Self-Stabilizing Broadcast with O(1)-Bit Messages*

Emanuele Natale†

joint work with

Lucas Boczkowski* and Amos Korman*

* CNRS IRIF INSTITUT DE RECHERCHE EN INFORMATIQUE FONDAMENTALE

† SAPIENZA UNIVERSITÀ DI ROMA

4th Workshop on Biological Distributed Algorithms (BDA)

July 25-29, 2016

Chicago, Illinois

*preprint at **goo.gl/ETNc64**

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(Bit Dissemination)

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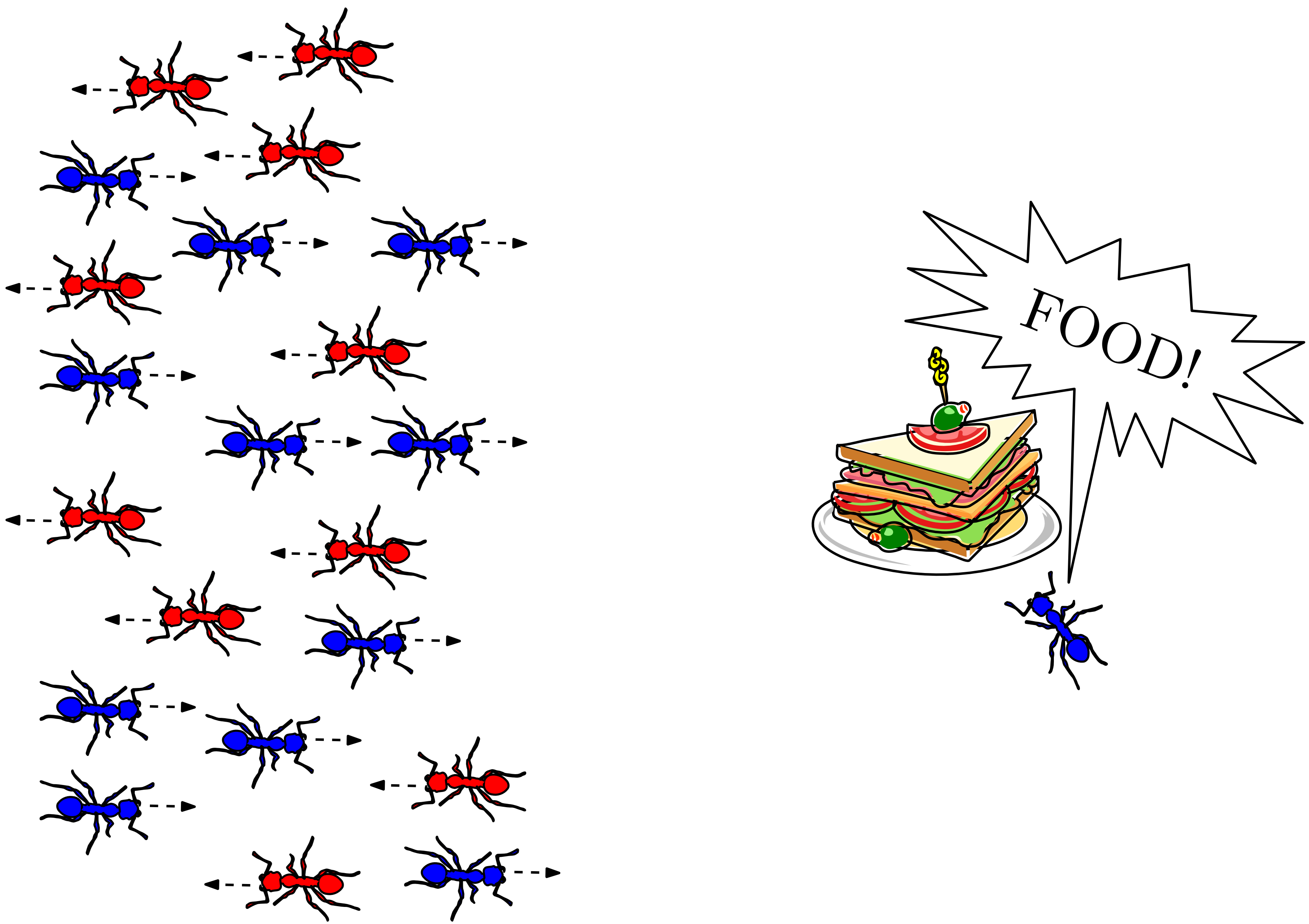
Bit Dissemination Problem



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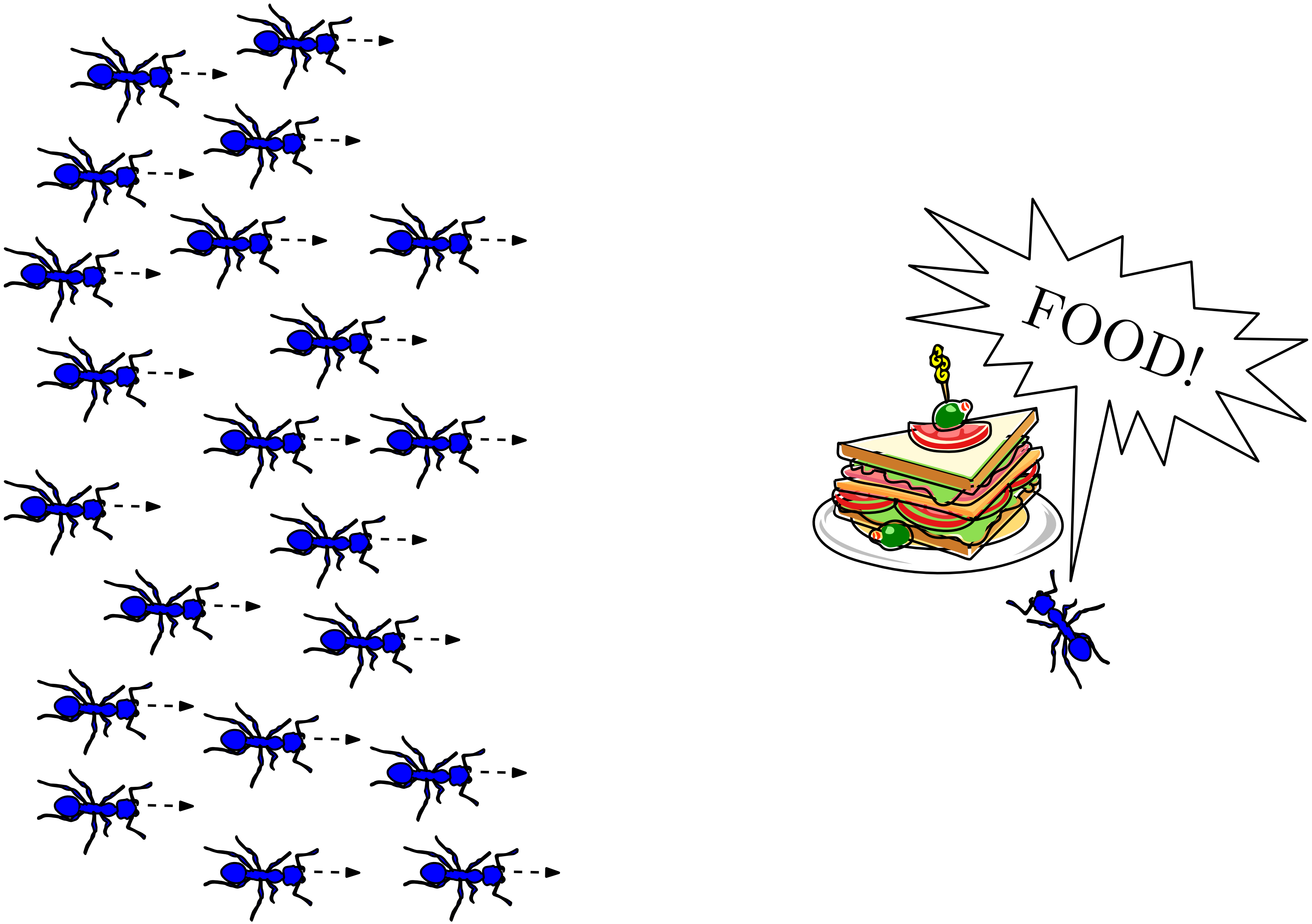

