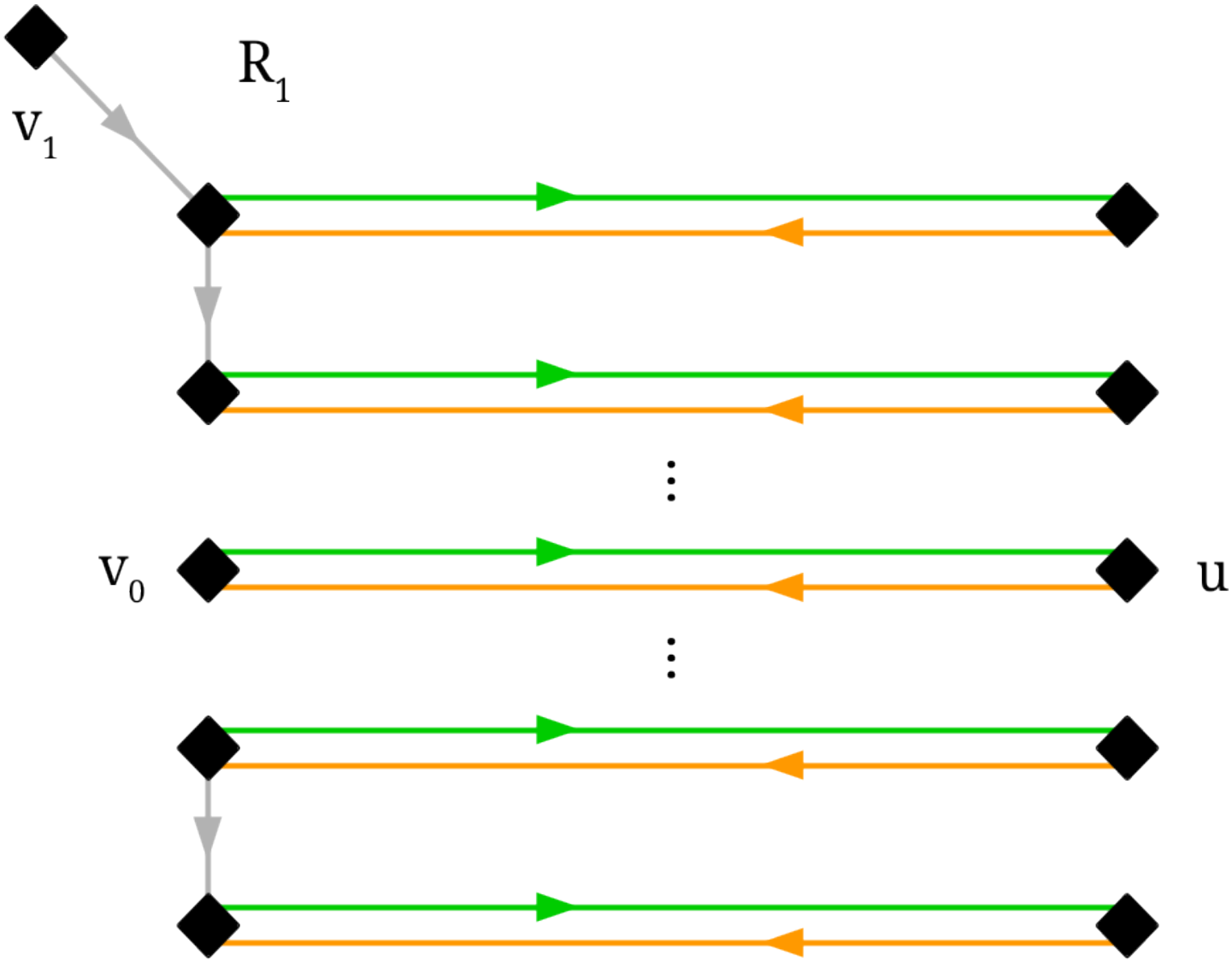

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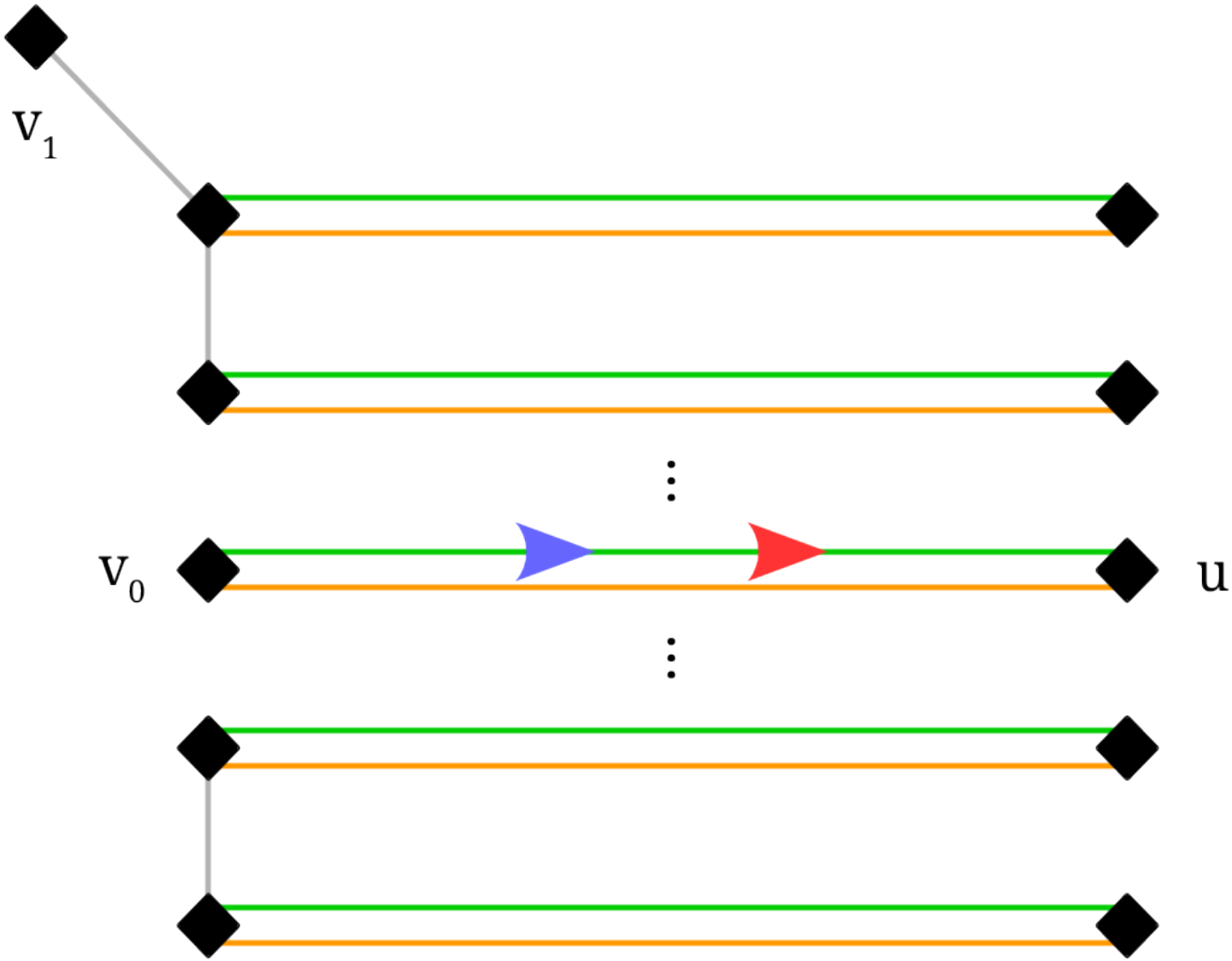

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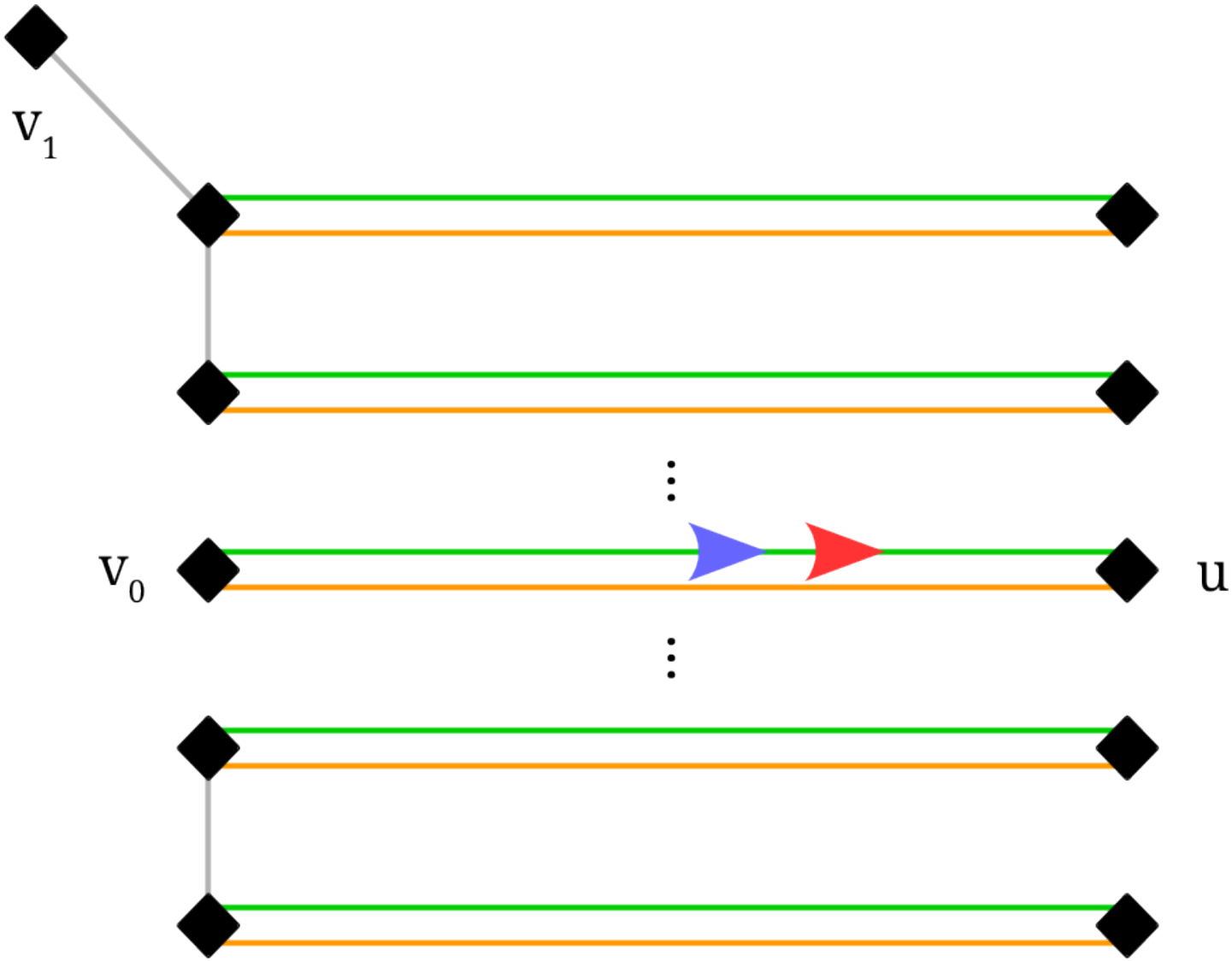

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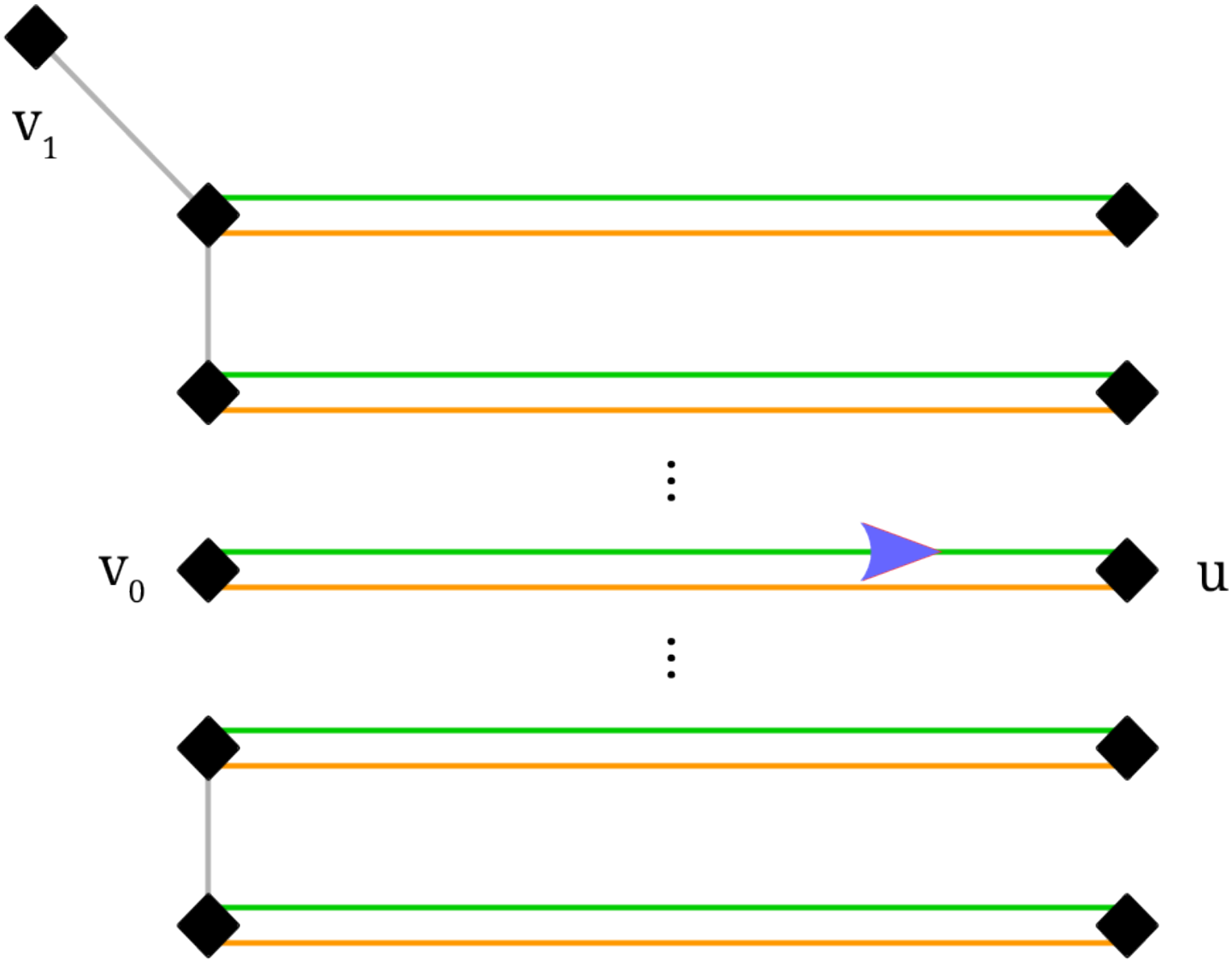

