Modeling P2P protocols by cellular automata

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Outline

1. P2P networks
   - Concept of P2P networks
   - Use of P2P networks
   - Protocols to model
2. P2P modeling technics
   - Stochastic modeling
   - Discrete event simulation
3. Cellular automata
   - Definition
   - Neighborhoods
4. Examples
   - Message delivery
   - Synchronization
   - BitTorrent simulation
5. Main bibliography

Concept of P2P networks

- Peer-to-peer means the overlay type: the peers are interconnected.
- A peer-to-peer network breaks up with the tradition of using client/server architecture.
- No dedicated network is needed, simple internet connection per peer is used instead.
- Peers interconnect in an ad-hoc manner.
- Use of decentralized distributed algorithms.

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- This approach makes us possible to use modern chat-voice-video clients.
  - Microsoft Live (MSN) Messenger.
  - Skype.
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  - VoIP telephony also.
- Also widely used in file-sharing systems.
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  - Any kind of parameter is measurable.
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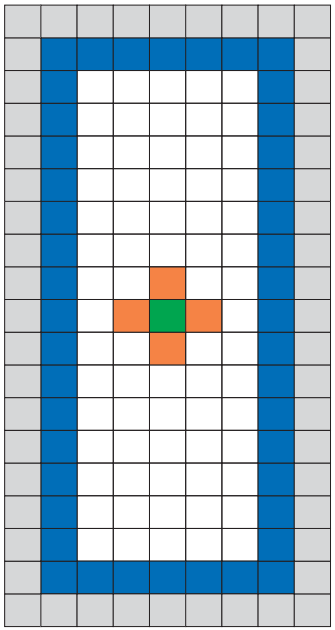

- We put a copy of a deterministic finite automaton (DFA) into each cell of a finite closed area of the $\mathbb{Z}^n$ space.
- This DFA has a state transition function depending on the state of the cell's neighbors as well.
- Special neighborhoods are used.
- From outside, the system is not touchable.

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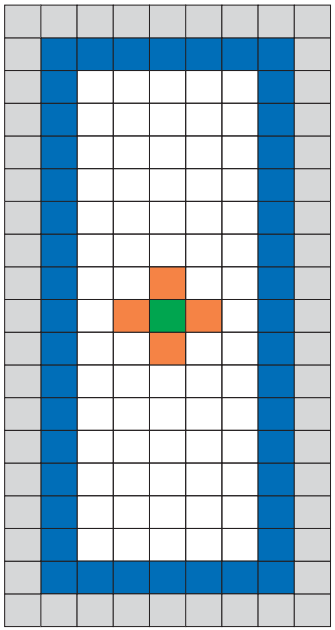

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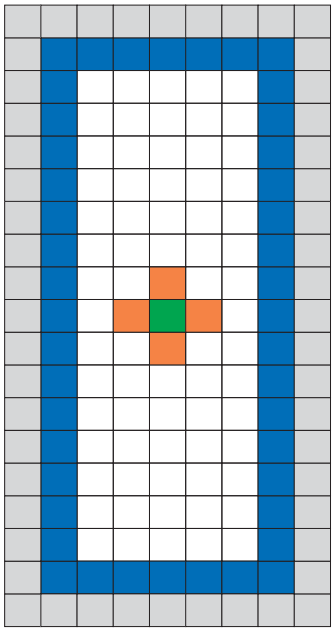

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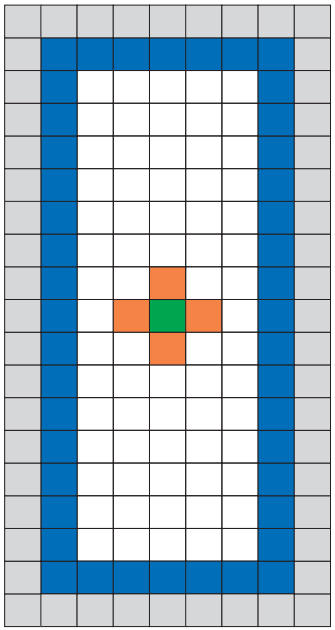

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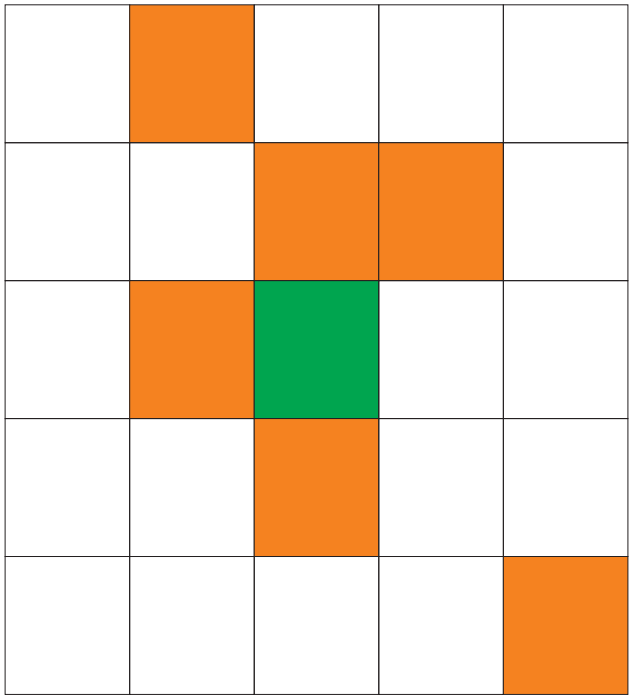