Examples

Flocks of birds
[Ben-Shahar et al. '10]

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Schools of fish
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Insects colonies
[Franks et al. '02]

Communication Model

Animal communication:

- Chaotic
- Anonymous
- Passive
- Parsimonious

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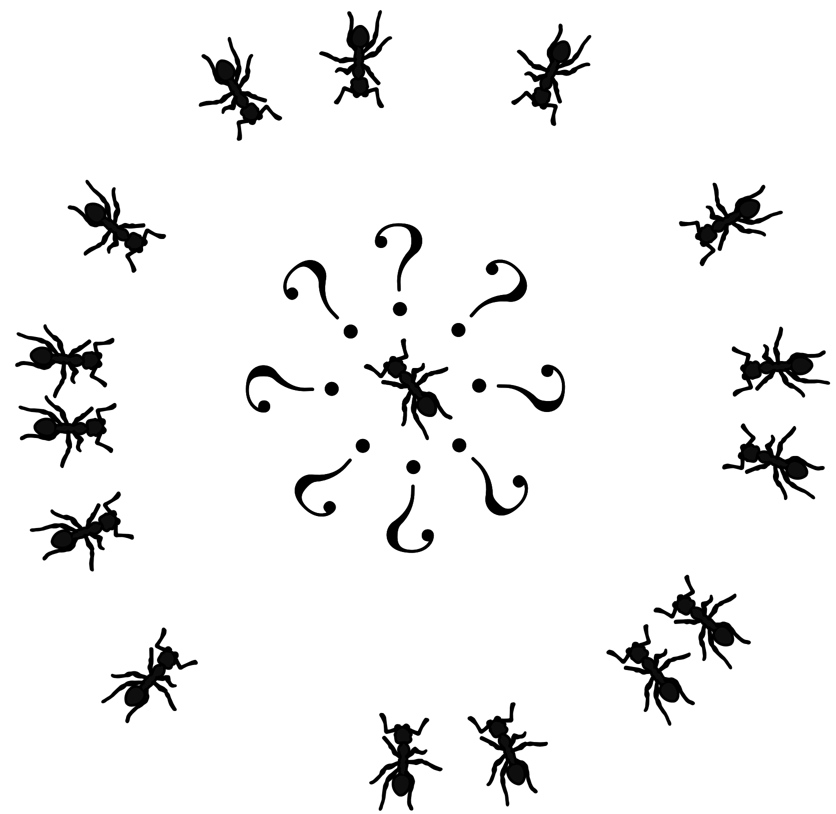
$\mathcal{PULL}(h, \ell)$ **model [Demers '88]**: at each round each agent can *observe* h other agents chosen independently and uniformly at random, and *shows* ℓ *bits* to her observers.



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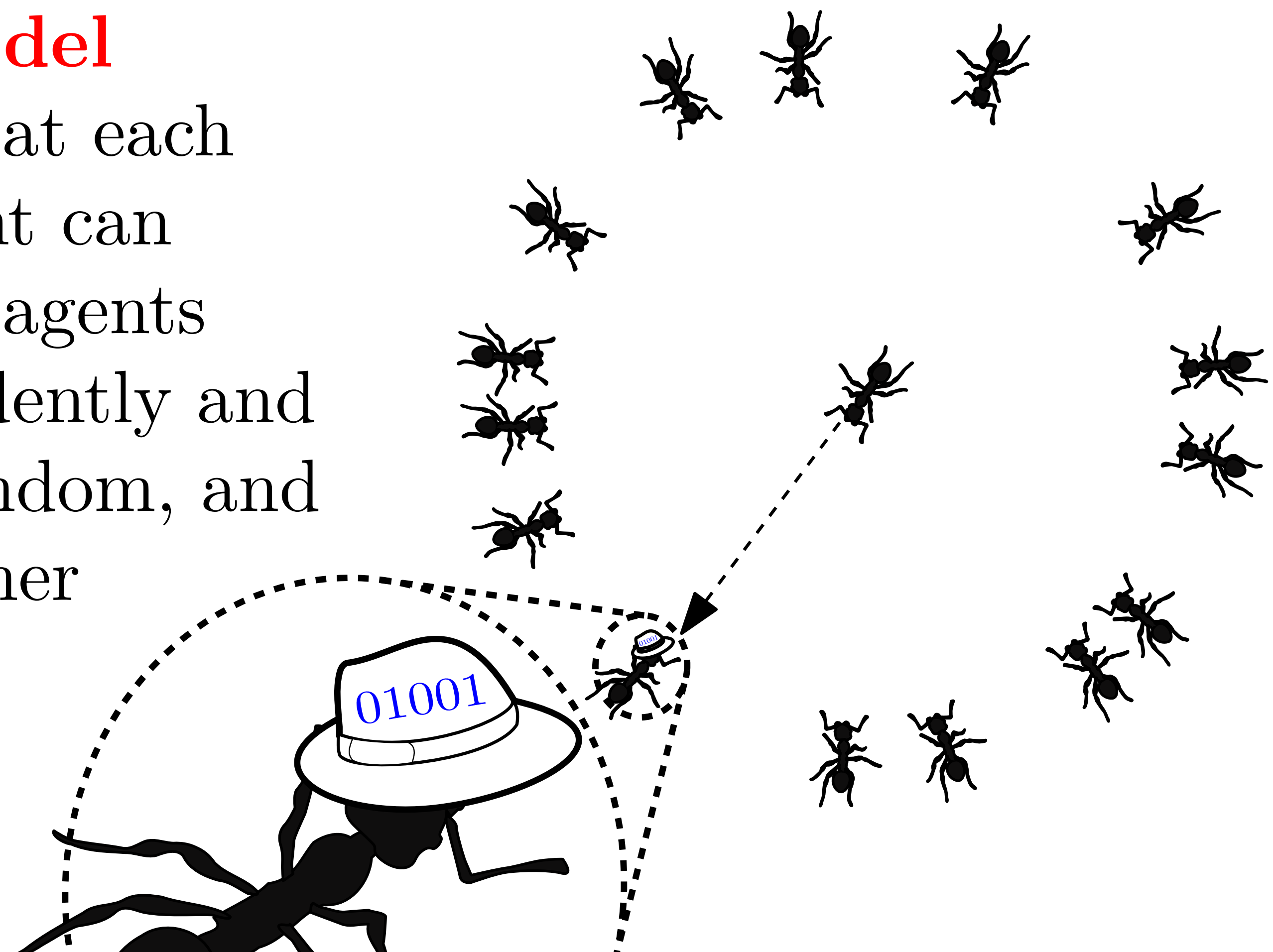