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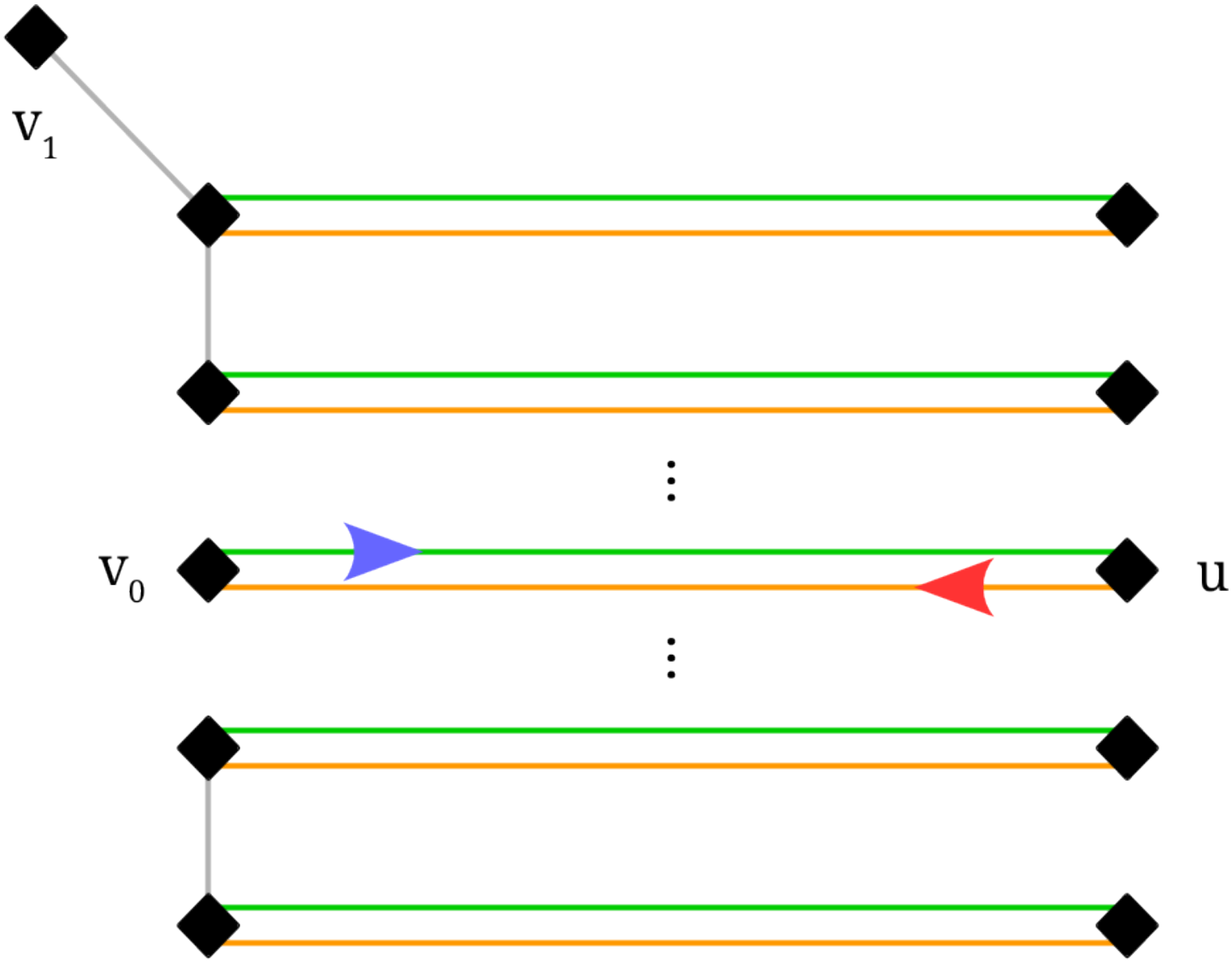

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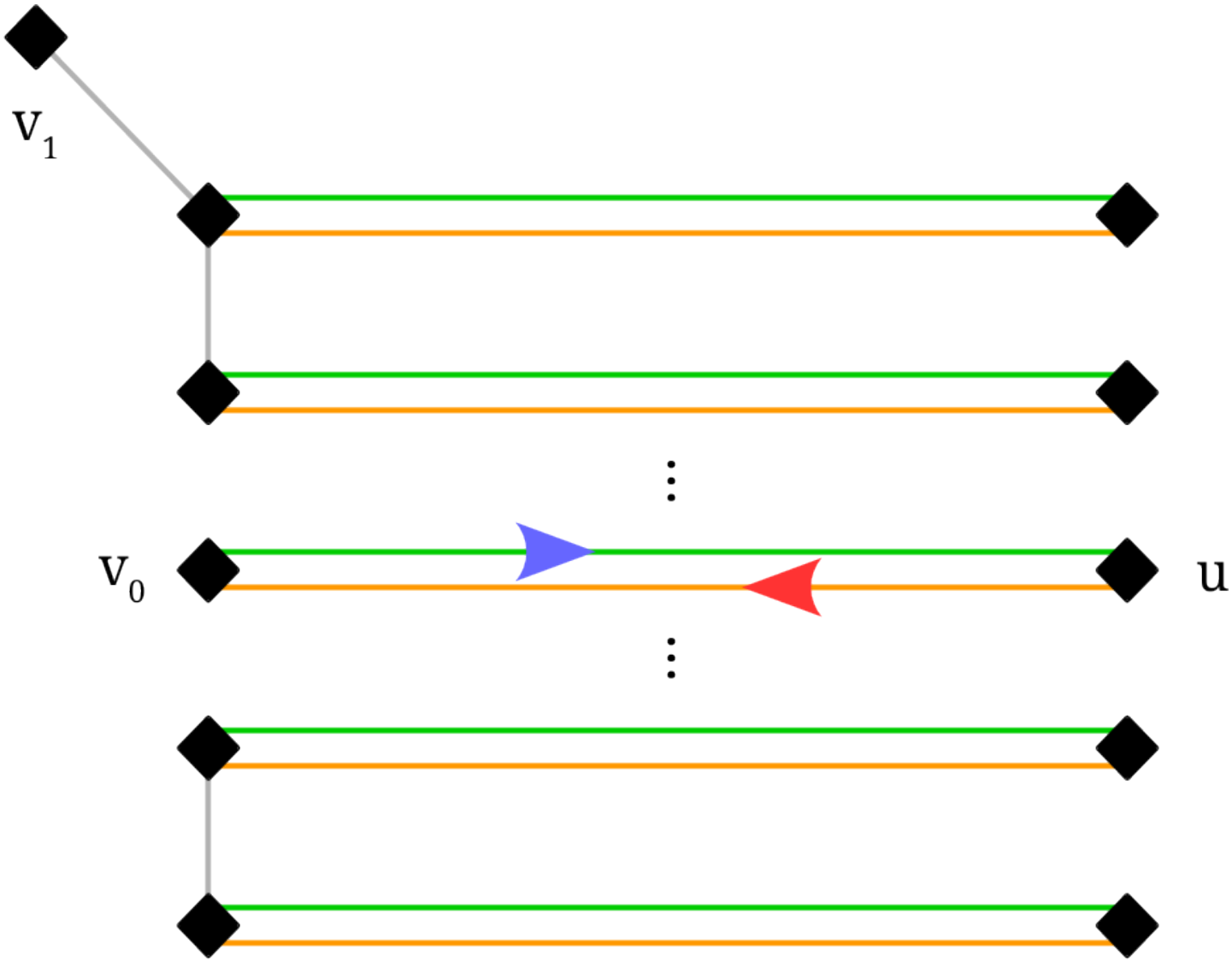

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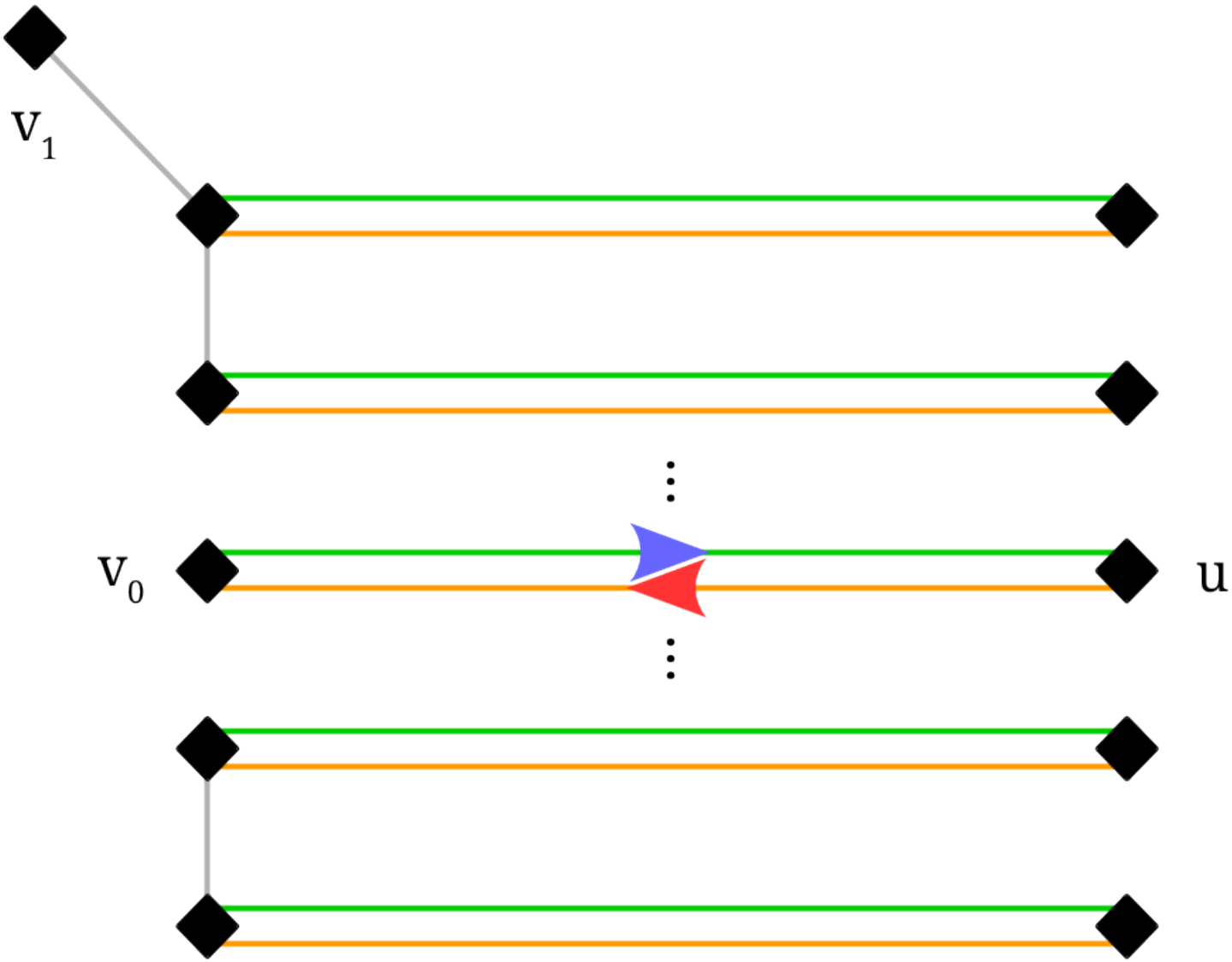

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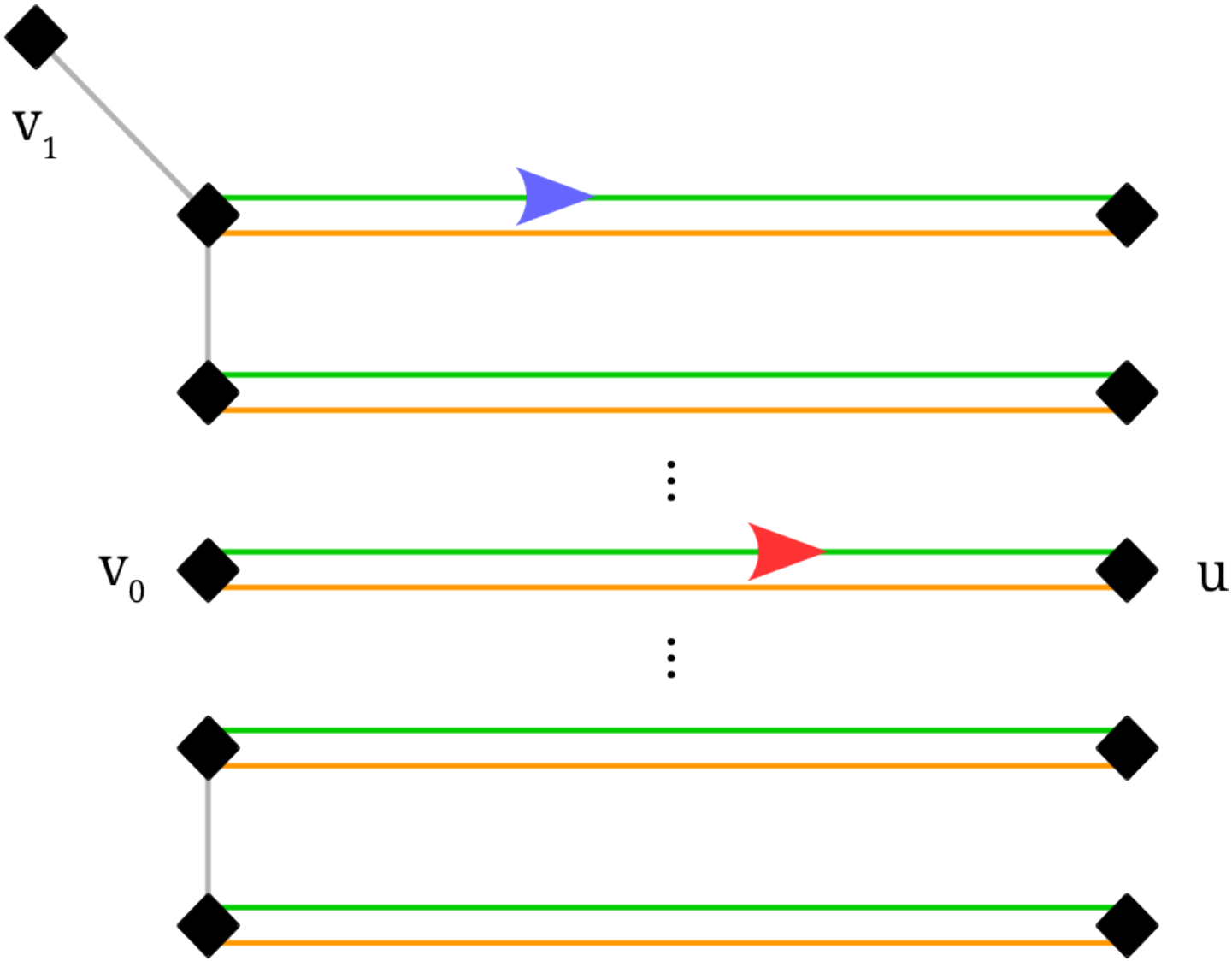

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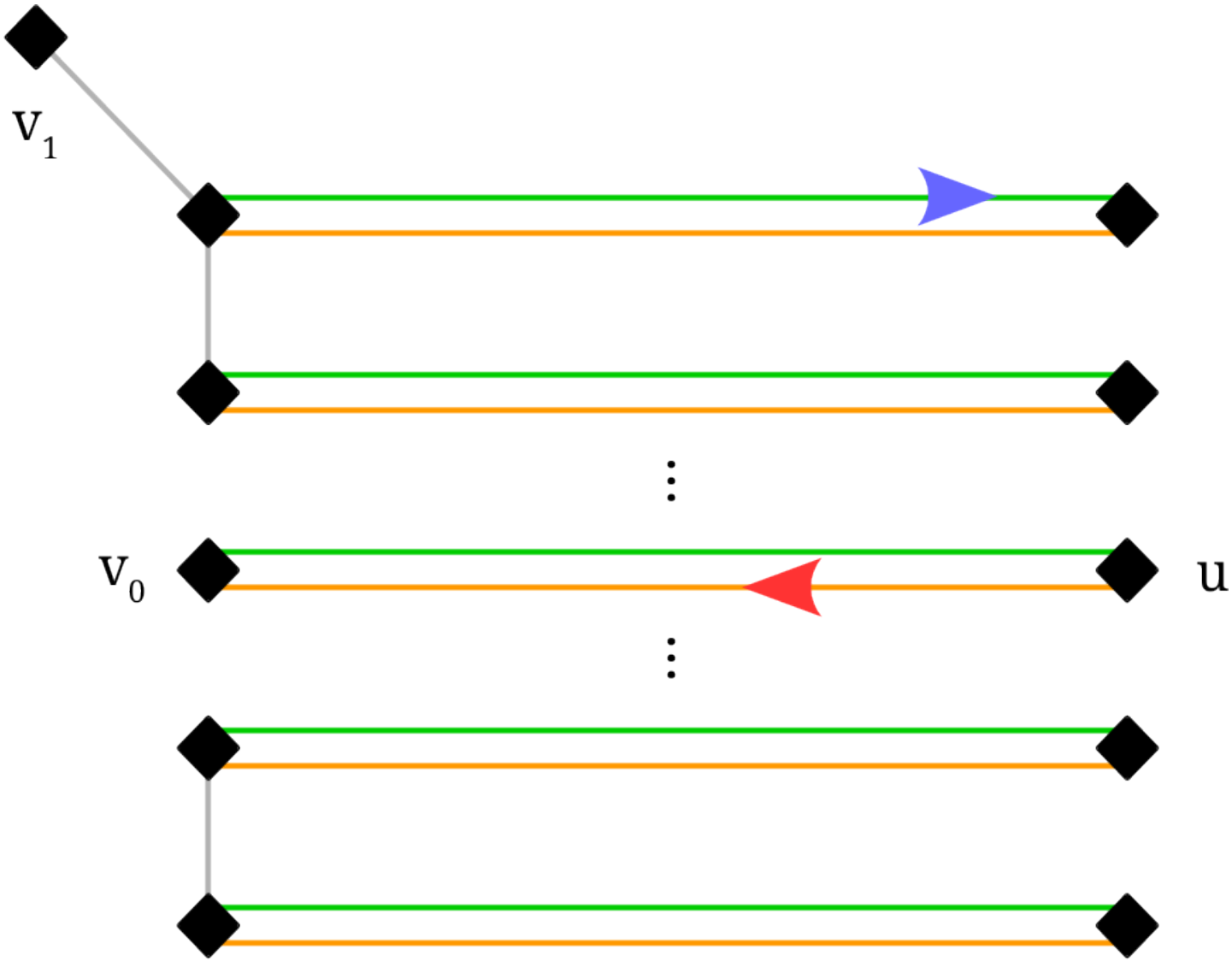