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- Moore neighborhood.
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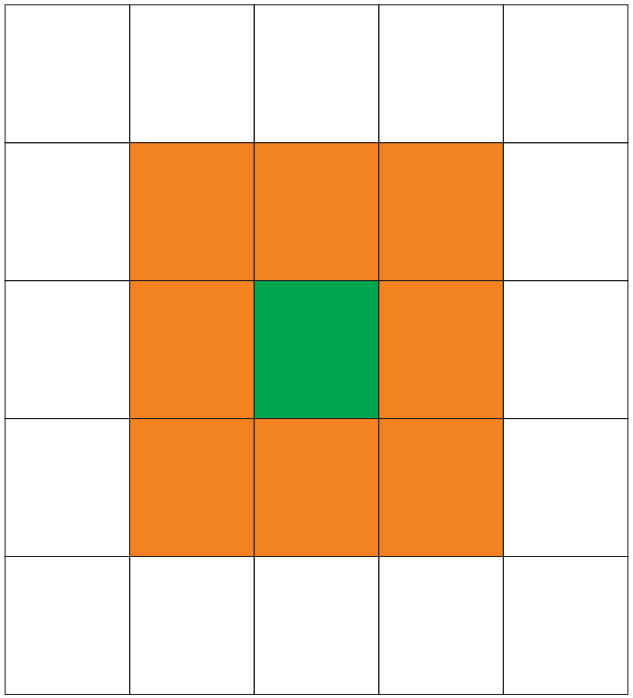

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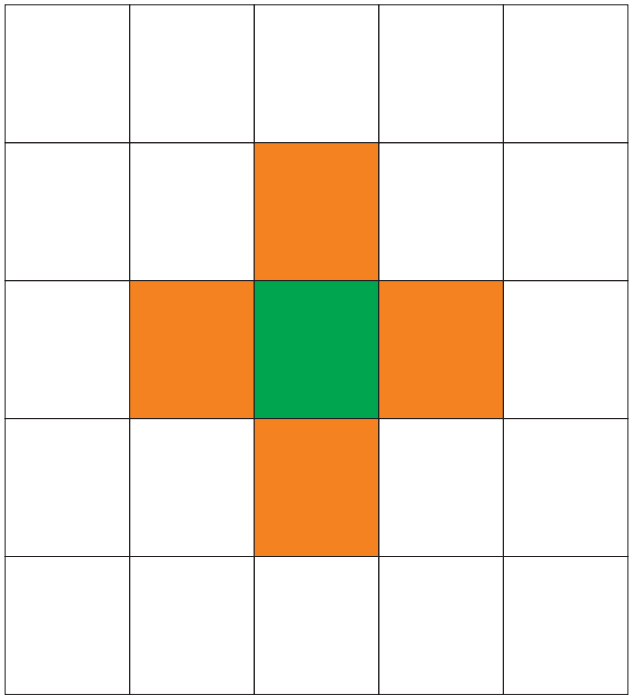

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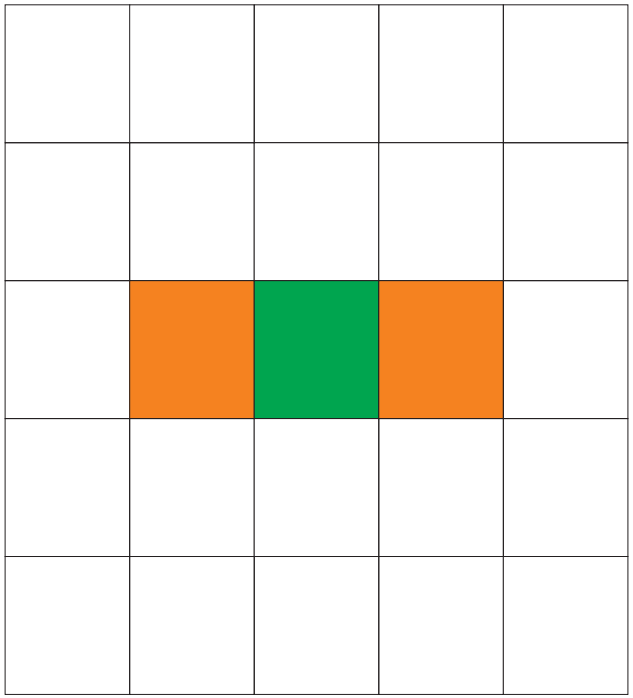

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Example - Message delivery

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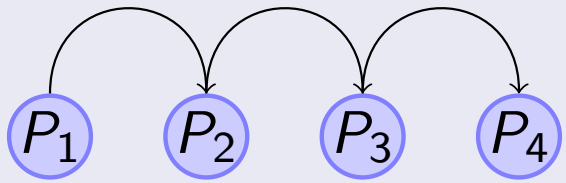

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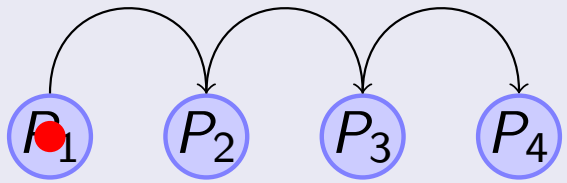