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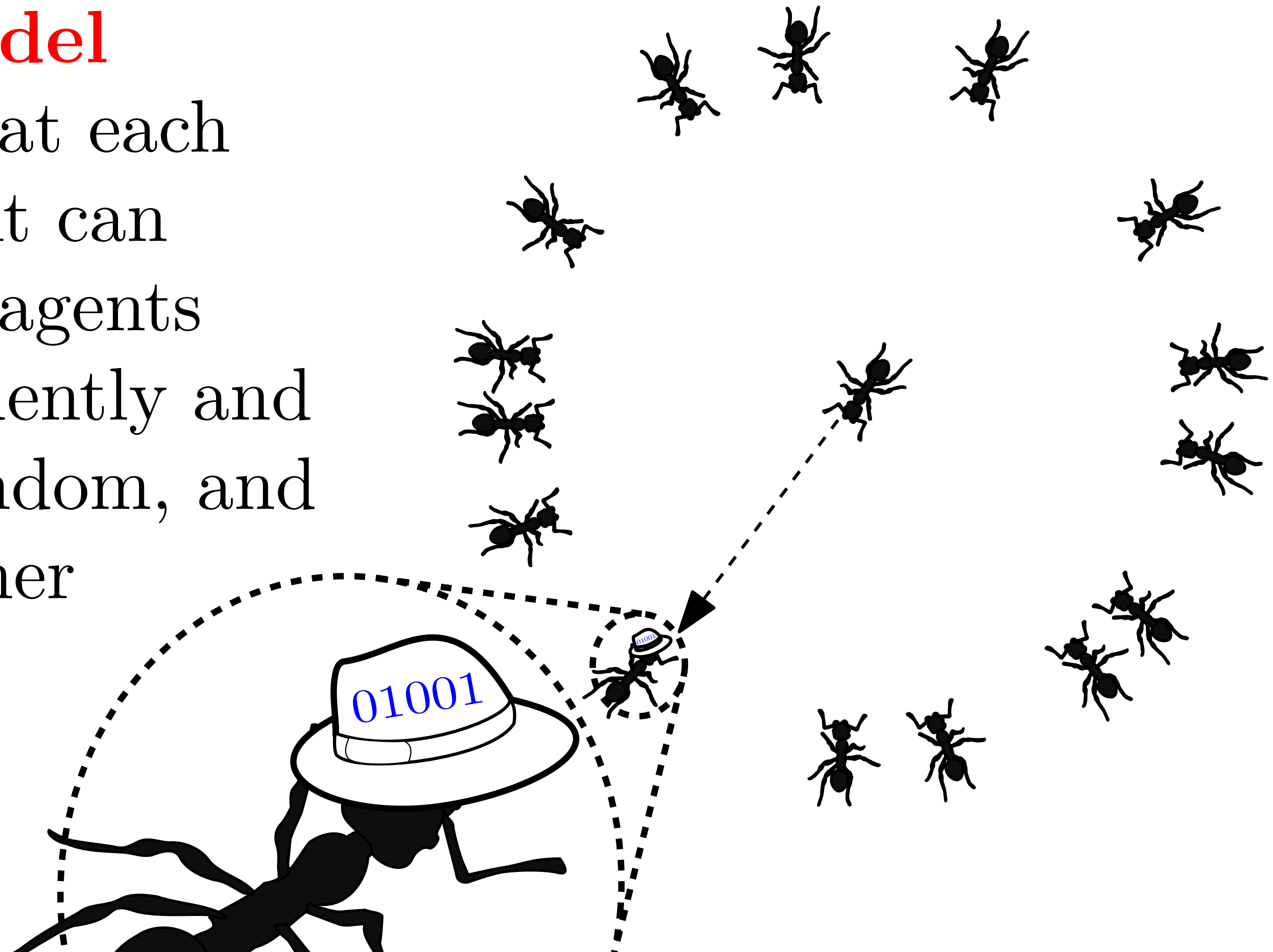

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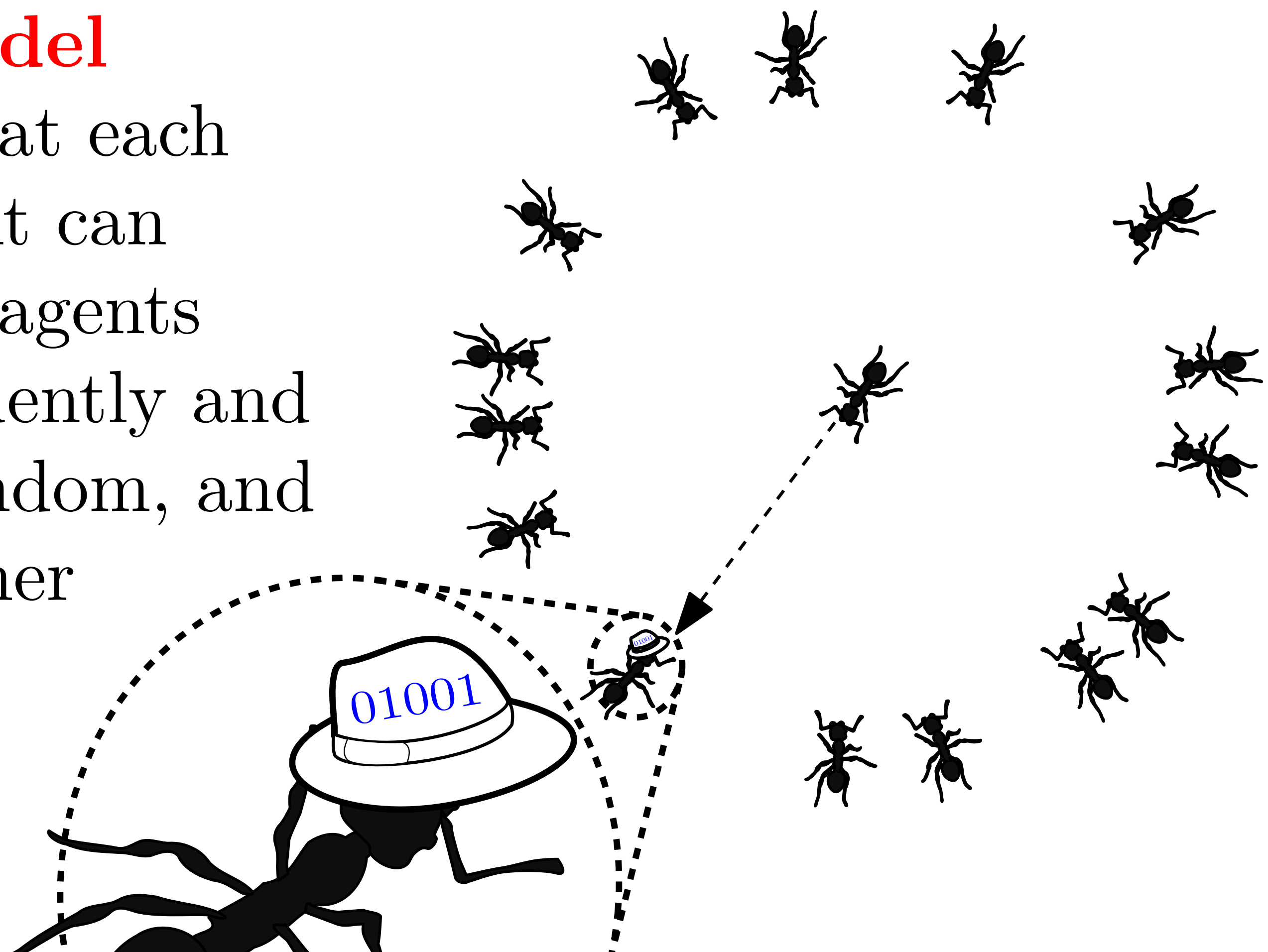
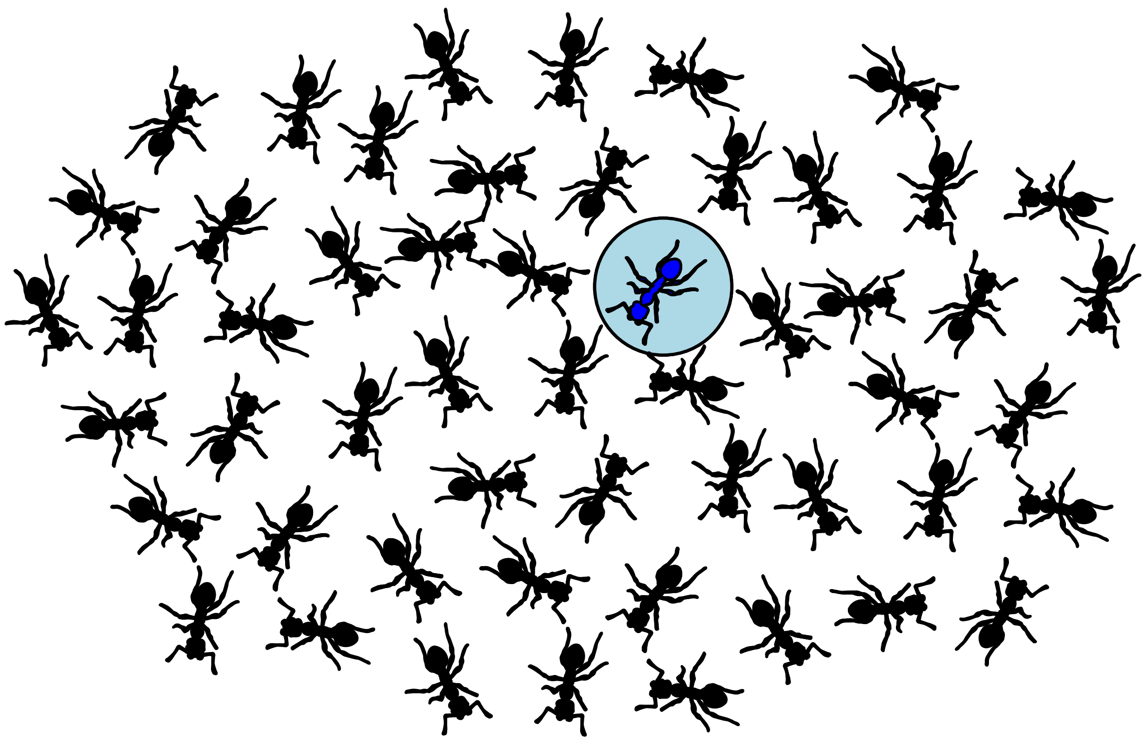