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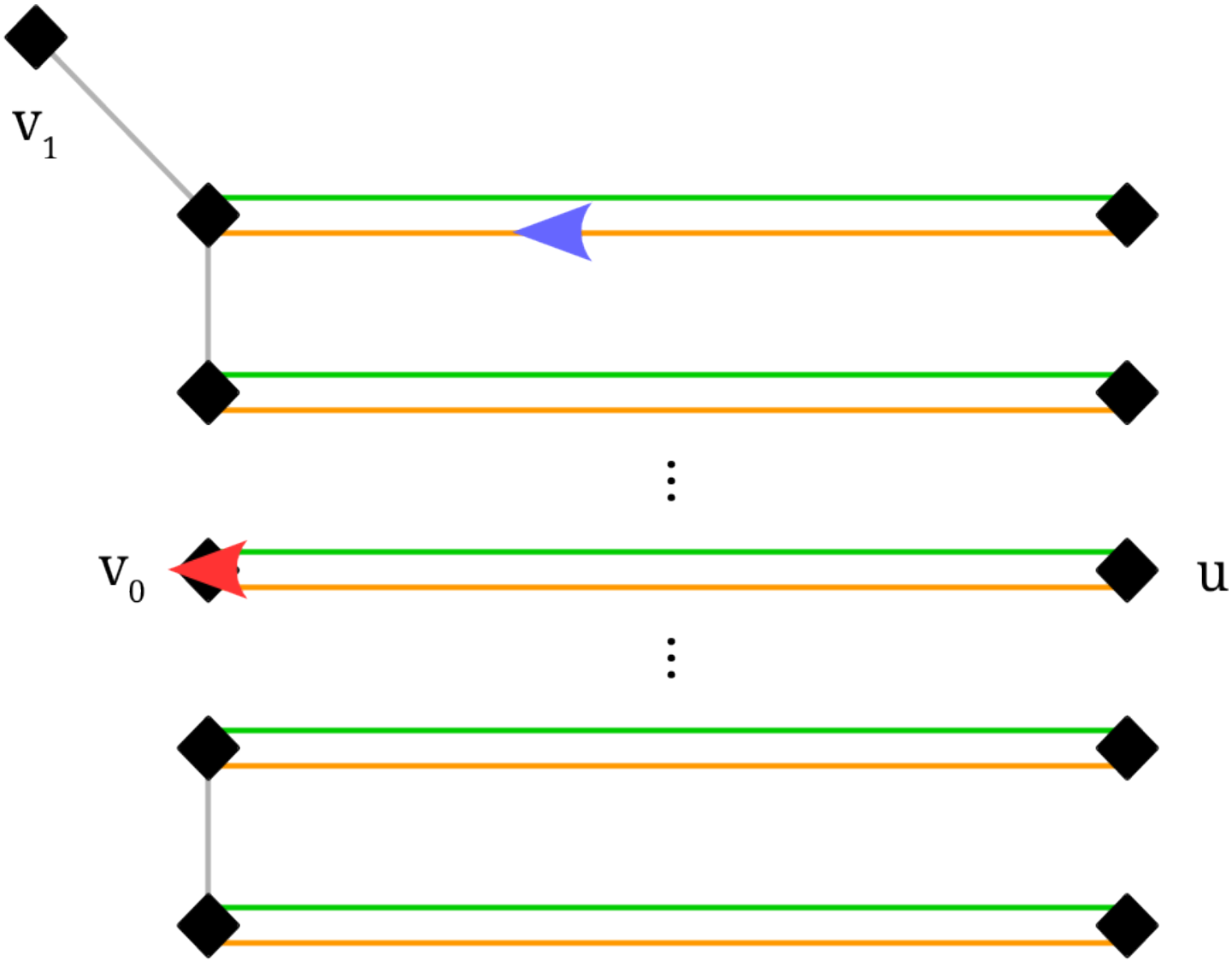

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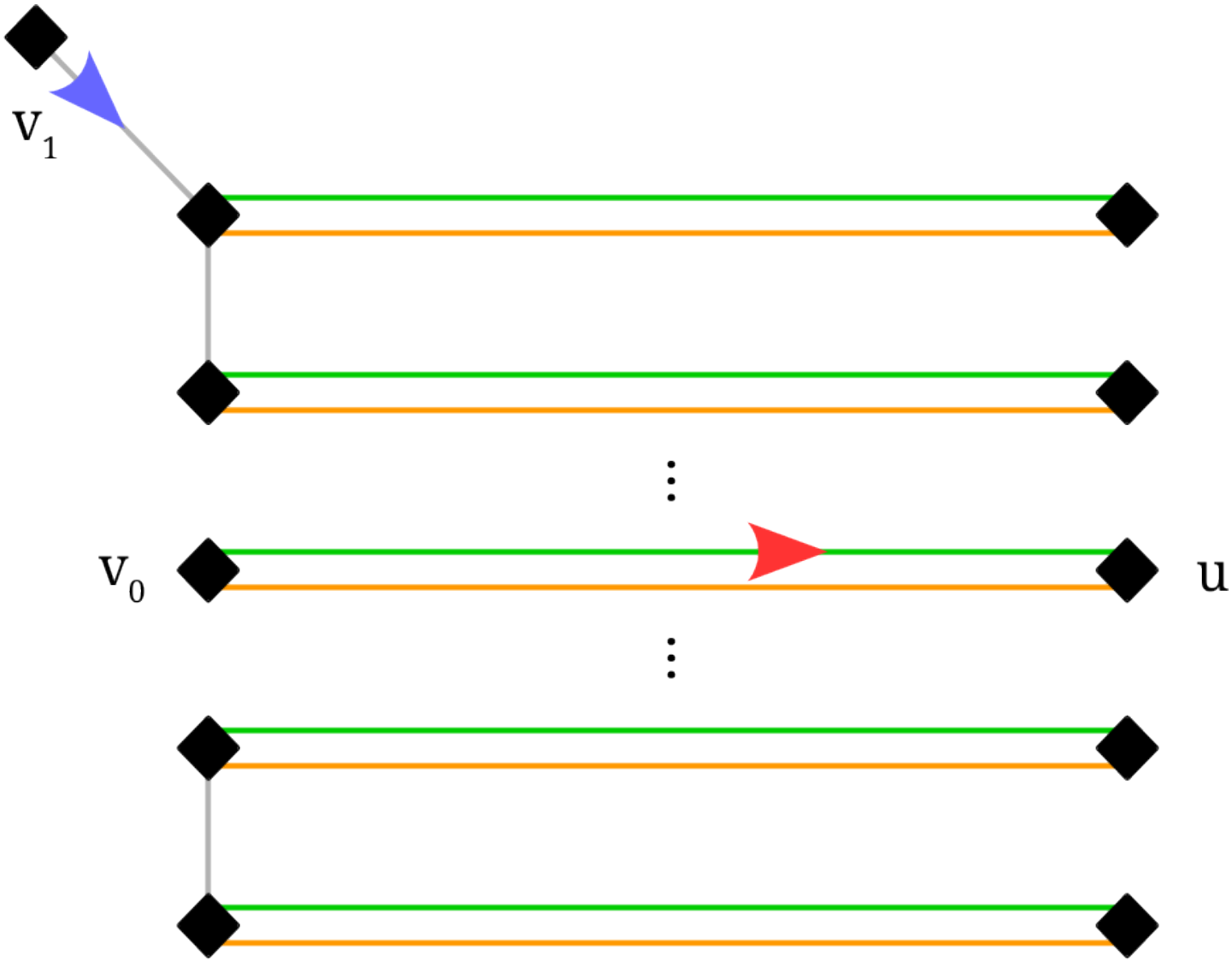

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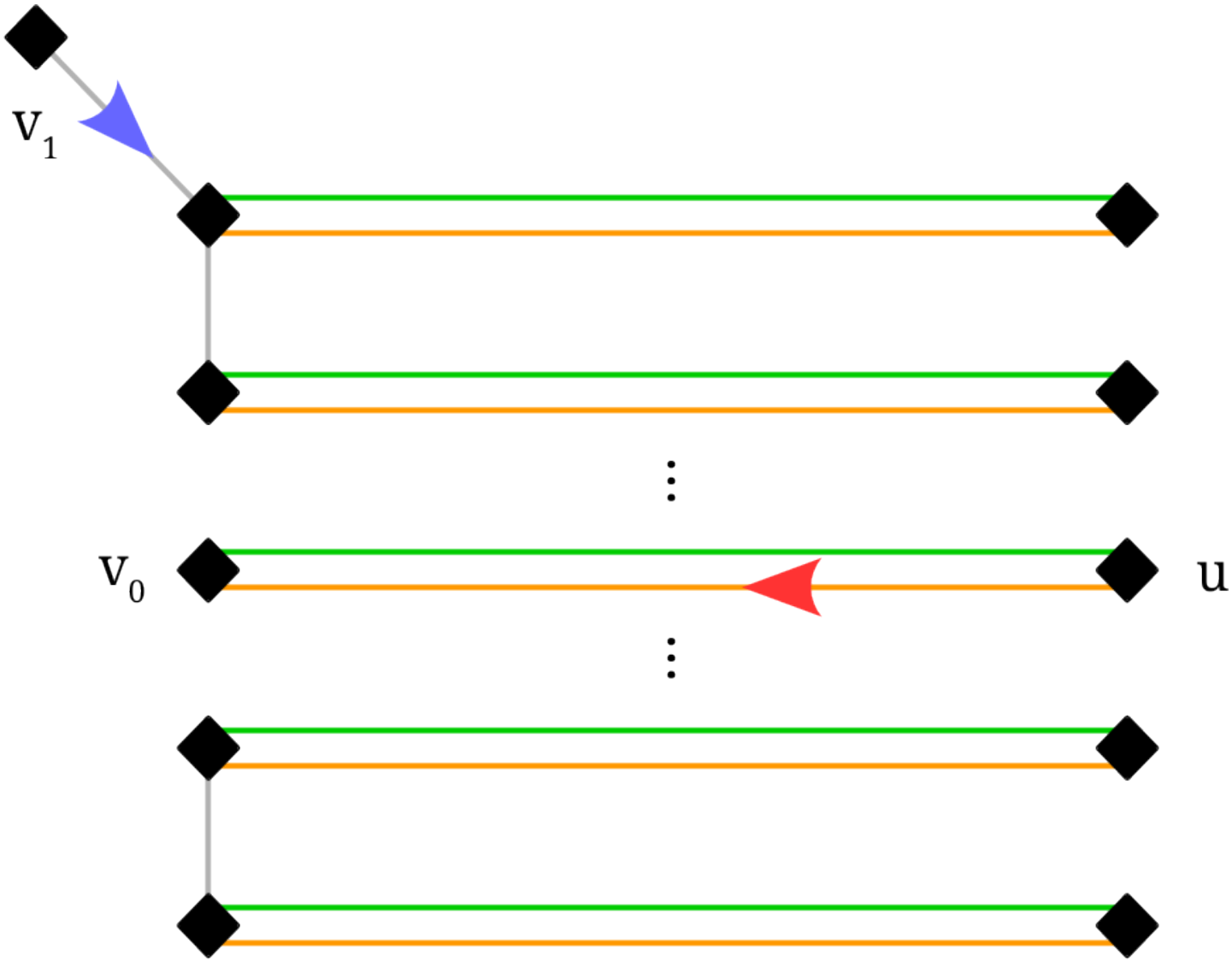

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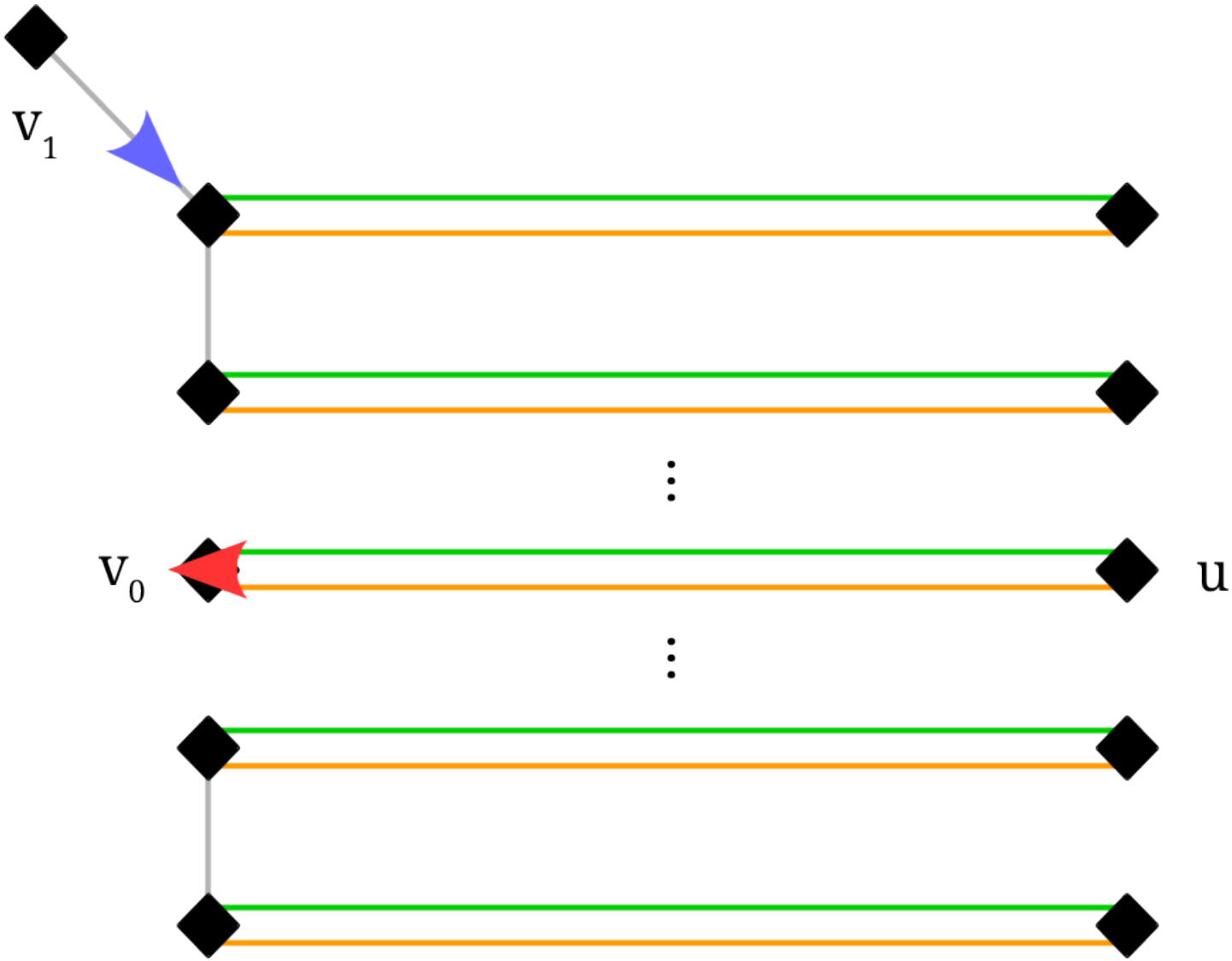
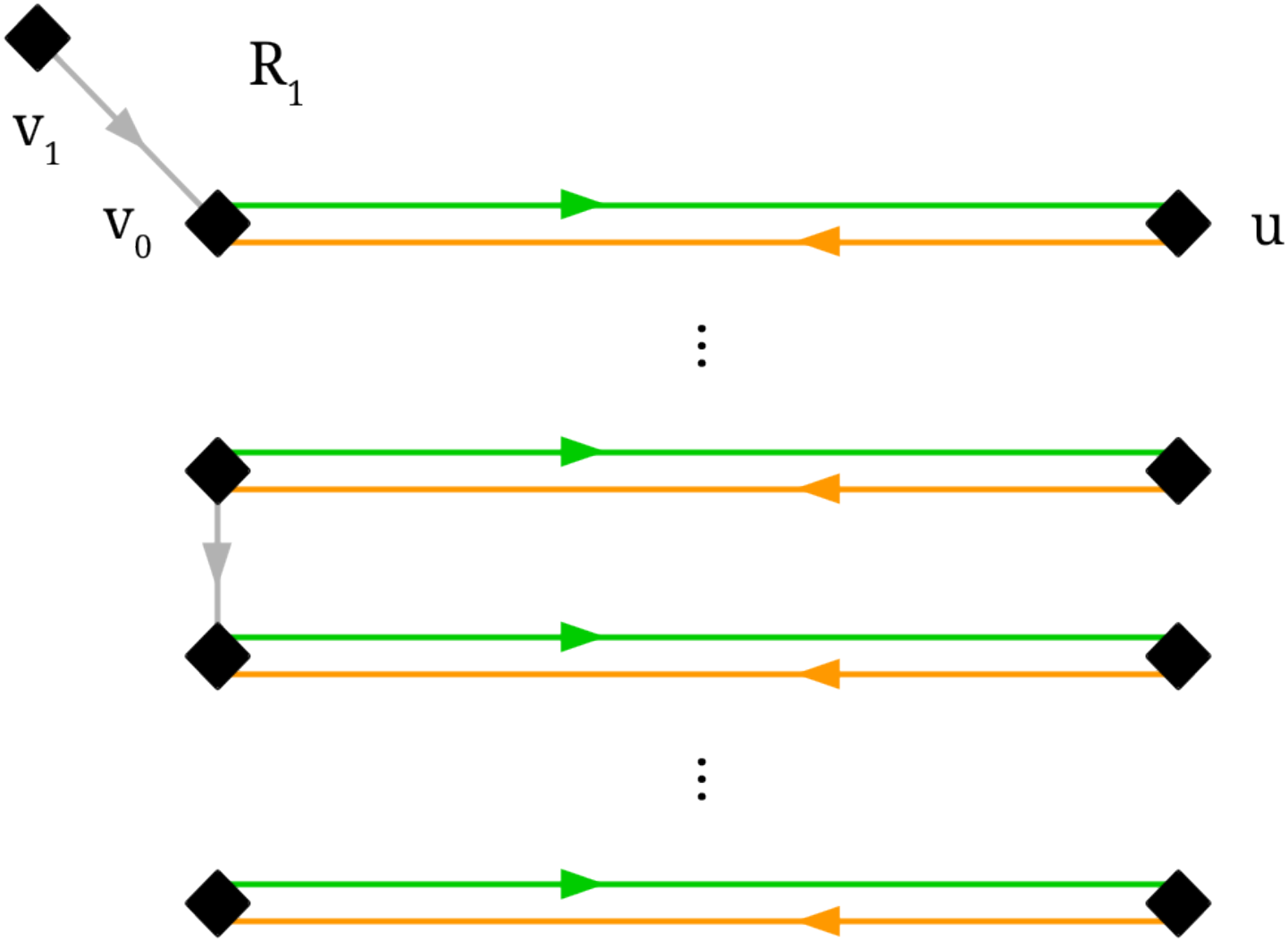