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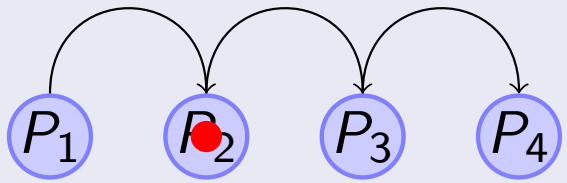

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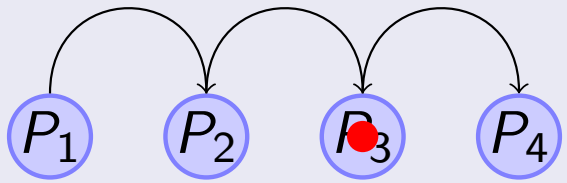

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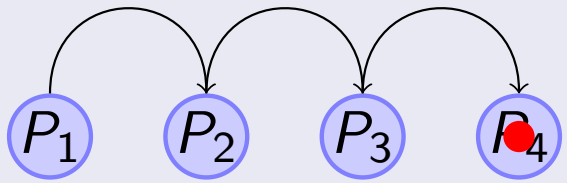

Example - Synchronization

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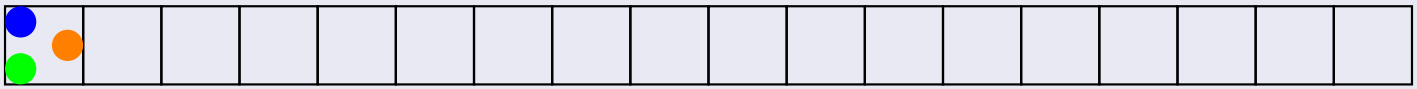

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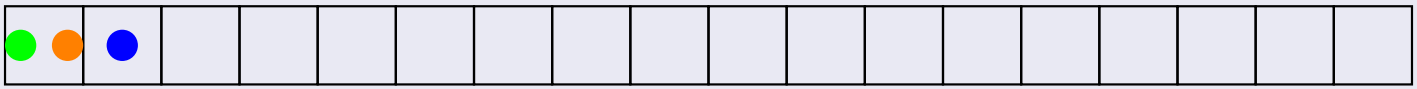

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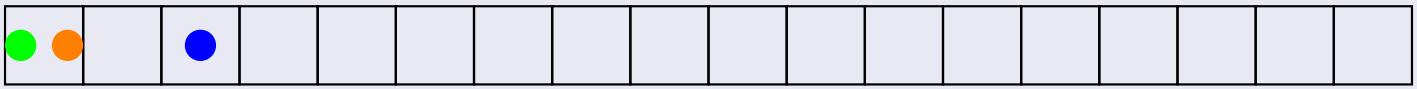

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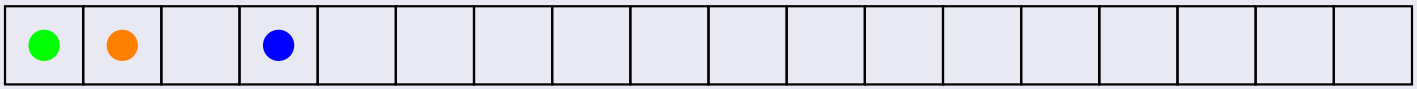

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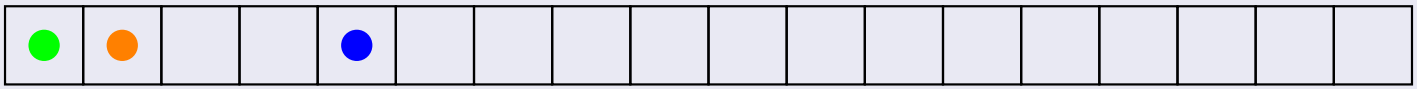

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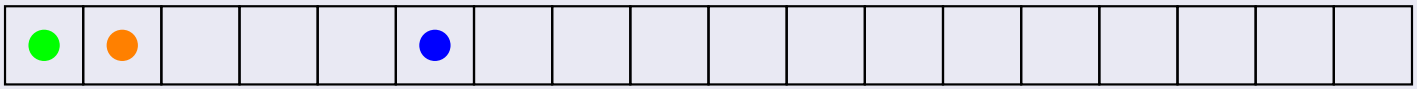

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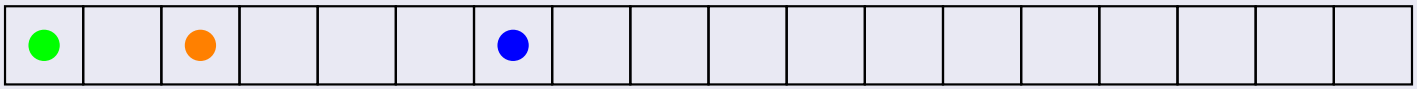

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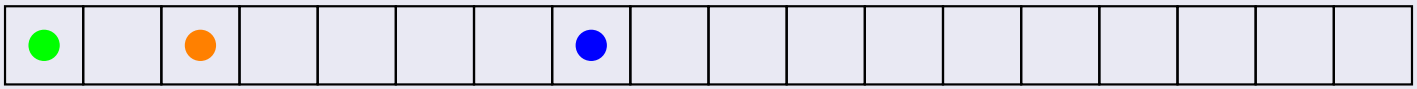

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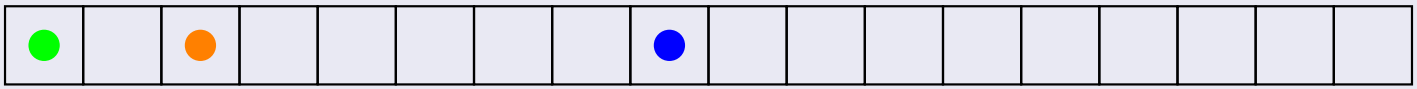