(Probabilistic) Self-Stabilization

Sources' bits (and other agents' states) may change in response to *external environment*



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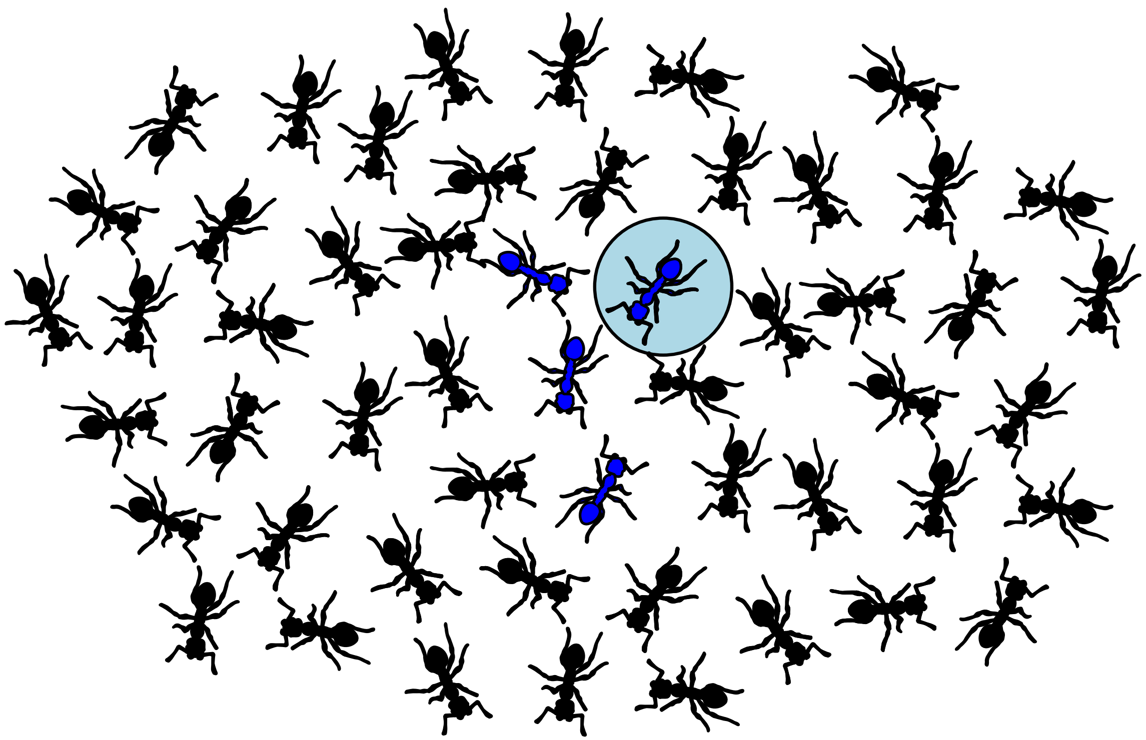

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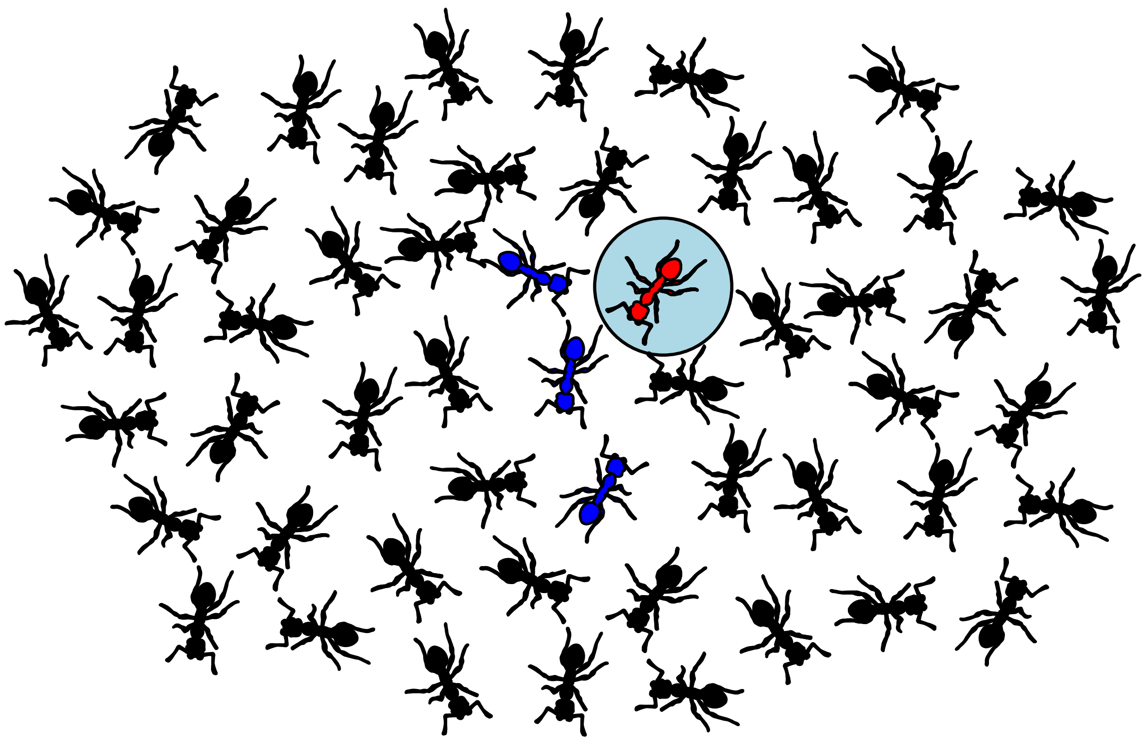

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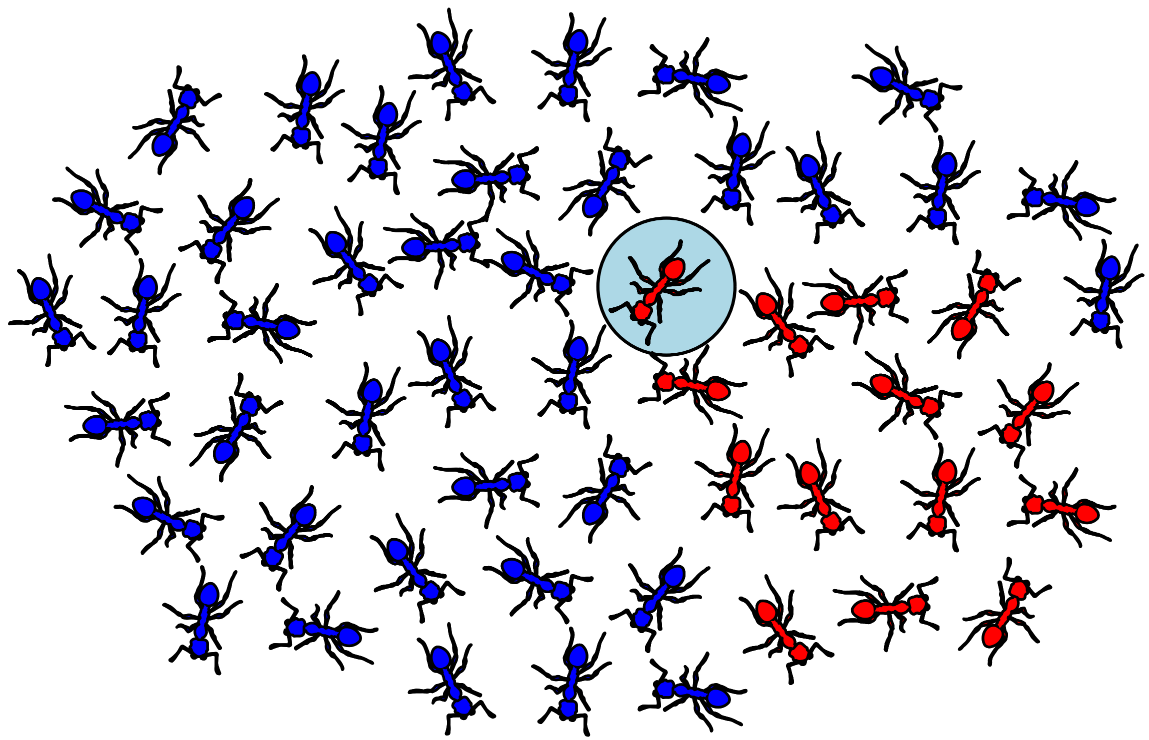