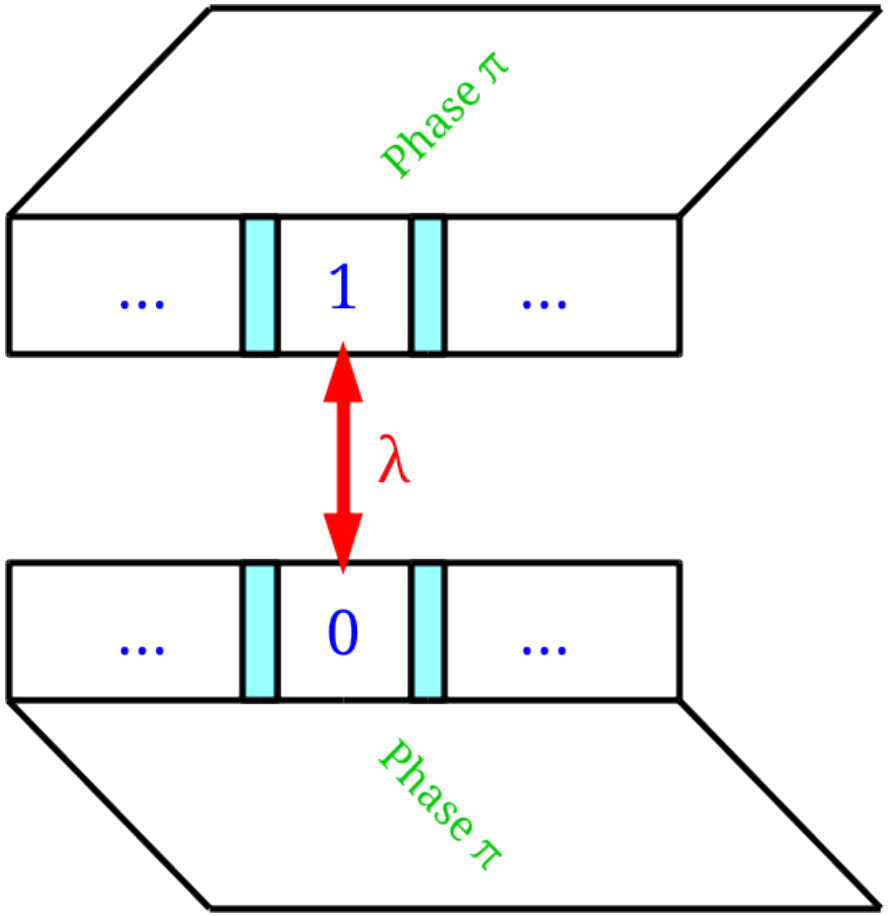
Second improvement: shorten the beginning of R_1



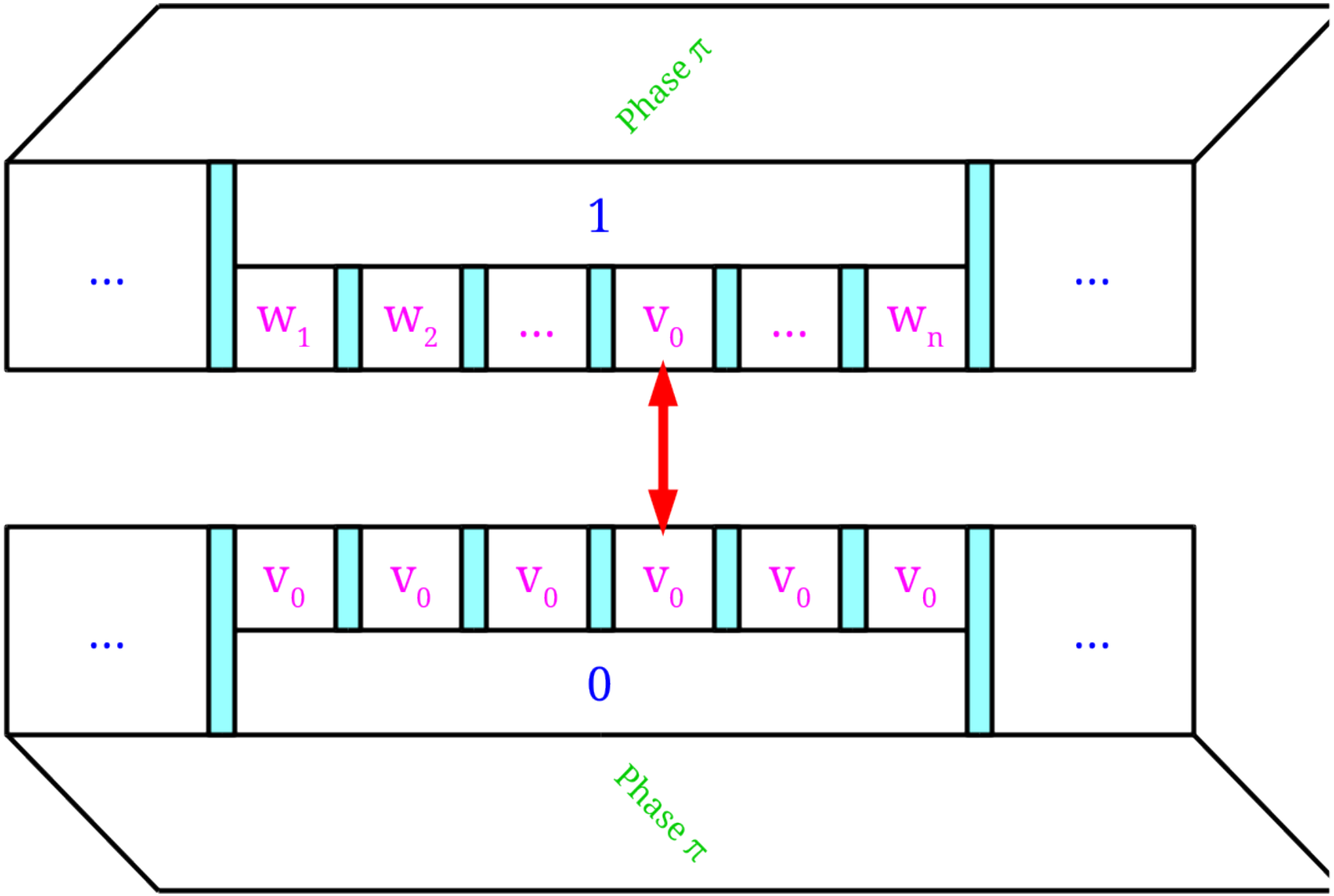
Second improvement: shorten the beginning of R_1

Let us make v_0 the first node from which A_1 follows R_0 during its R_1.
Once again, we use tests separated by the first synchronization mechanism.

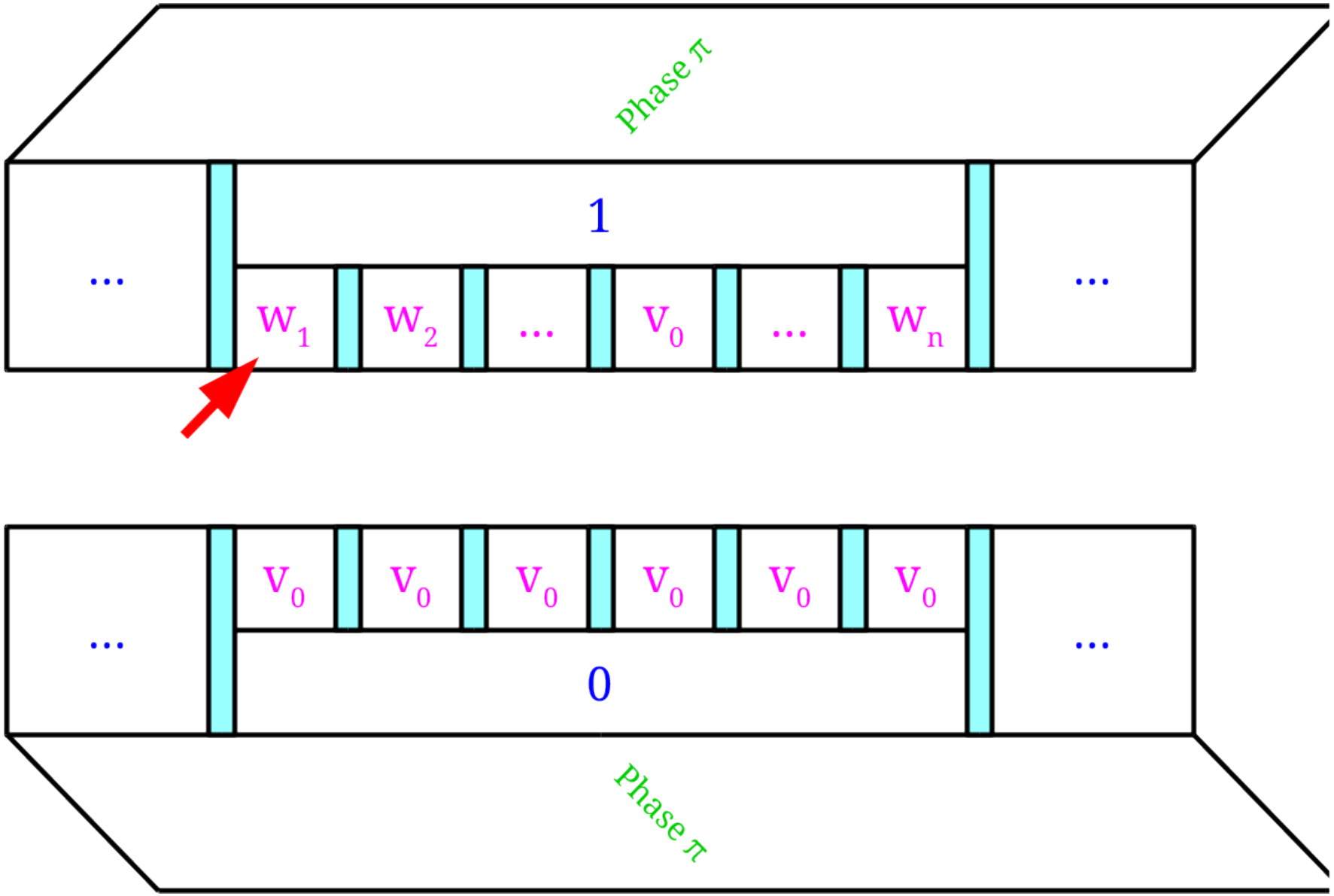
Second improvement: shorten the beginning of R_1



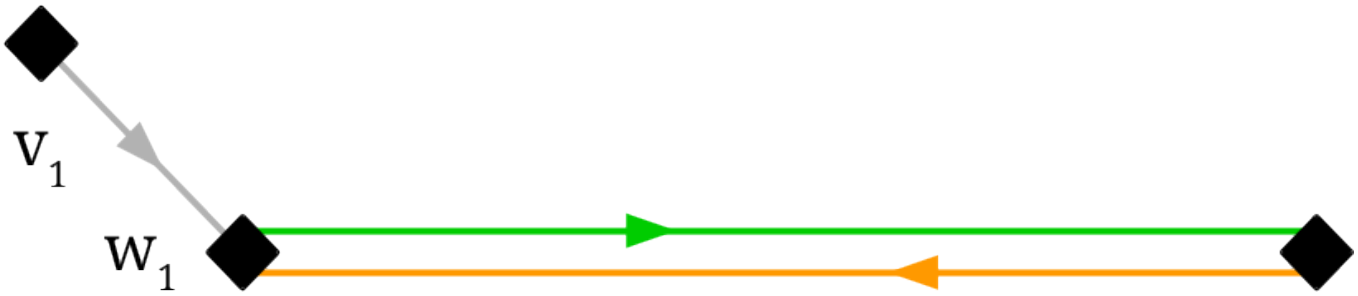
Second improvement: shorten the beginning of R_1



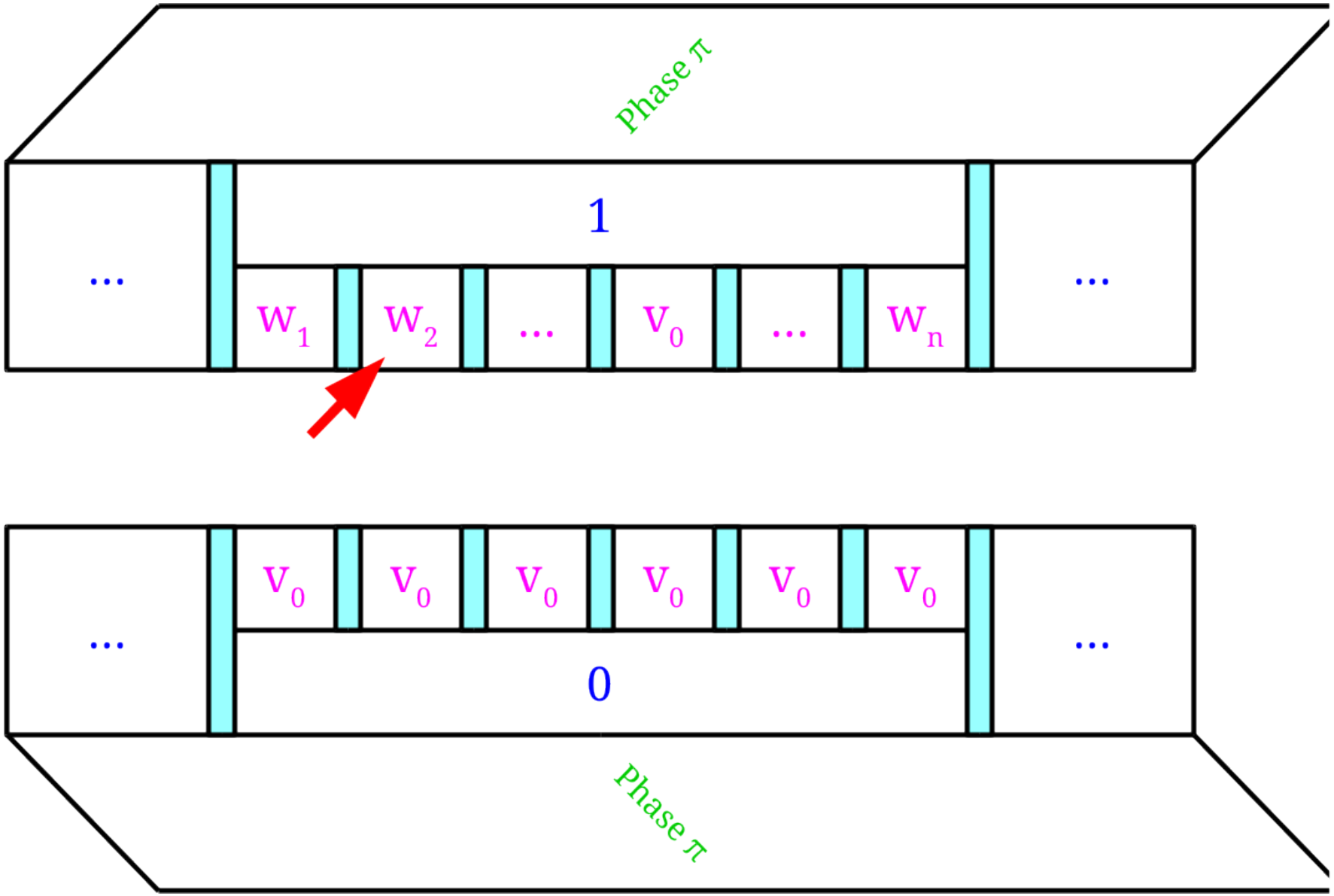
Second improvement: shorten the beginning of R_1