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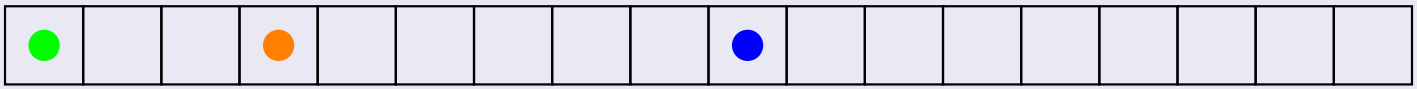

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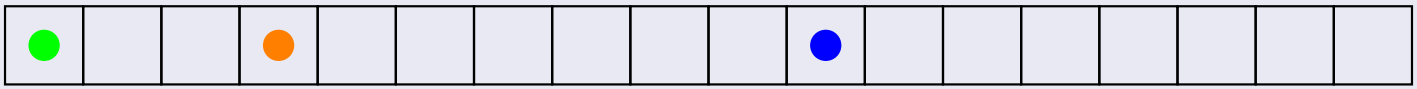

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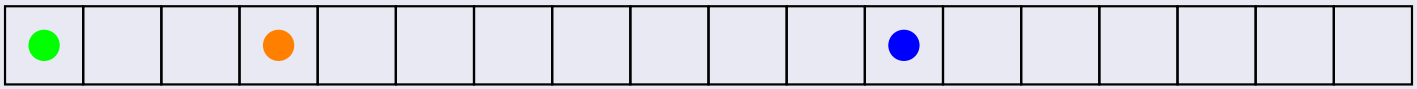

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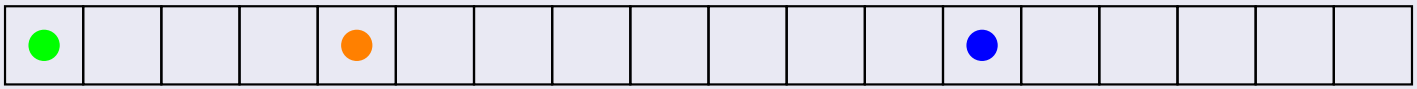

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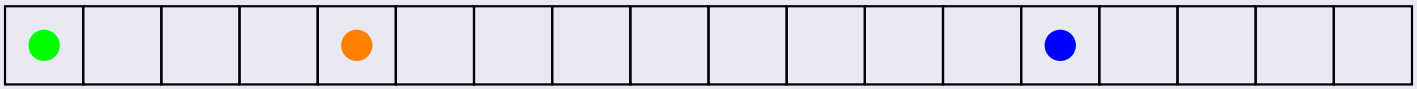

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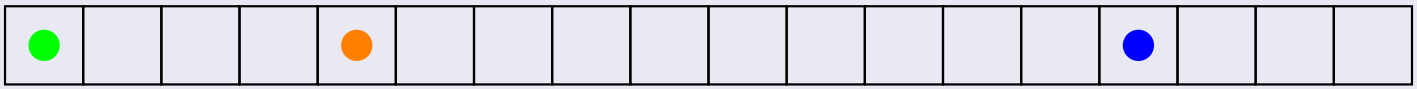

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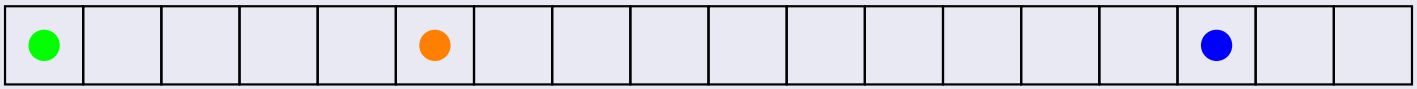

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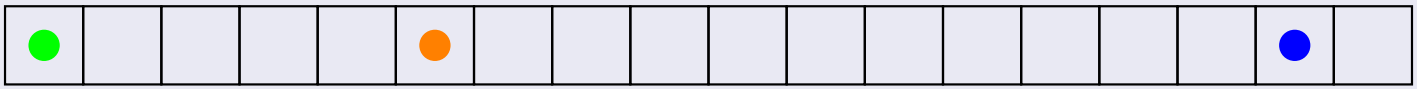

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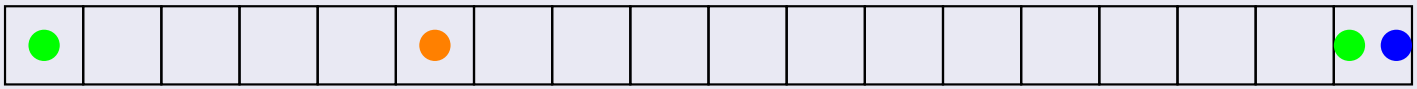

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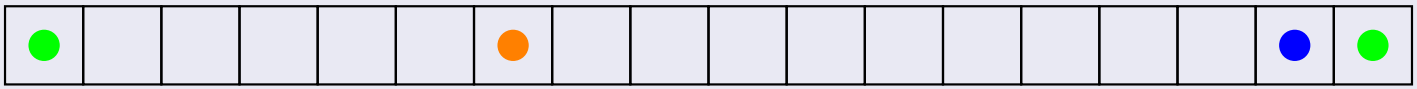