blue vs red:
$39/14 \approx 2.8$

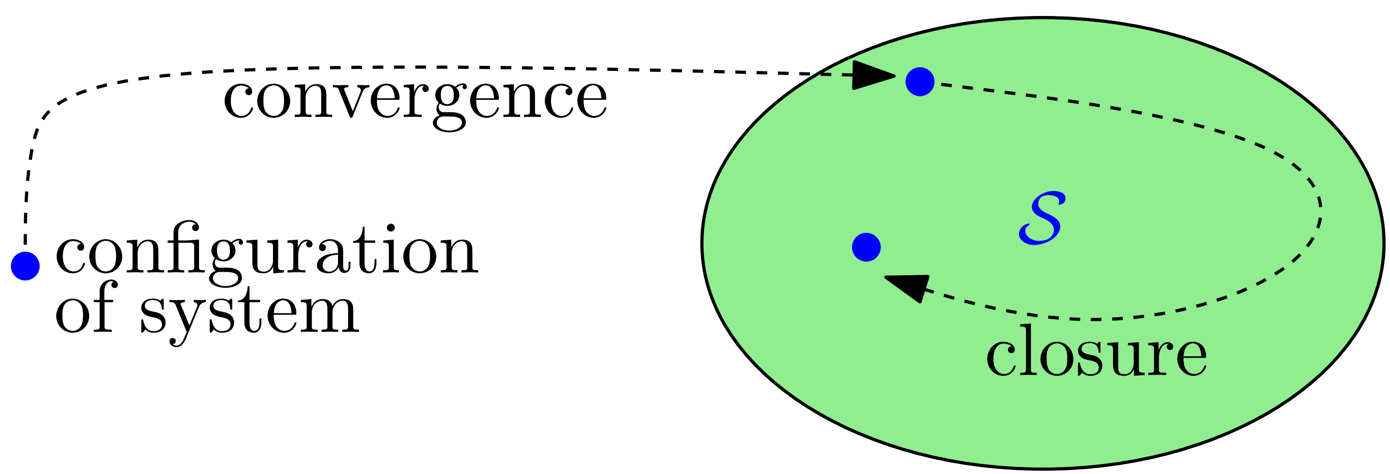
(Probabilistic) Self-Stabilization

(Probabilistic) self-stabilization:

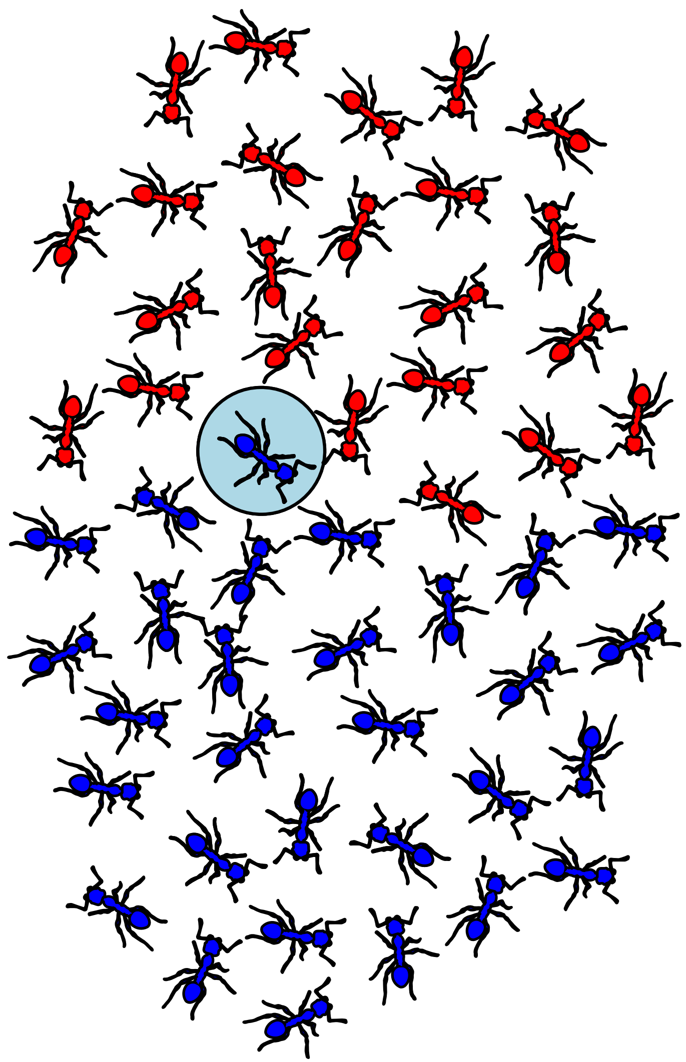
$\mathcal{S} := \{$"correct configurations of the system" $\}$
(= consensus on source's bit)

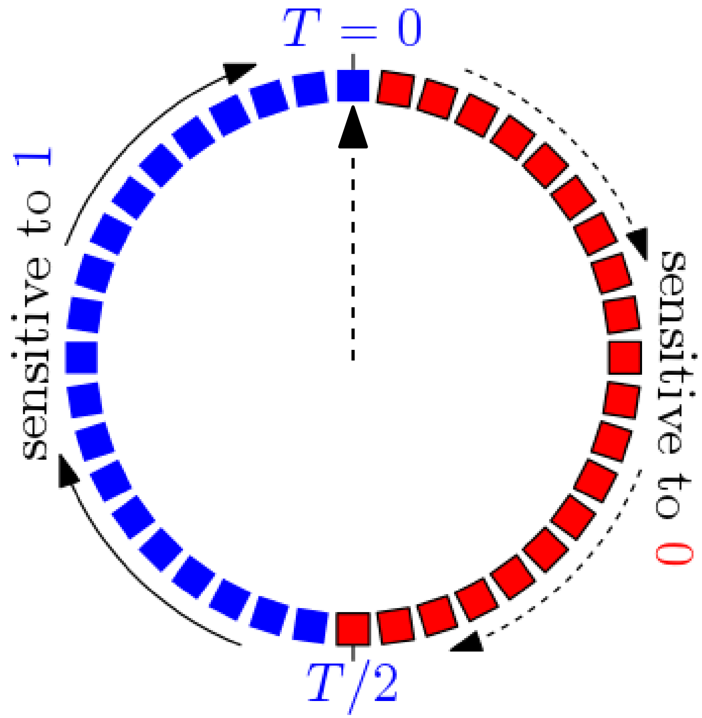
- **Convergence.** From *any* initial configuration, the system reaches $\mathcal{S}$ (w.h.p.)
- **Closure**. If in $\mathcal{S}$, the system stays in $\mathcal{S}$ (w.h.p.)