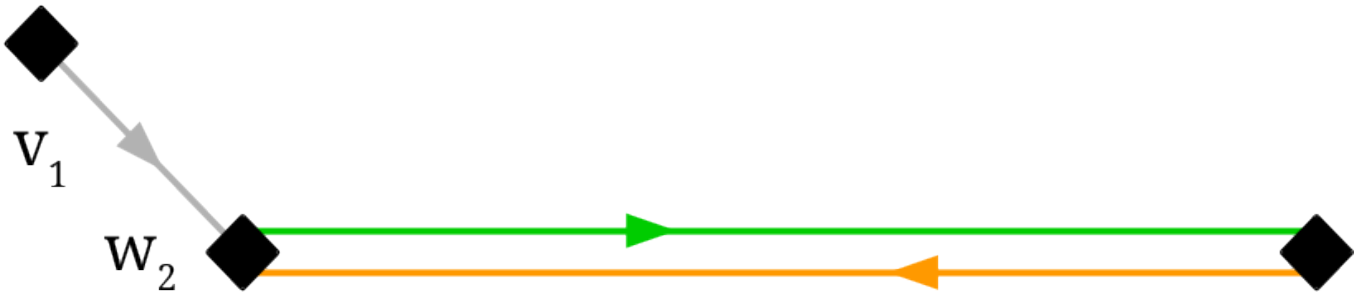
Second improvement: shorten the beginning of R_1



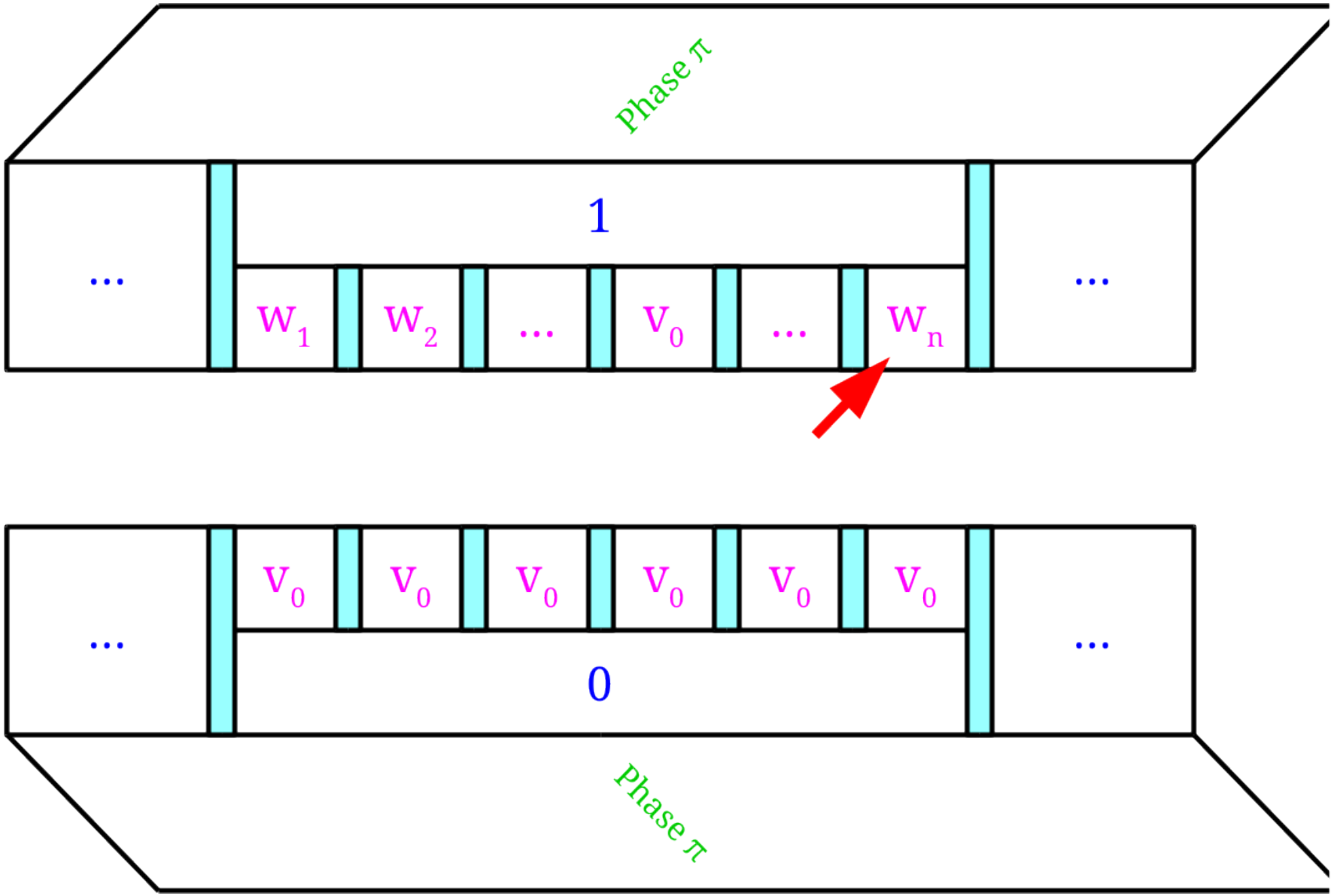
Second improvement: shorten the beginning of R_1



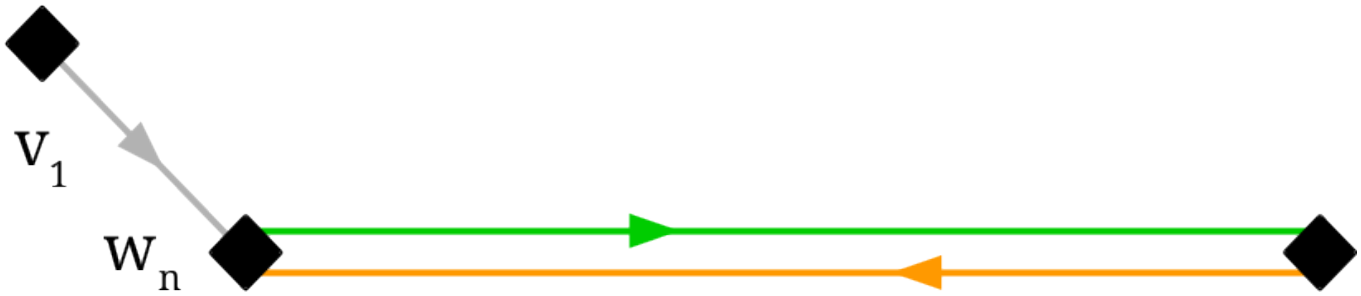
Second improvement: shorten the beginning of R_1



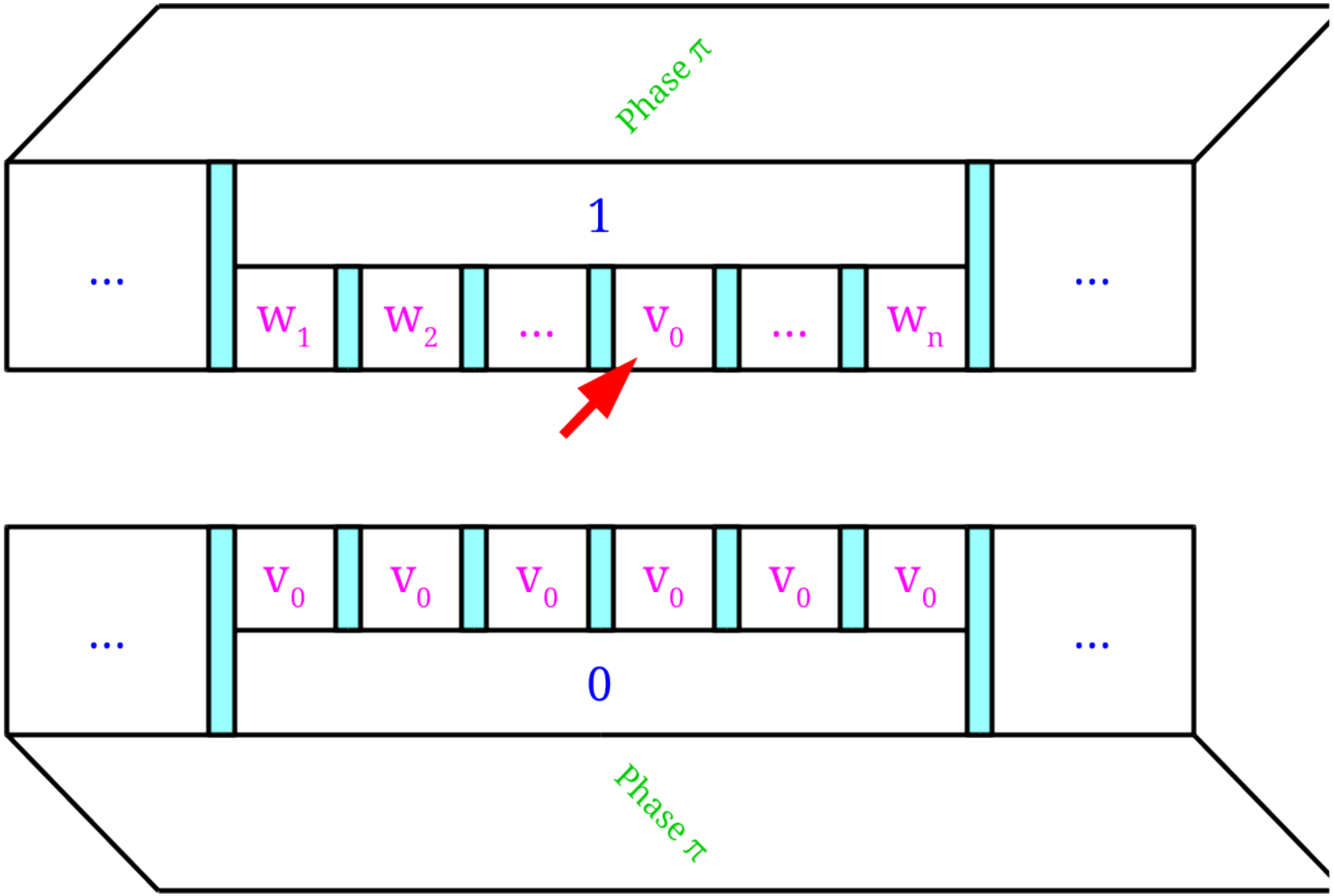
Second improvement: shorten the beginning of R_1



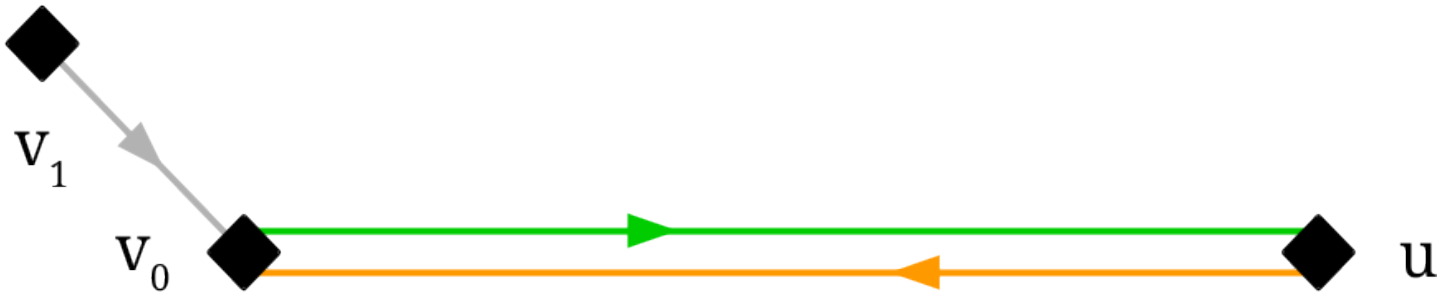
Second improvement: shorten the beginning of R_1



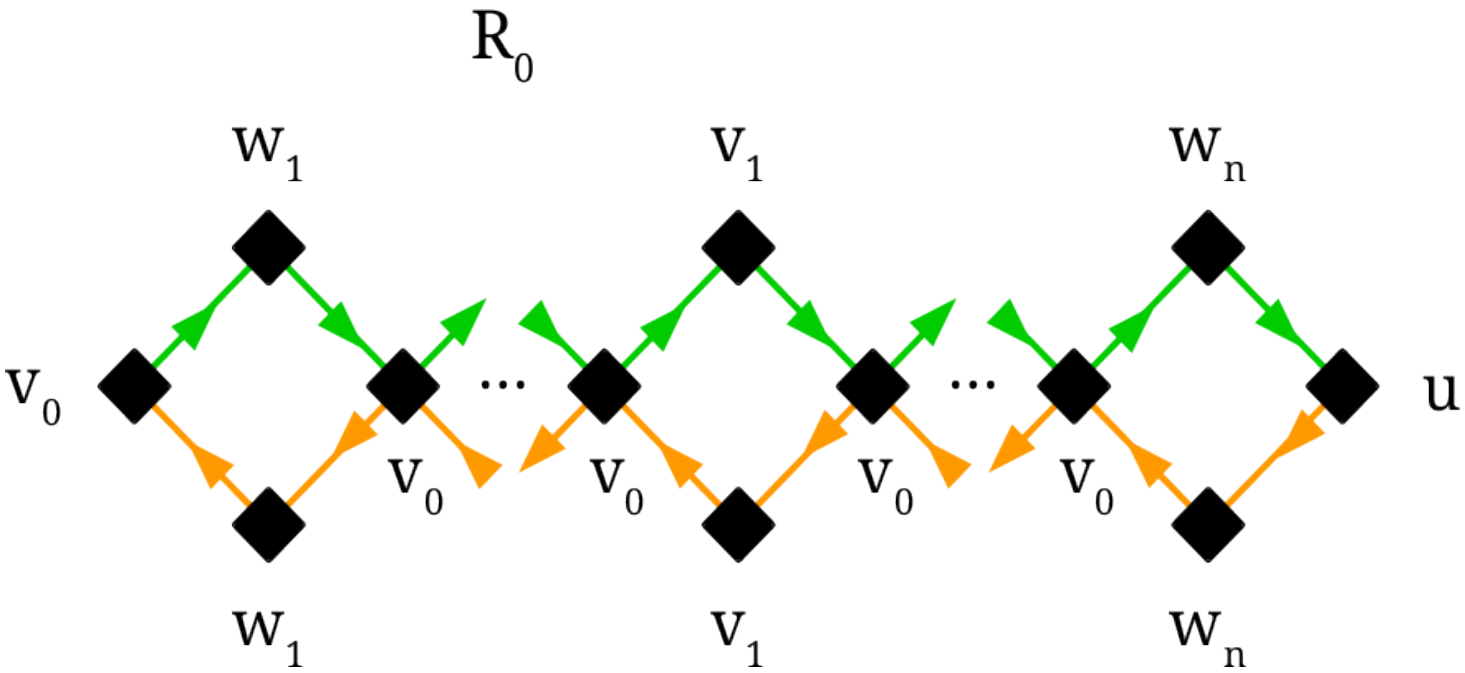
Second improvement: shorten the beginning of R_1