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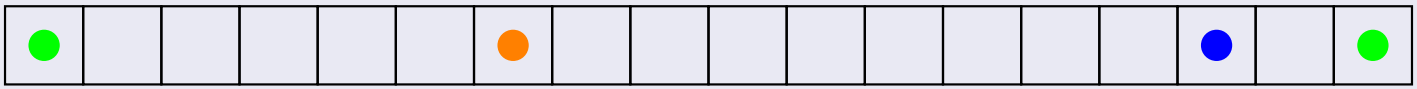

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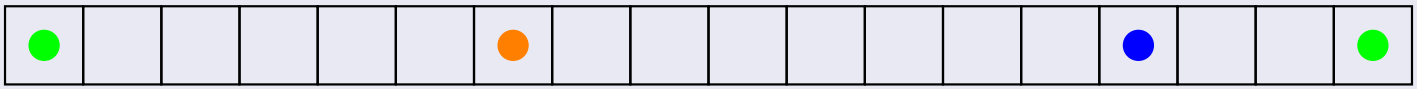

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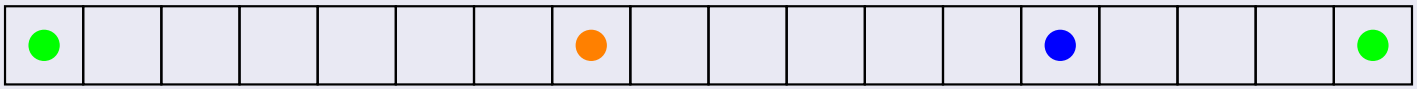

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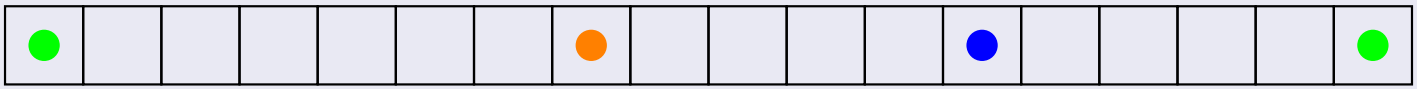

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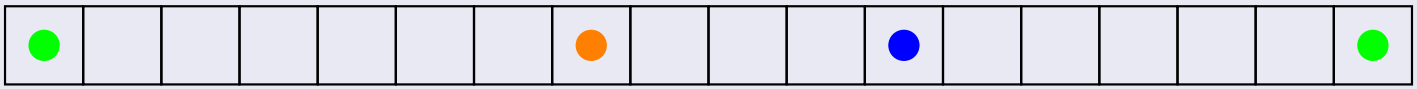

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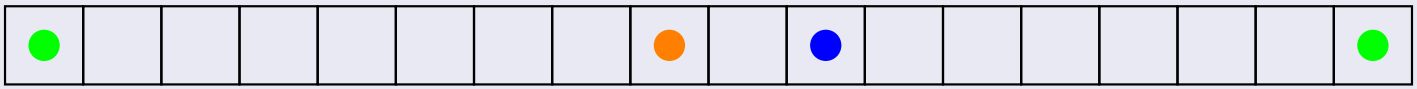

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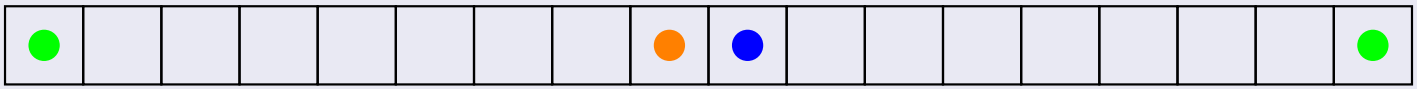

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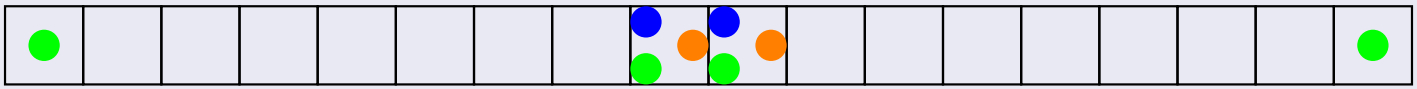

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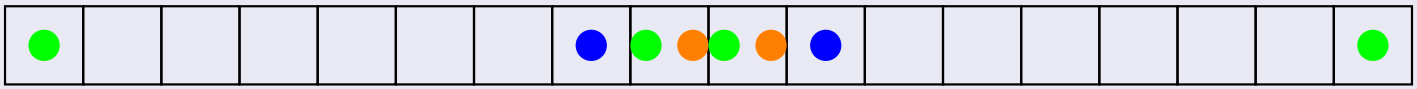

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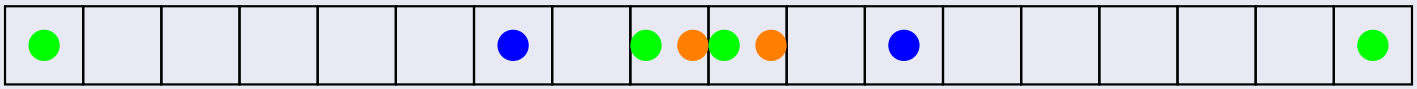