(Probabilistic) Self-stabilizing algorithm:
guarantees *convergence* and *closure* w.r.t. $\mathcal{S}$ *(w.h.p.)*



(Self-Stab.) Bit Dissemination vs Synchronization





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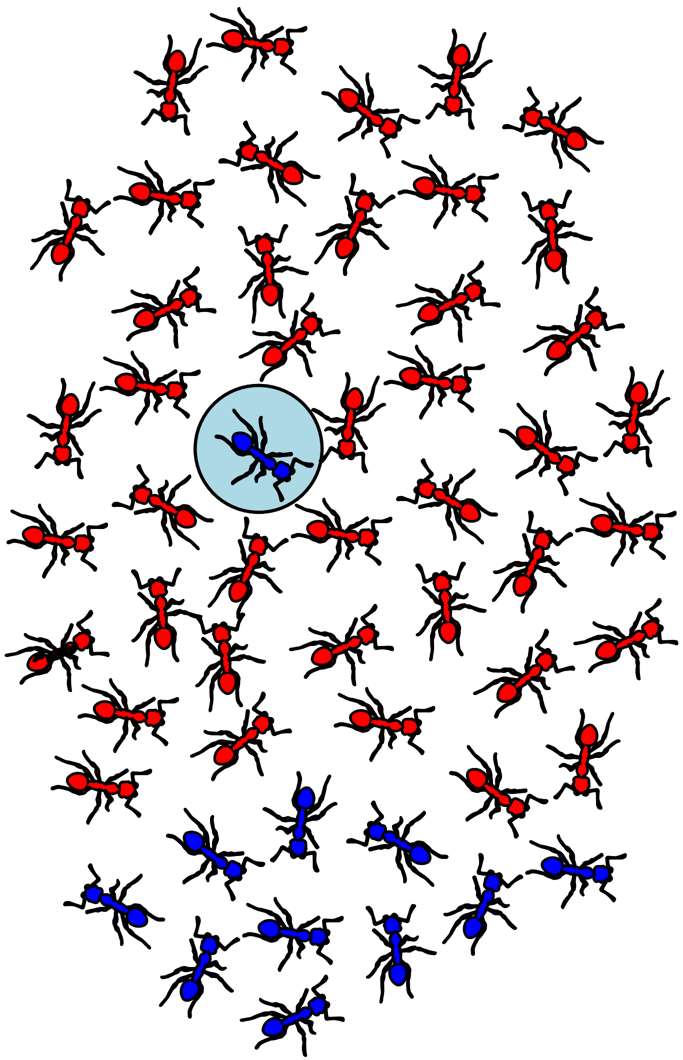

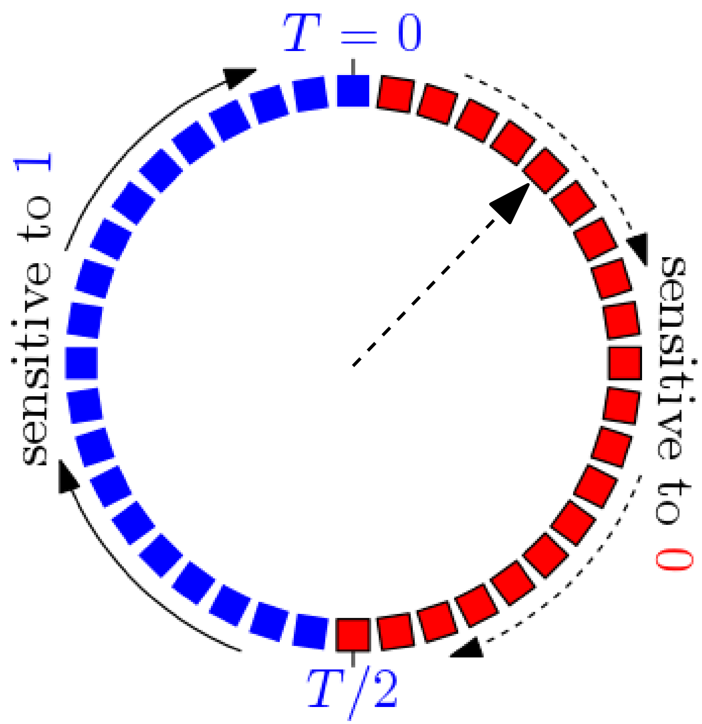

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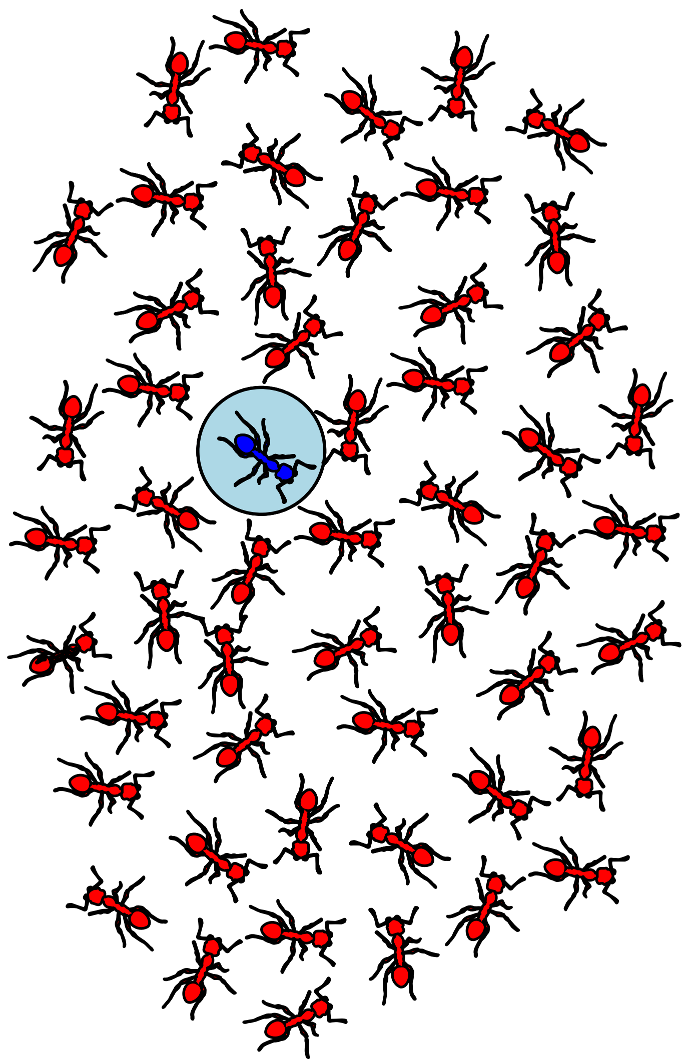