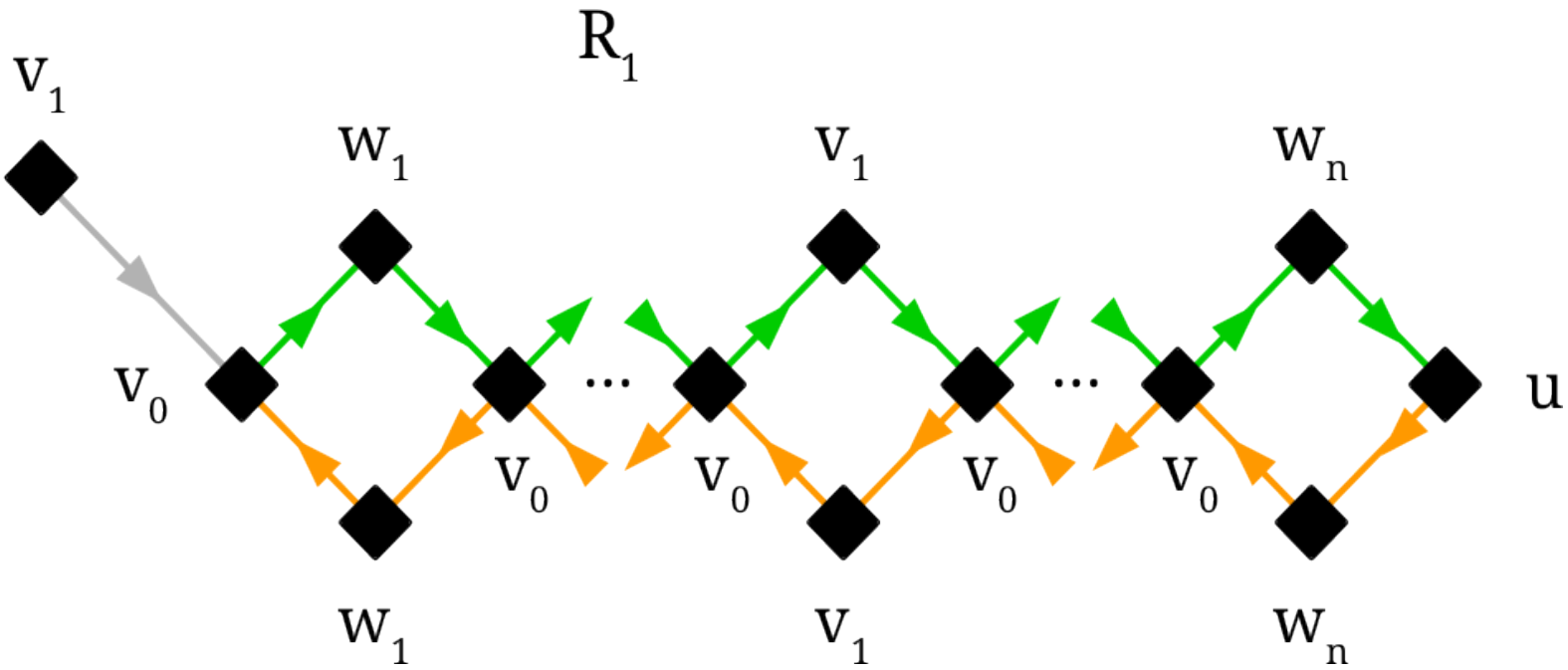
Second improvement: shorten the beginning of R_1



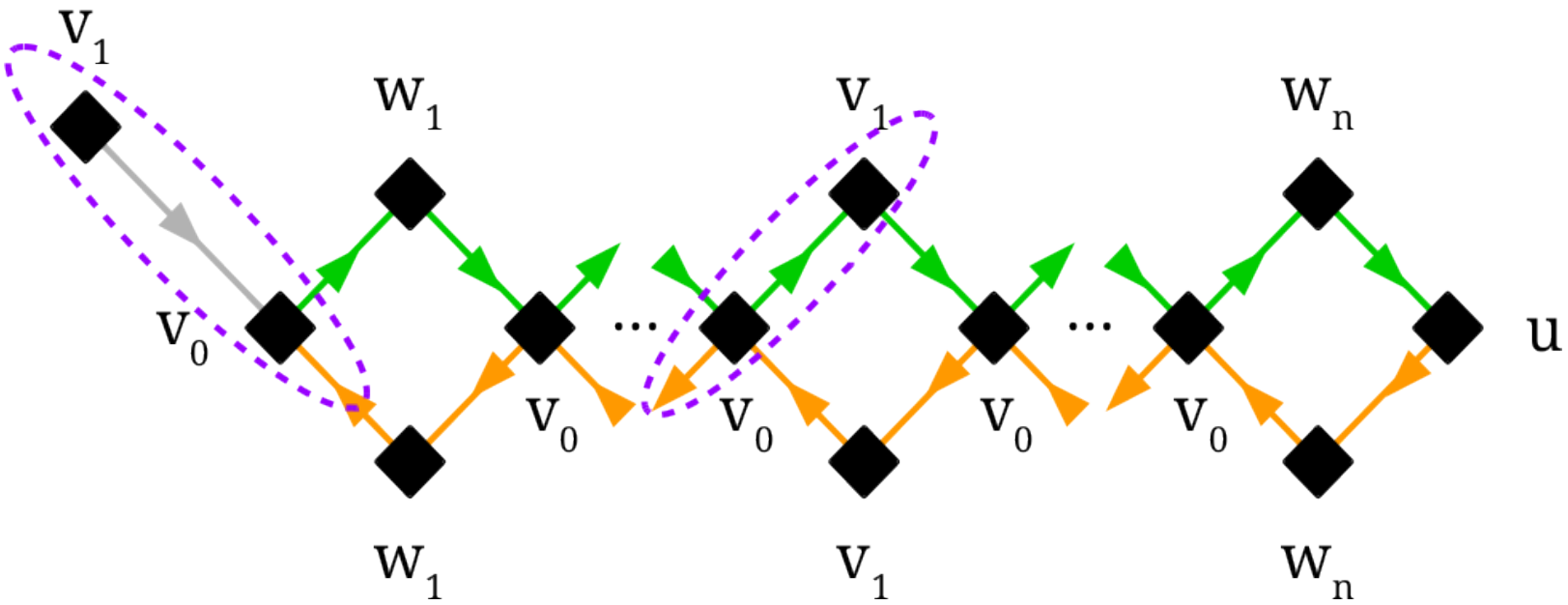
Third improvement once more based on tunnels



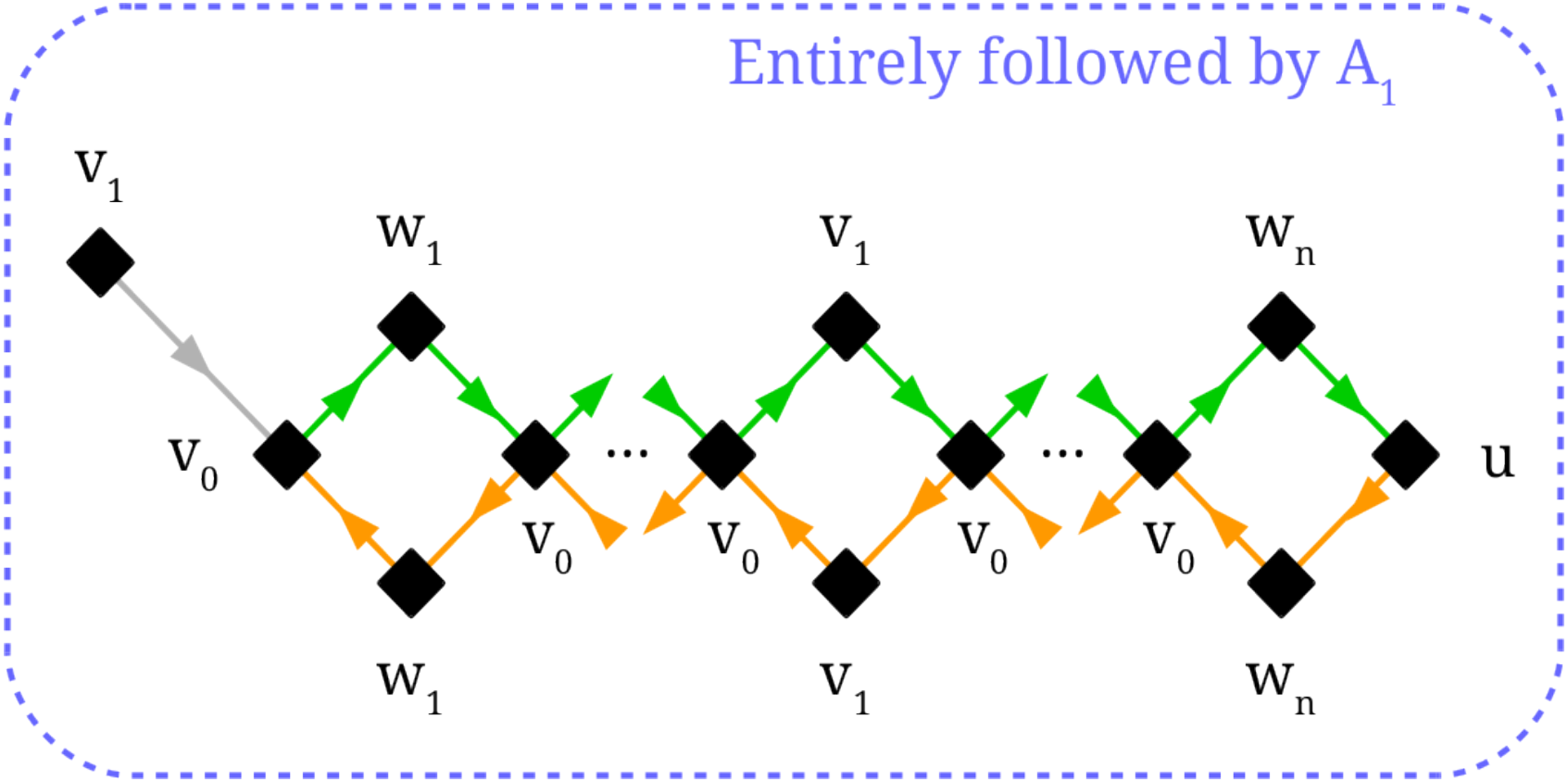
Third improvement once more based on tunnels



Third improvement once more based on tunnels



Small break (2)



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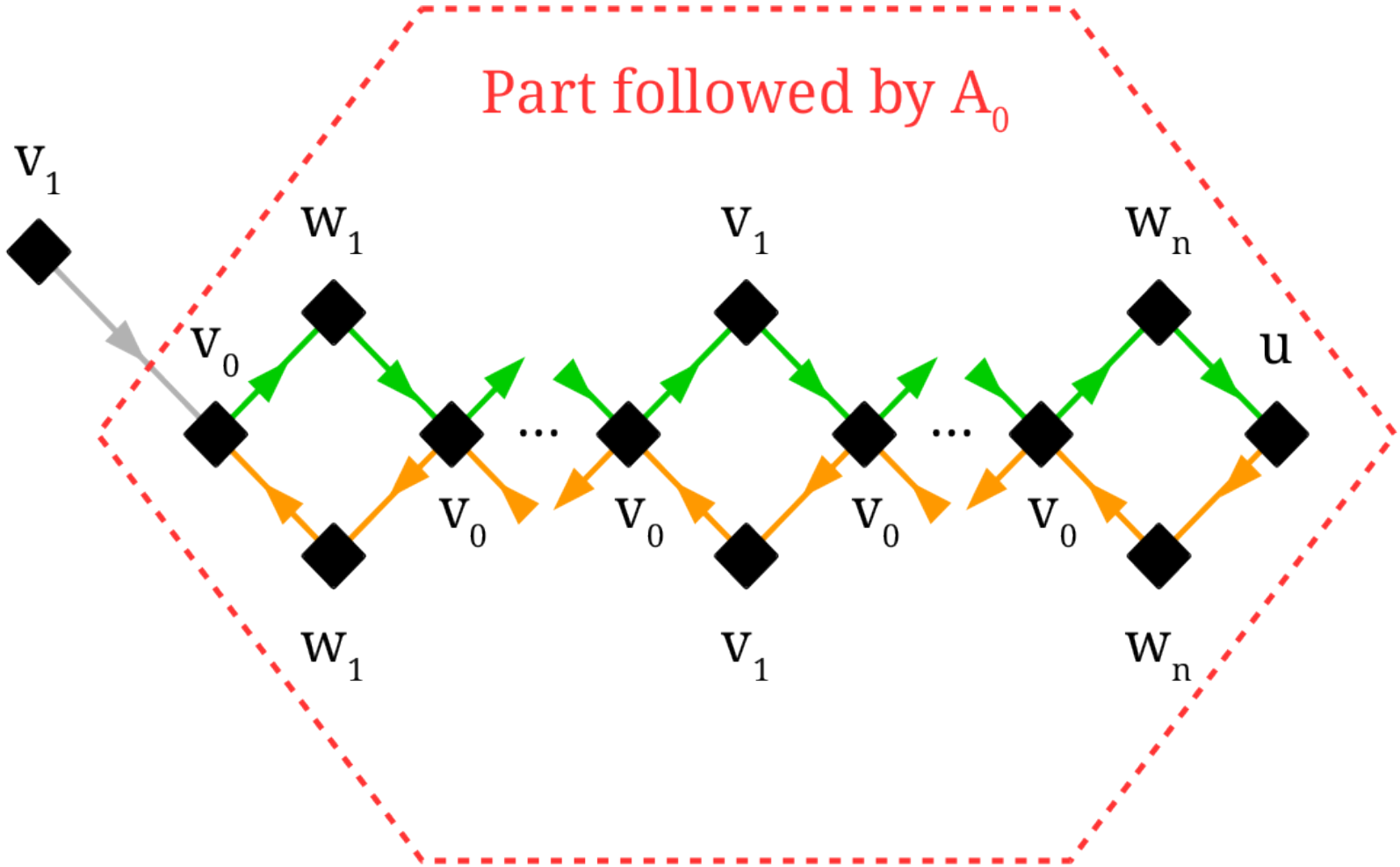

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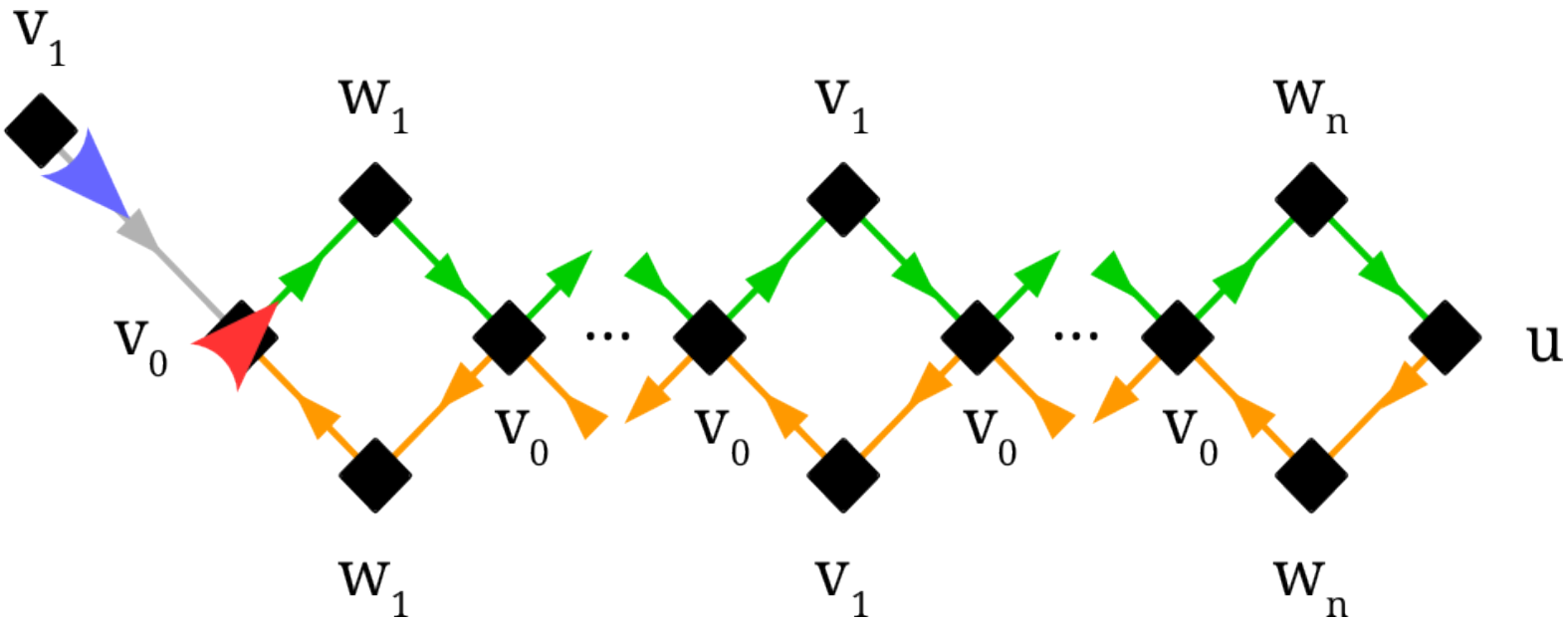