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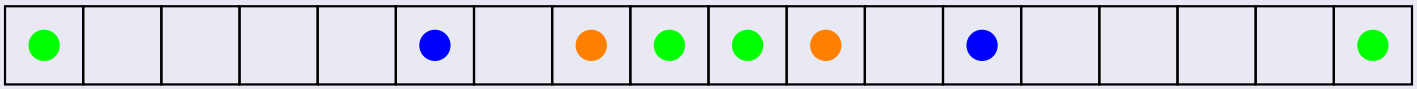

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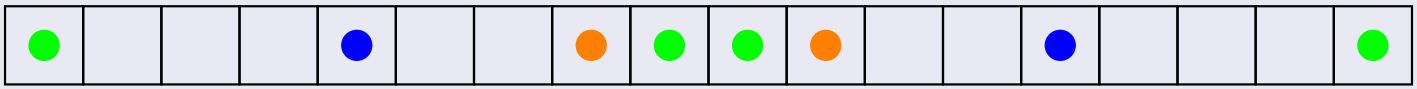

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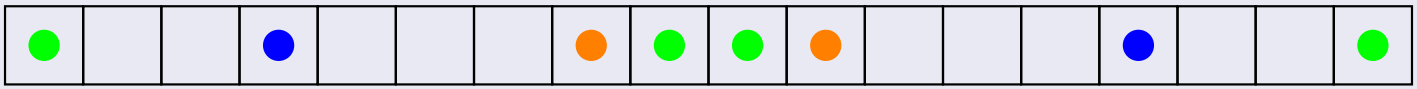

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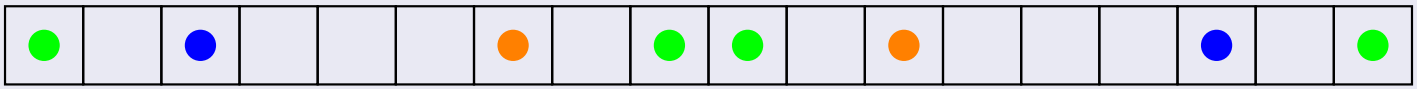

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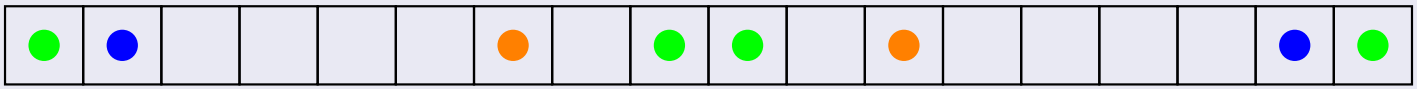

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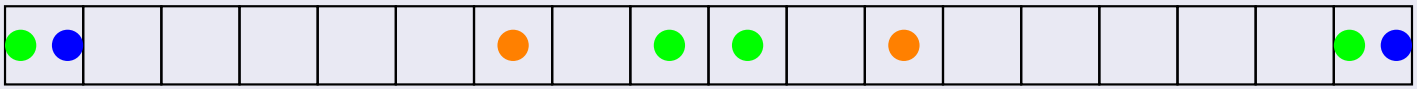

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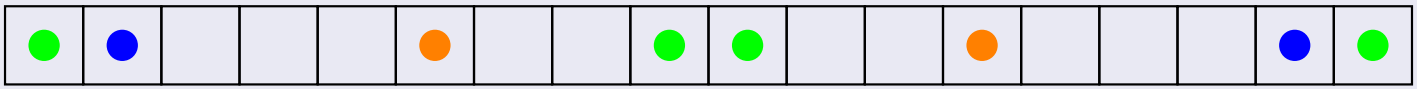

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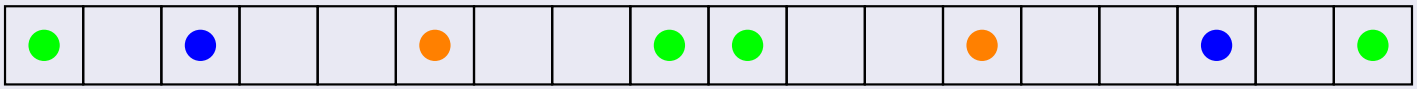

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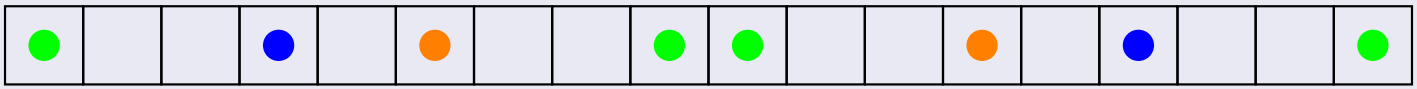

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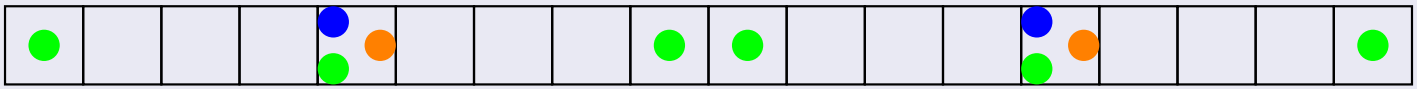

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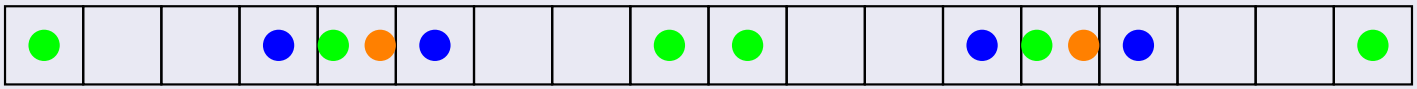