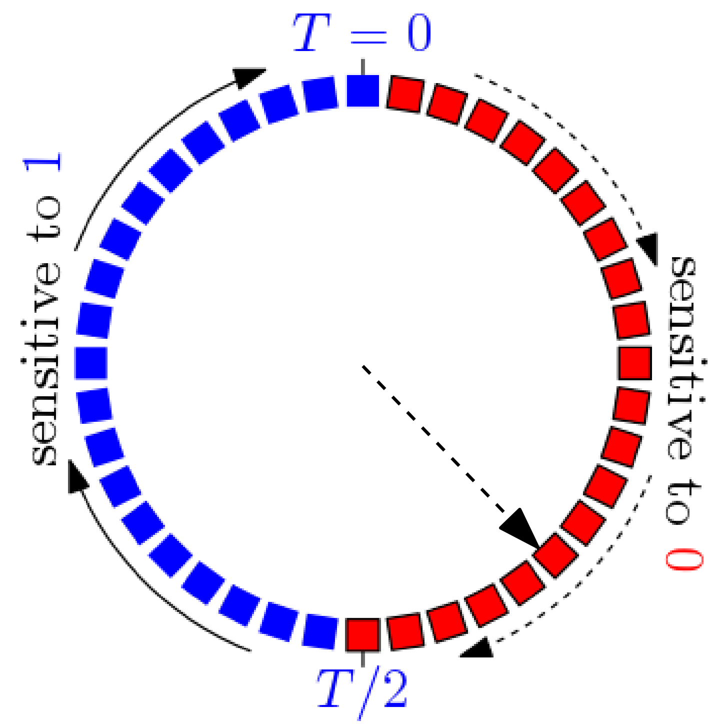

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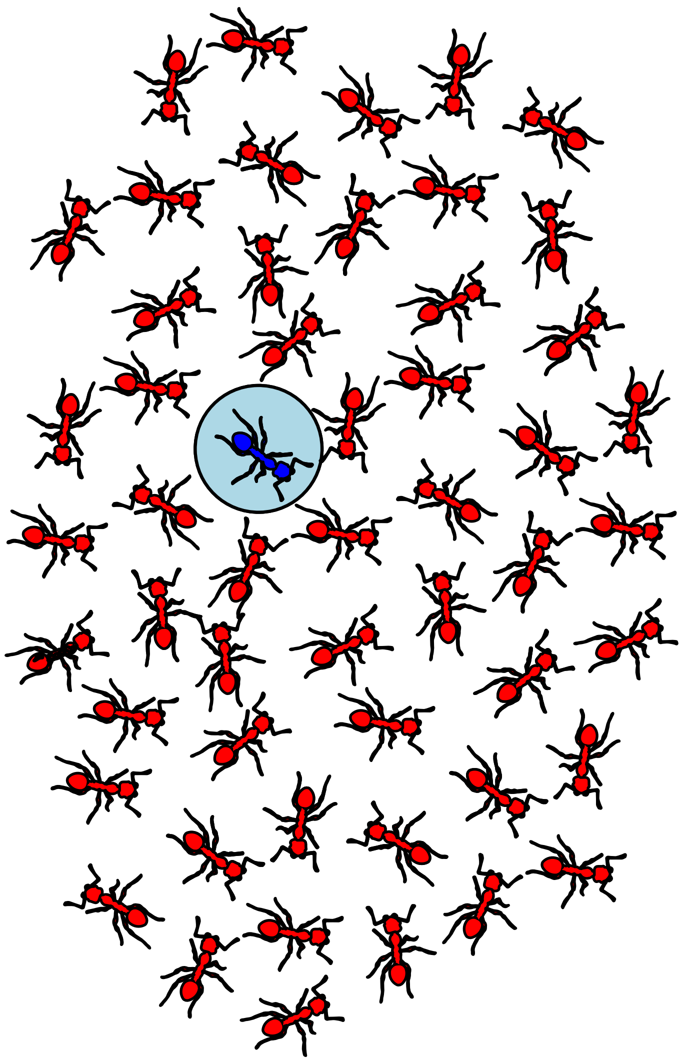

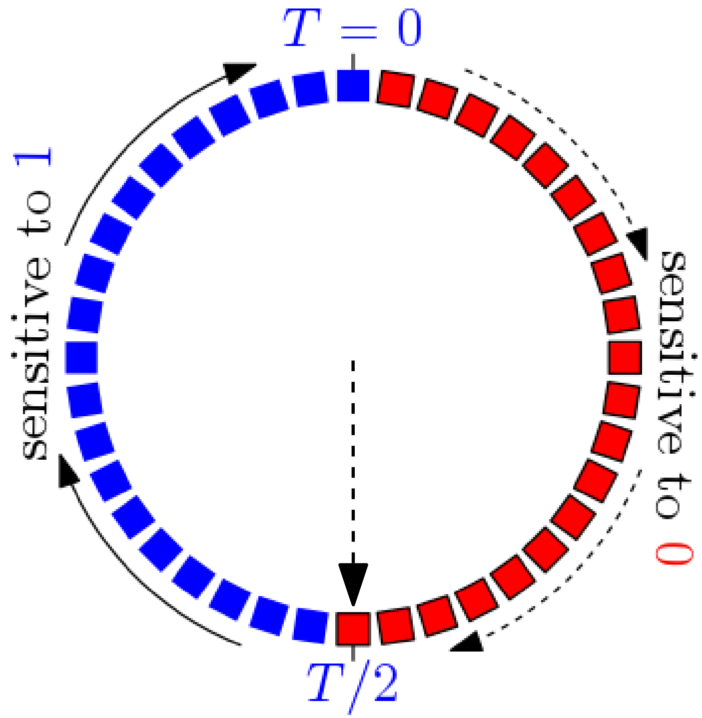

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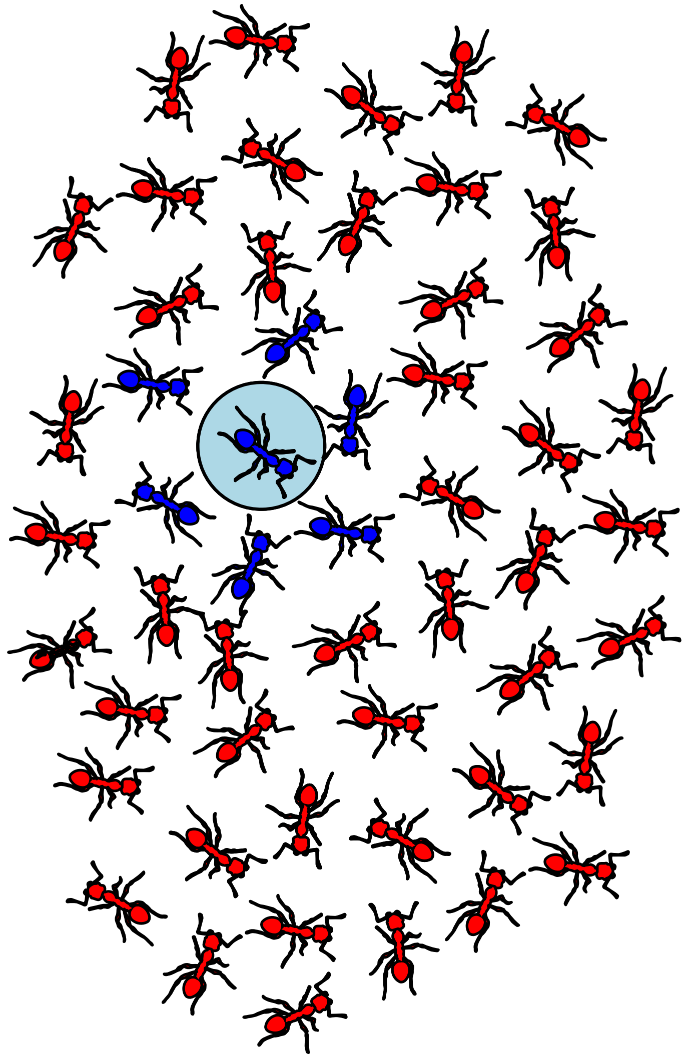