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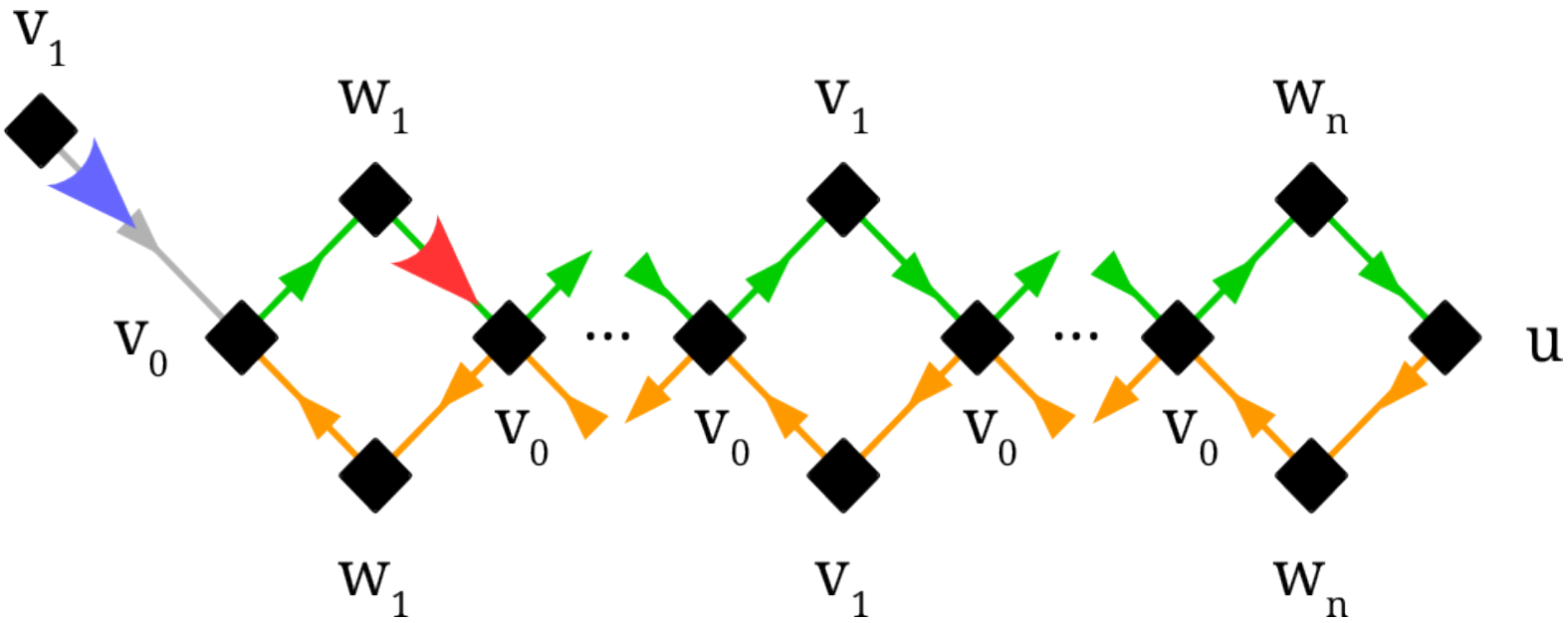

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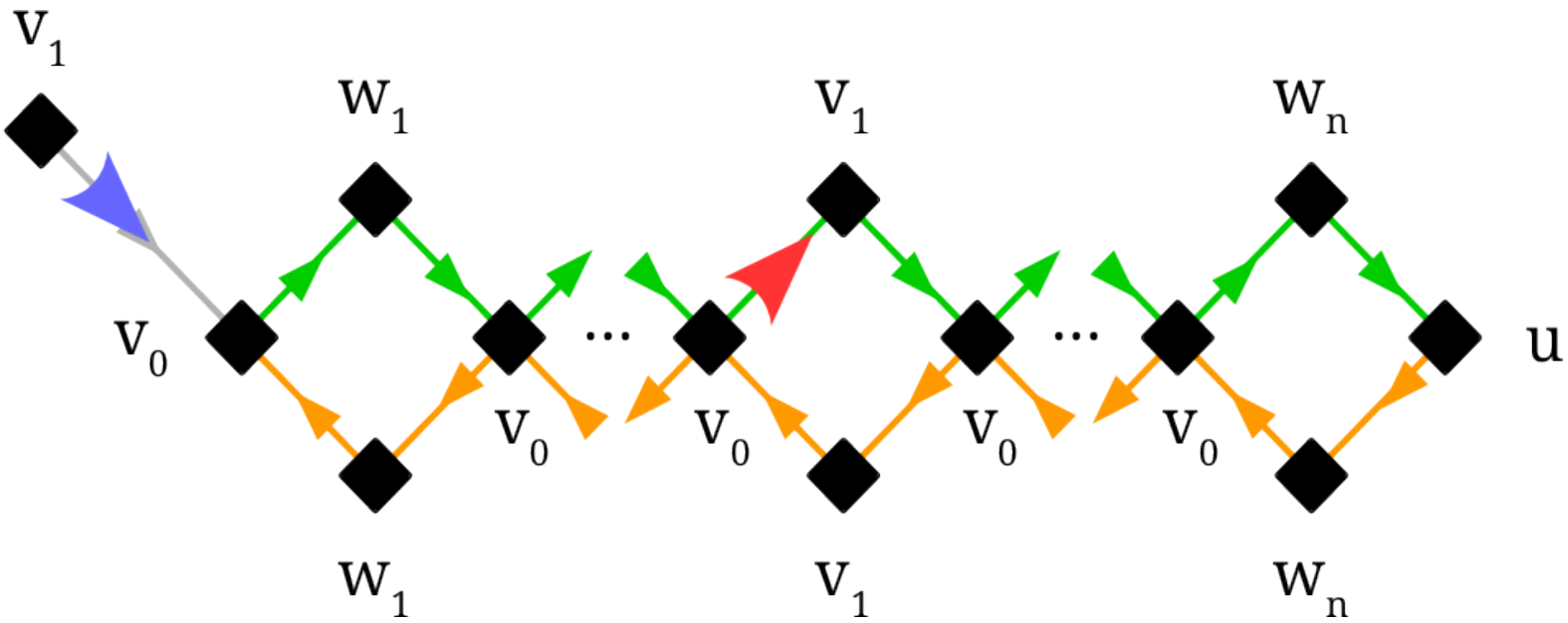

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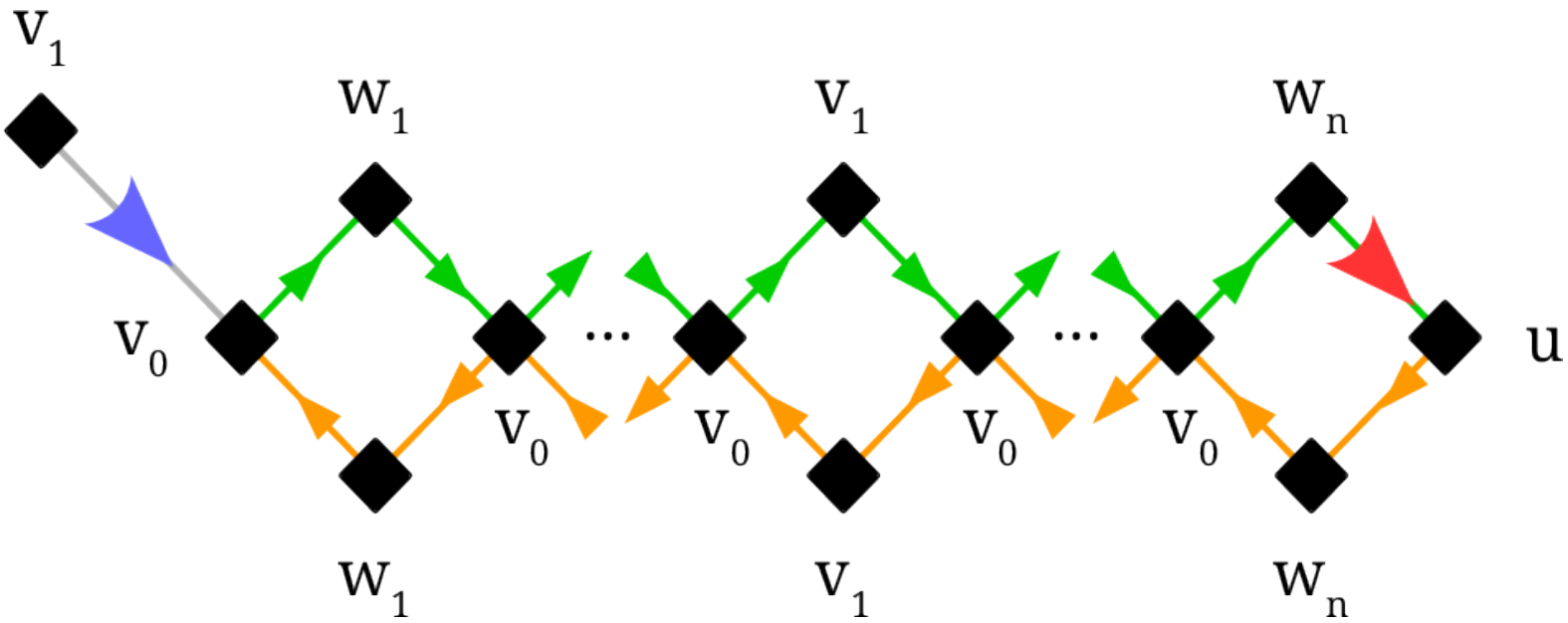

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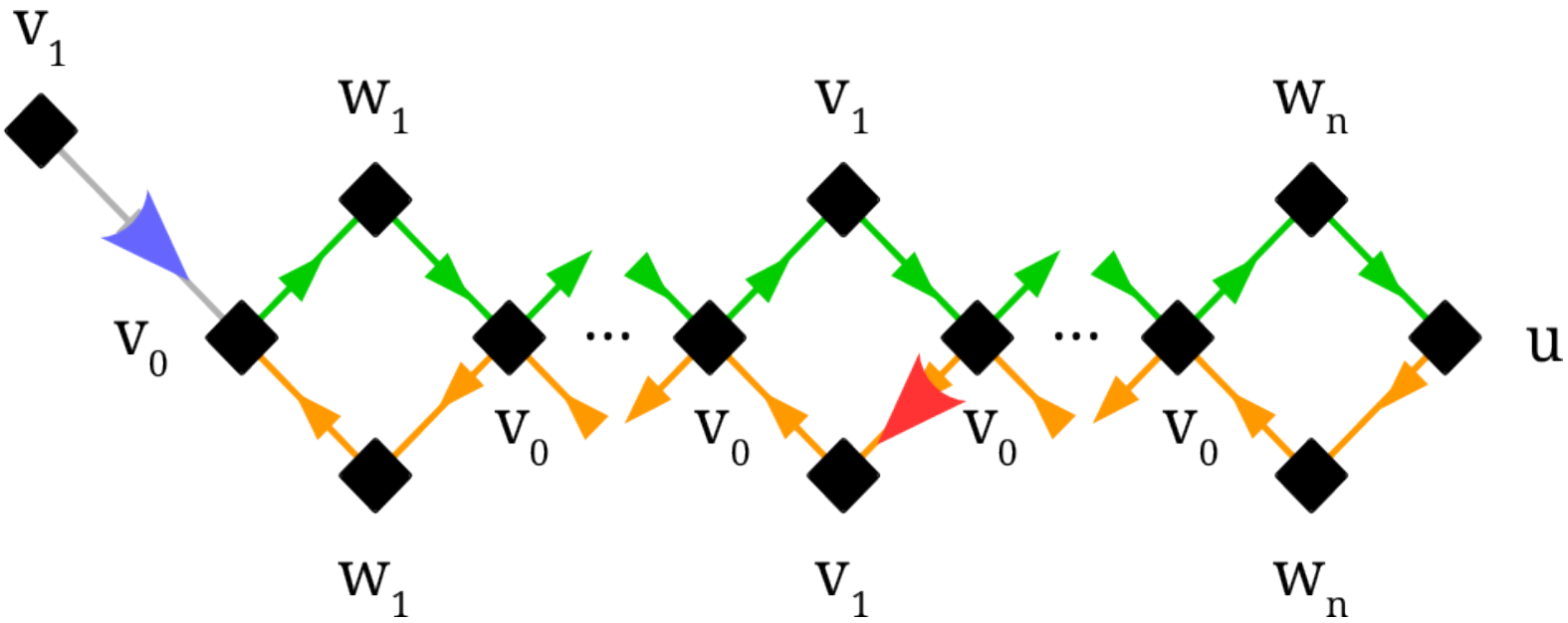

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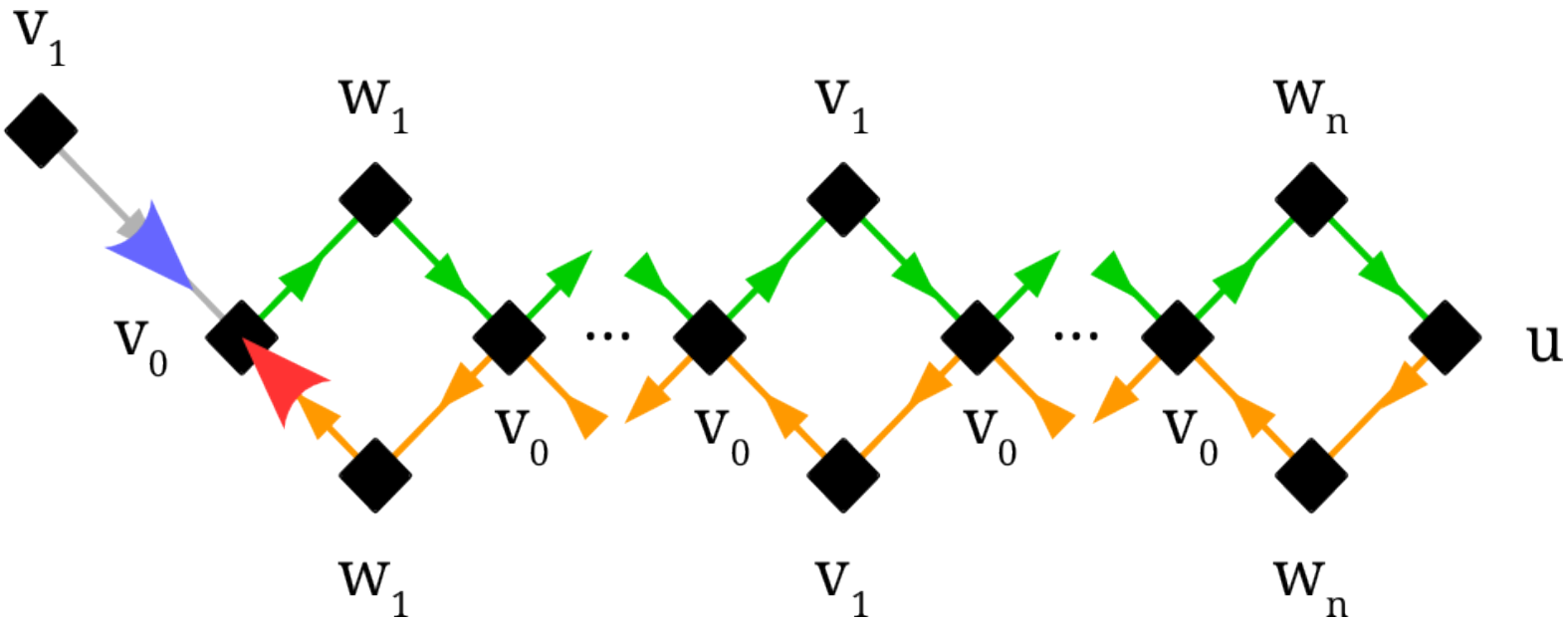