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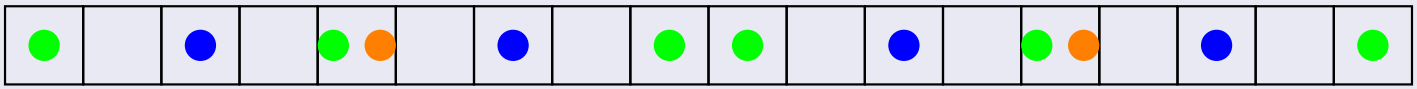

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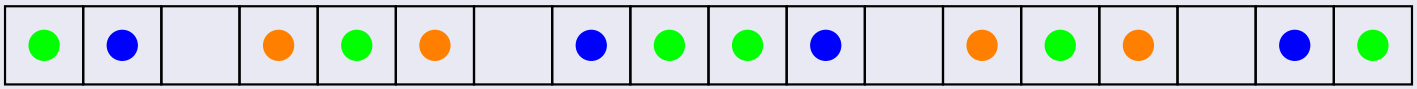

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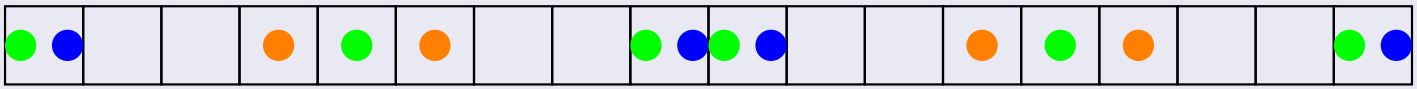

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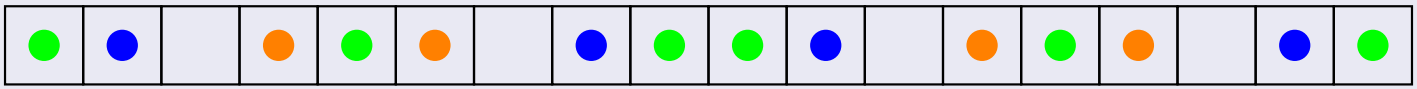

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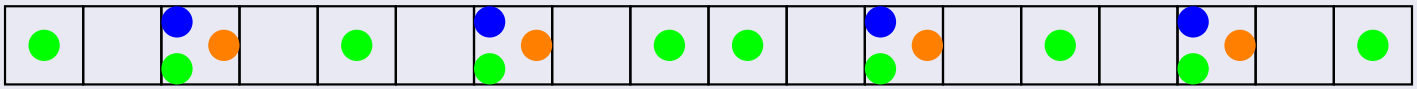

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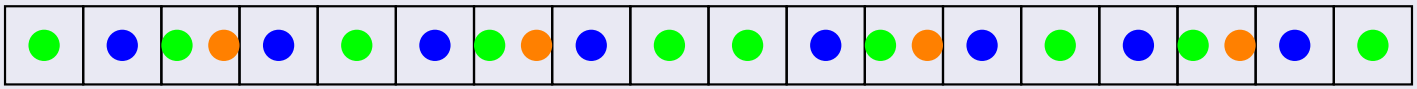

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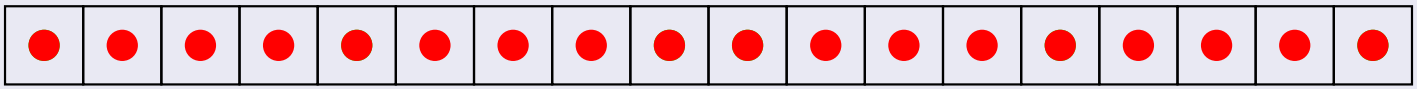