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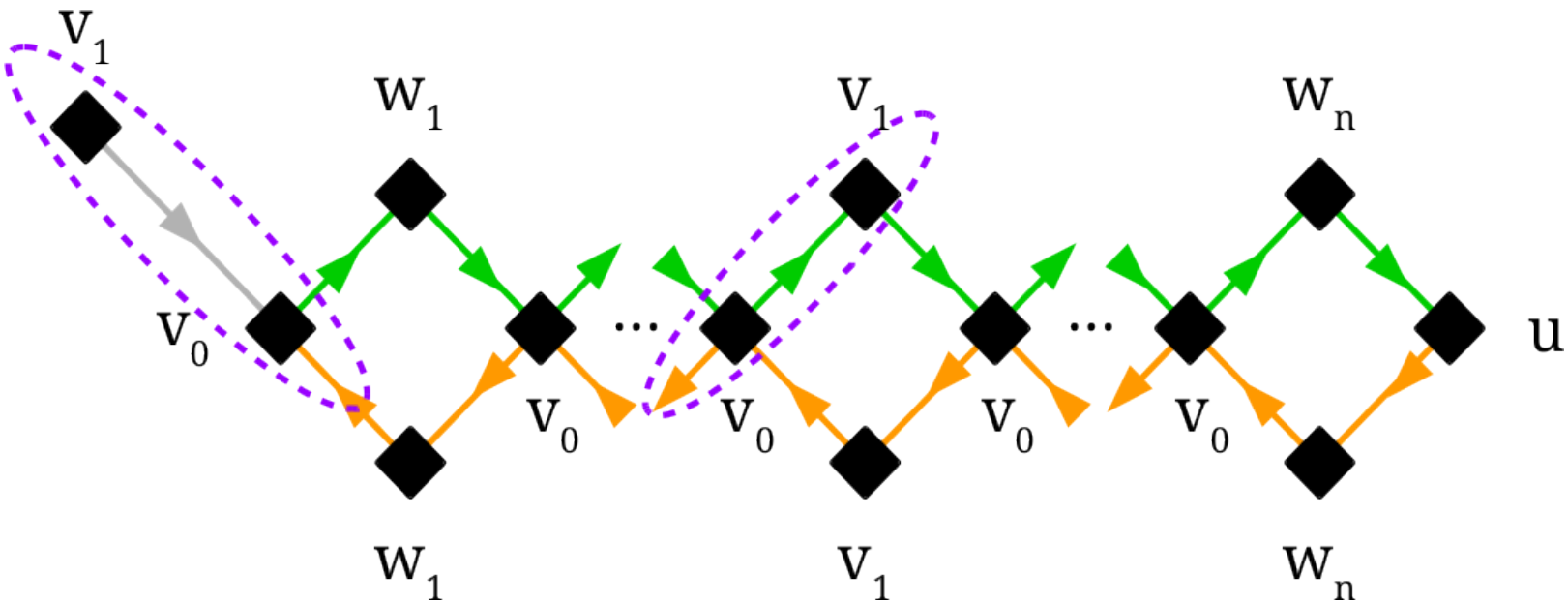
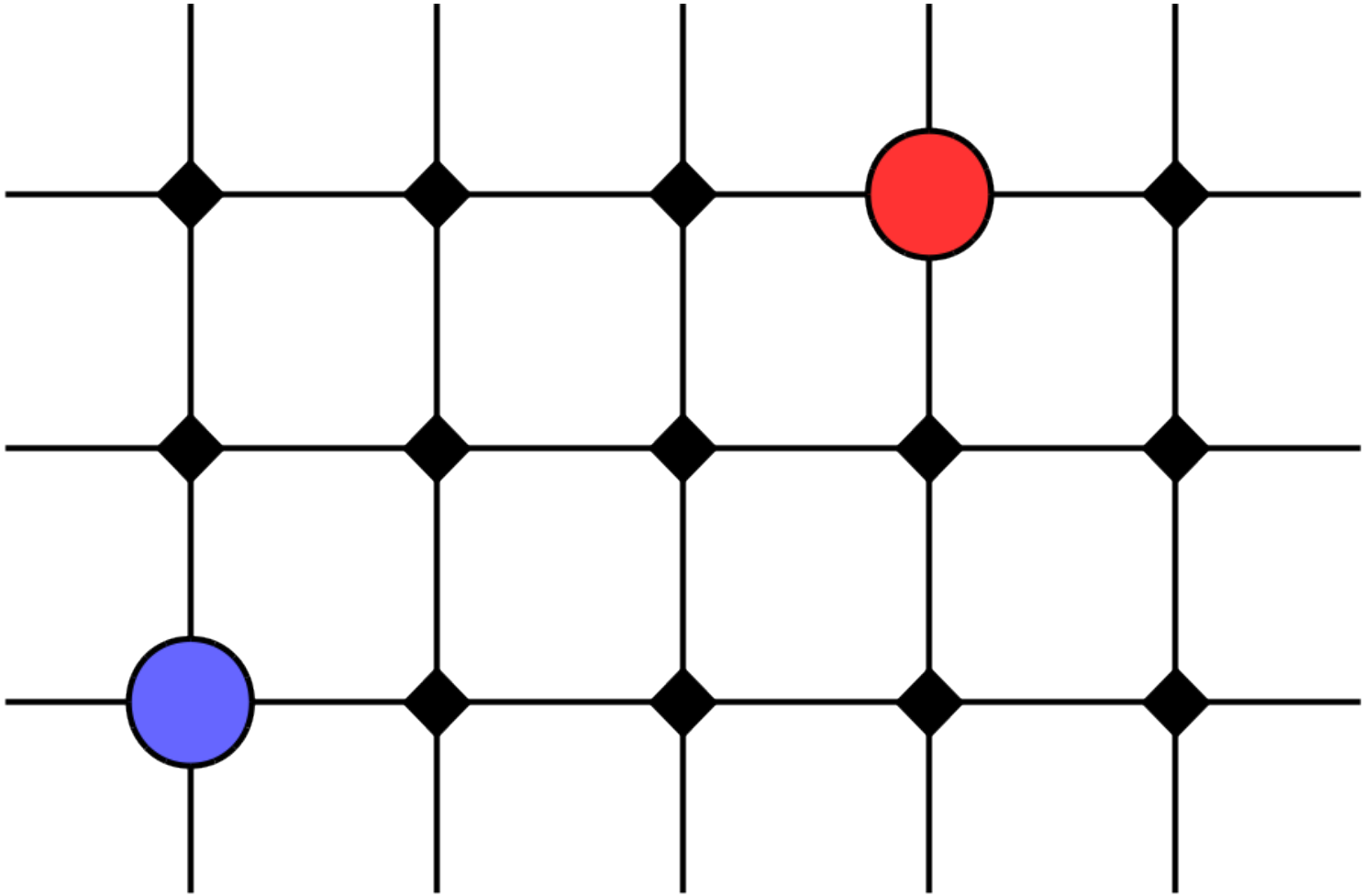
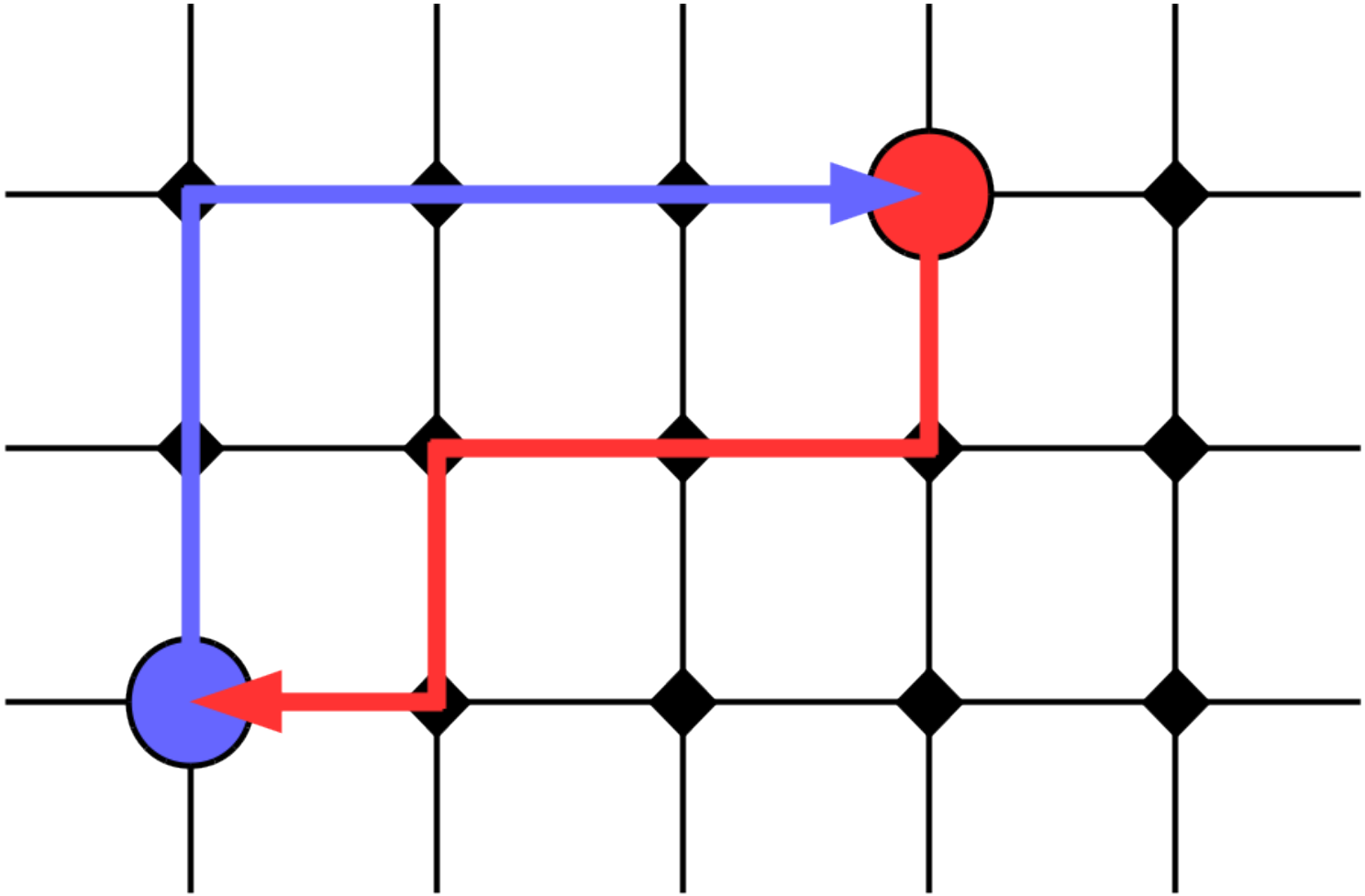


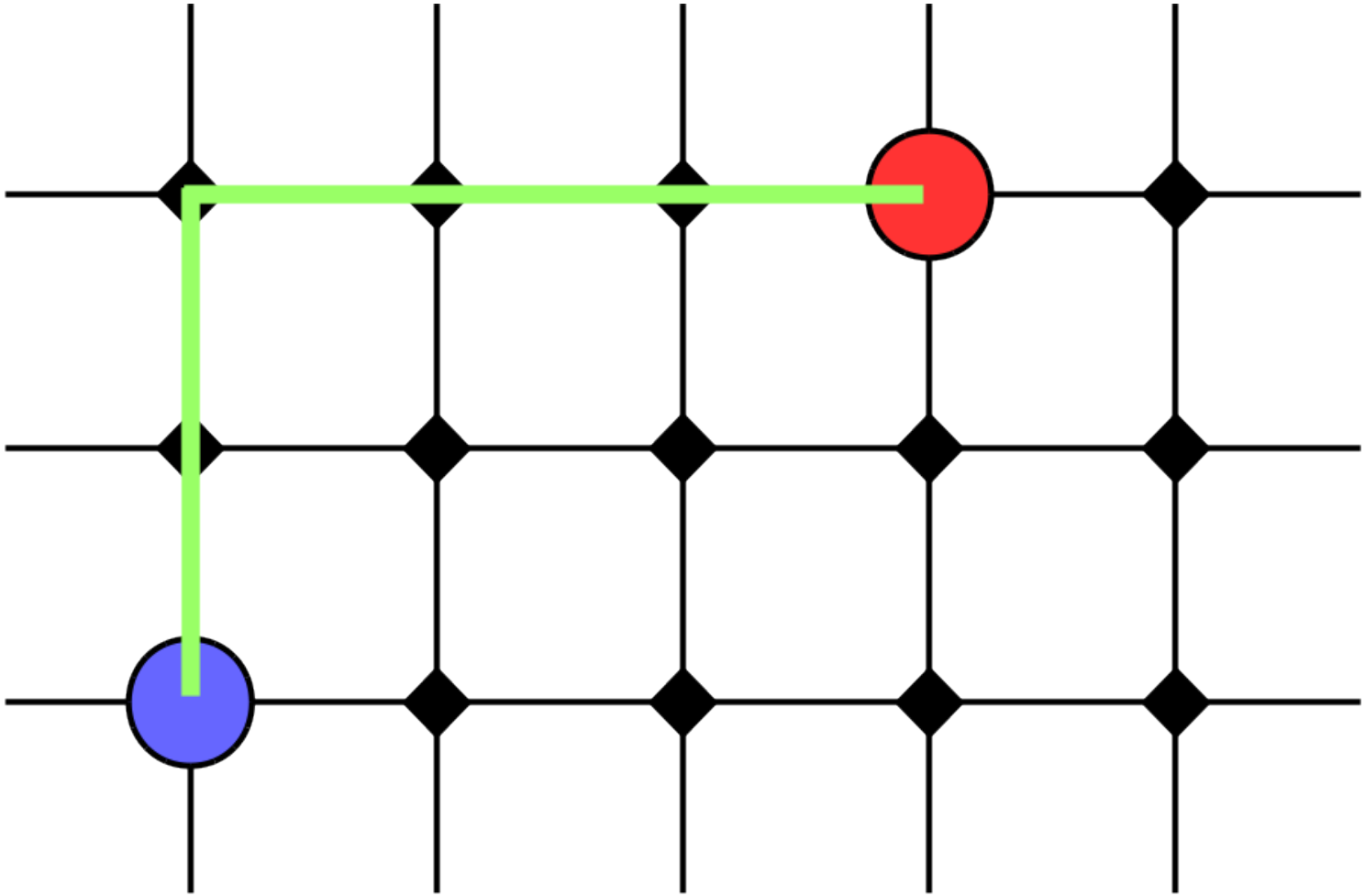
Last improvement: taking a look at the grid



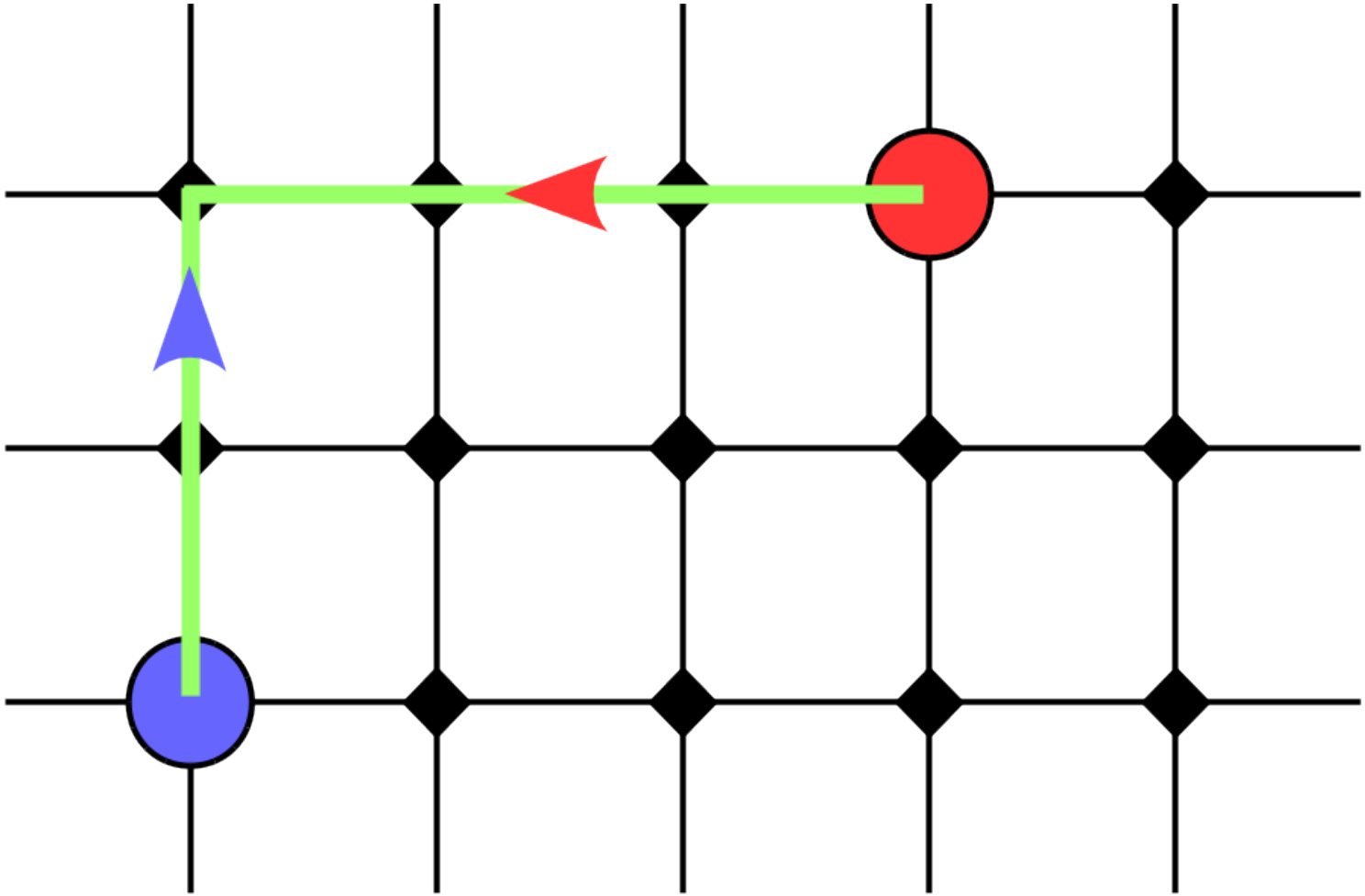
Last improvement: taking a look at the grid



Last improvement: taking a look at the grid



Last improvement: taking a look at the grid



Synchronization mechanisms constraints

We have introduced the main ideas but these are not the actual routes we use.
Unfortunately, due to the lack of time, we cannot explain them in more details.

Conclusion

Our contributions

First deterministic approach algorithm for a fully asynchronous setting whose cost is polynomial in the initial distance and the length of the labels.

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First deterministic approach algorithm for a fully asynchronous setting whose cost is polynomial in the initial distance and the length of the labels.

Open question

Impact of the GPS on the cost ?