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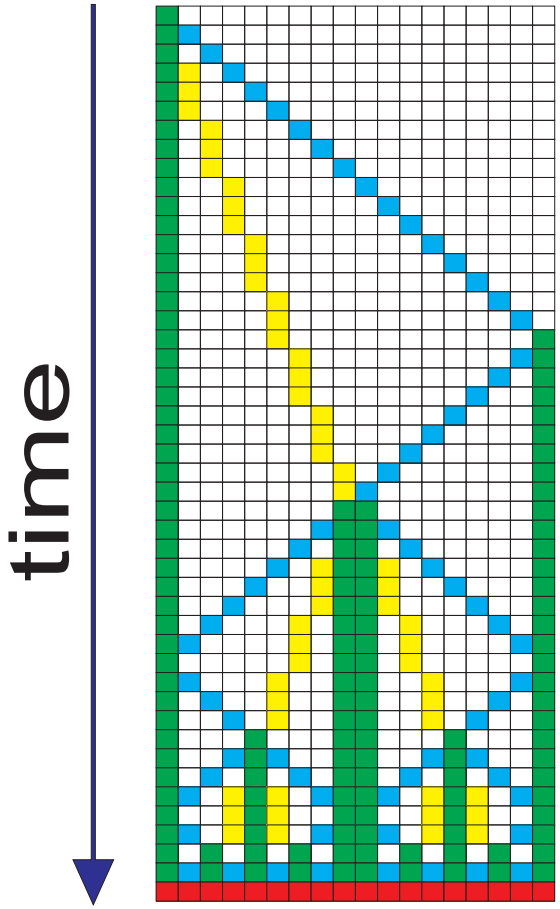
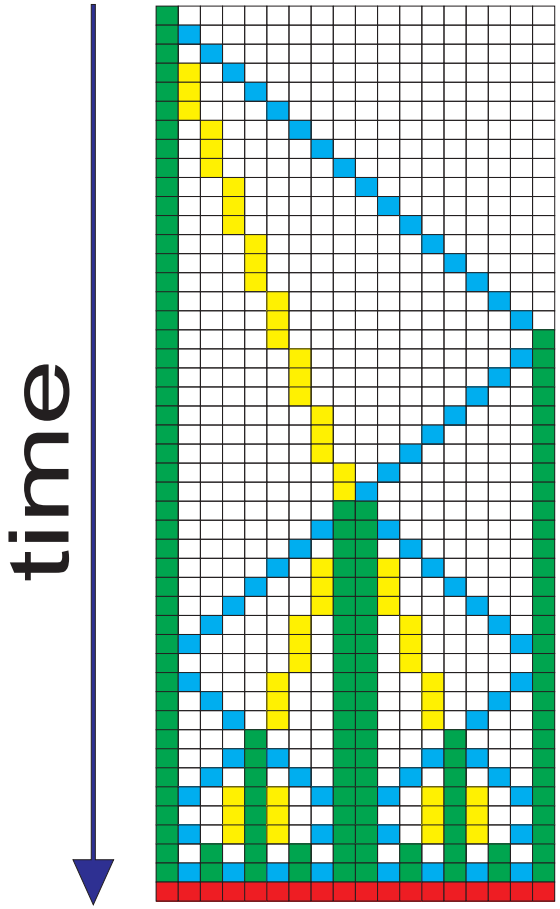


- Information is passed to every node.
- All of them knows, when they have to fire.

Example



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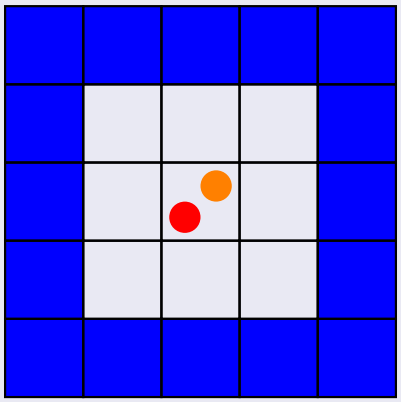
Example - BitTorrent simulation

9 node network



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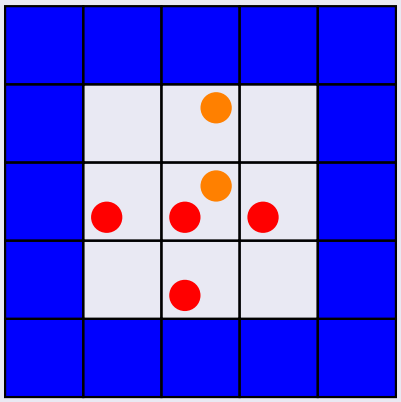

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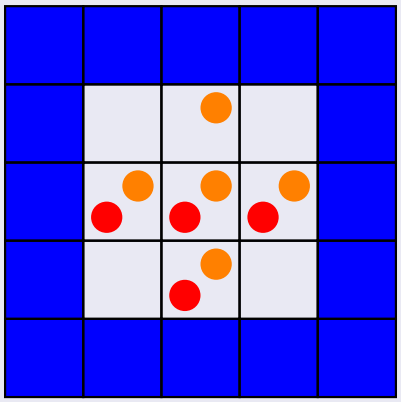

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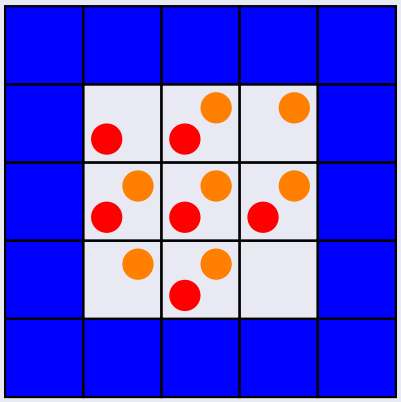

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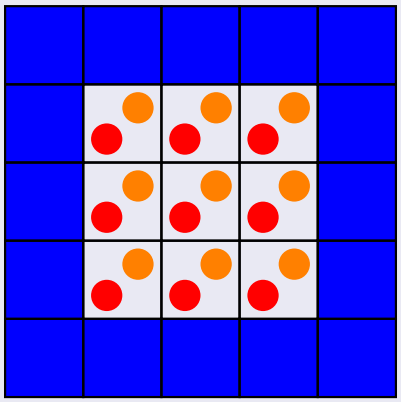

Main bibliography

Lindenmayer, A. – Rozenberg, G.: *Automata, Languages, Development*, North-Holland, 1976

Farmer, J. D. – Toffoli, T. – Wolfram, S.: *Cellular Automata: Proceedings of an Interdisciplinary Workshop at Los Alamos,* New Mexico, March 7-11, 1983, North-Holland, 1984

Mullender, S.: *Distributed systems*, Wokingham: Addison-Wesley, 2nd ed., 1993

Anceaume, E. – Puaut, I.: *Performance evaluation of clock synchronization algorithms,* Technical report, RR-3526, INRIA, Rennes, France, 1998

Tanembaum, A. – van Steen, M.: Distributed systems: Principles and paradigms, *Prentice-Hall*, 2004