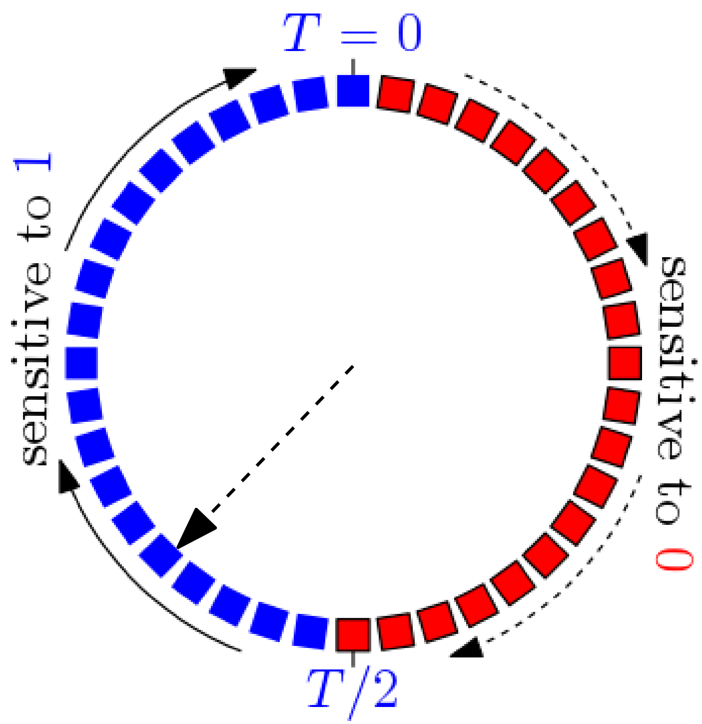

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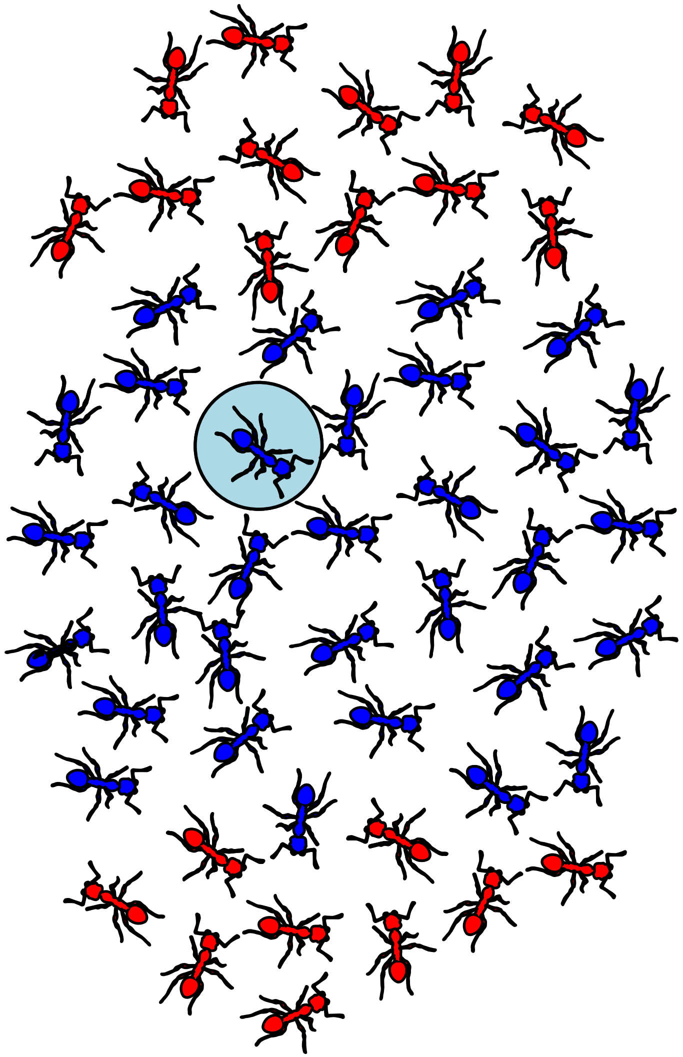

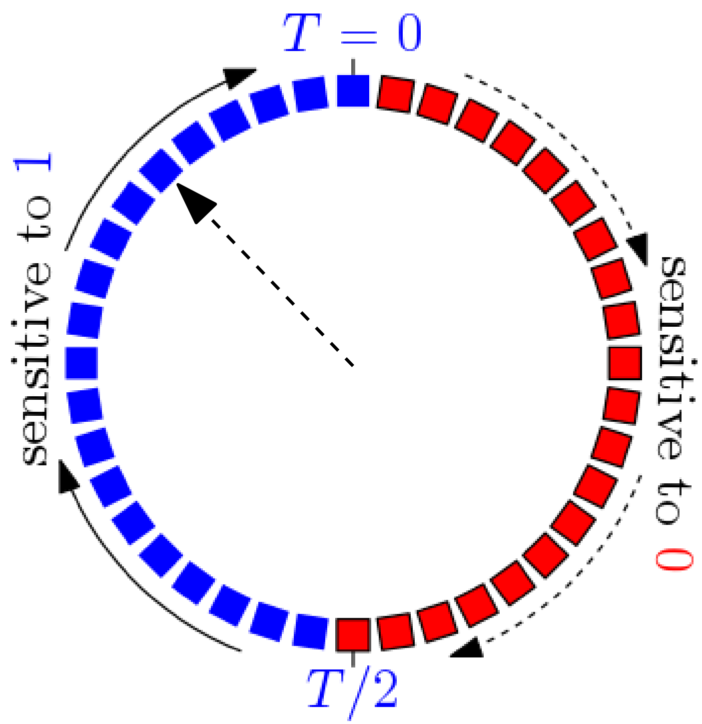

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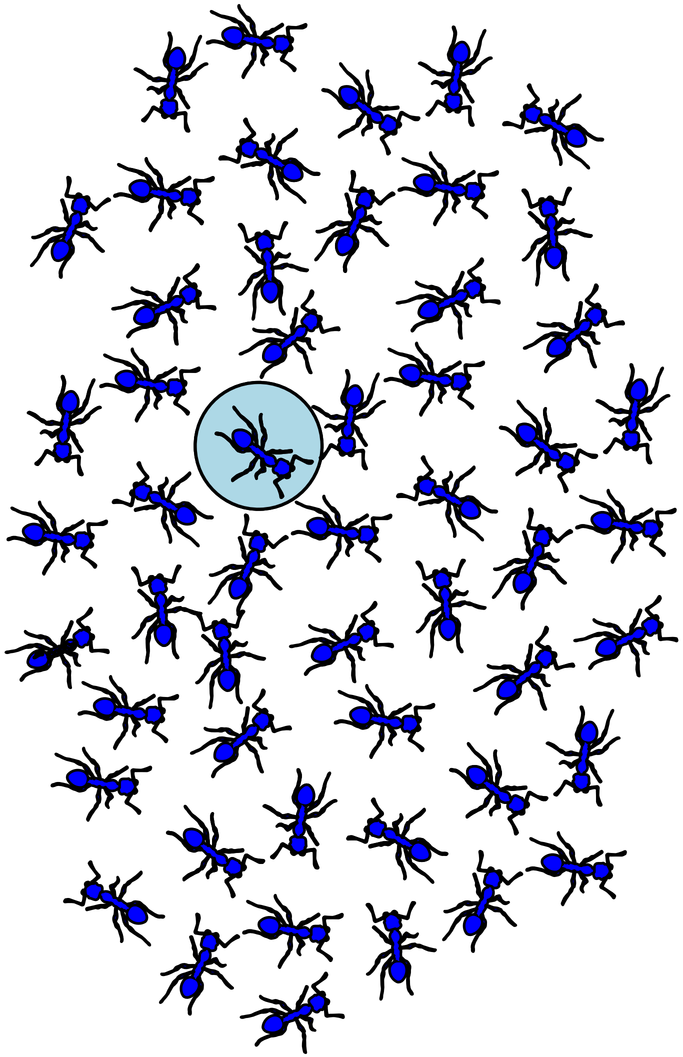
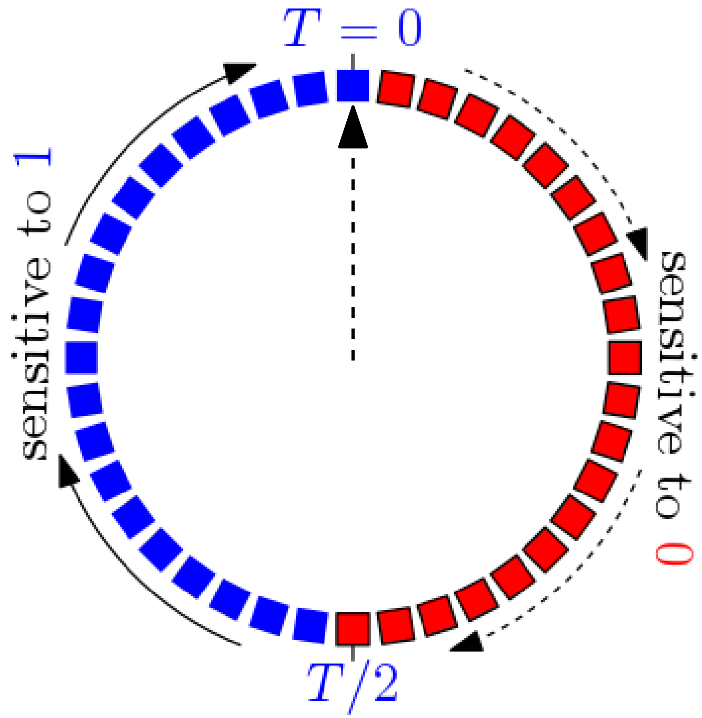
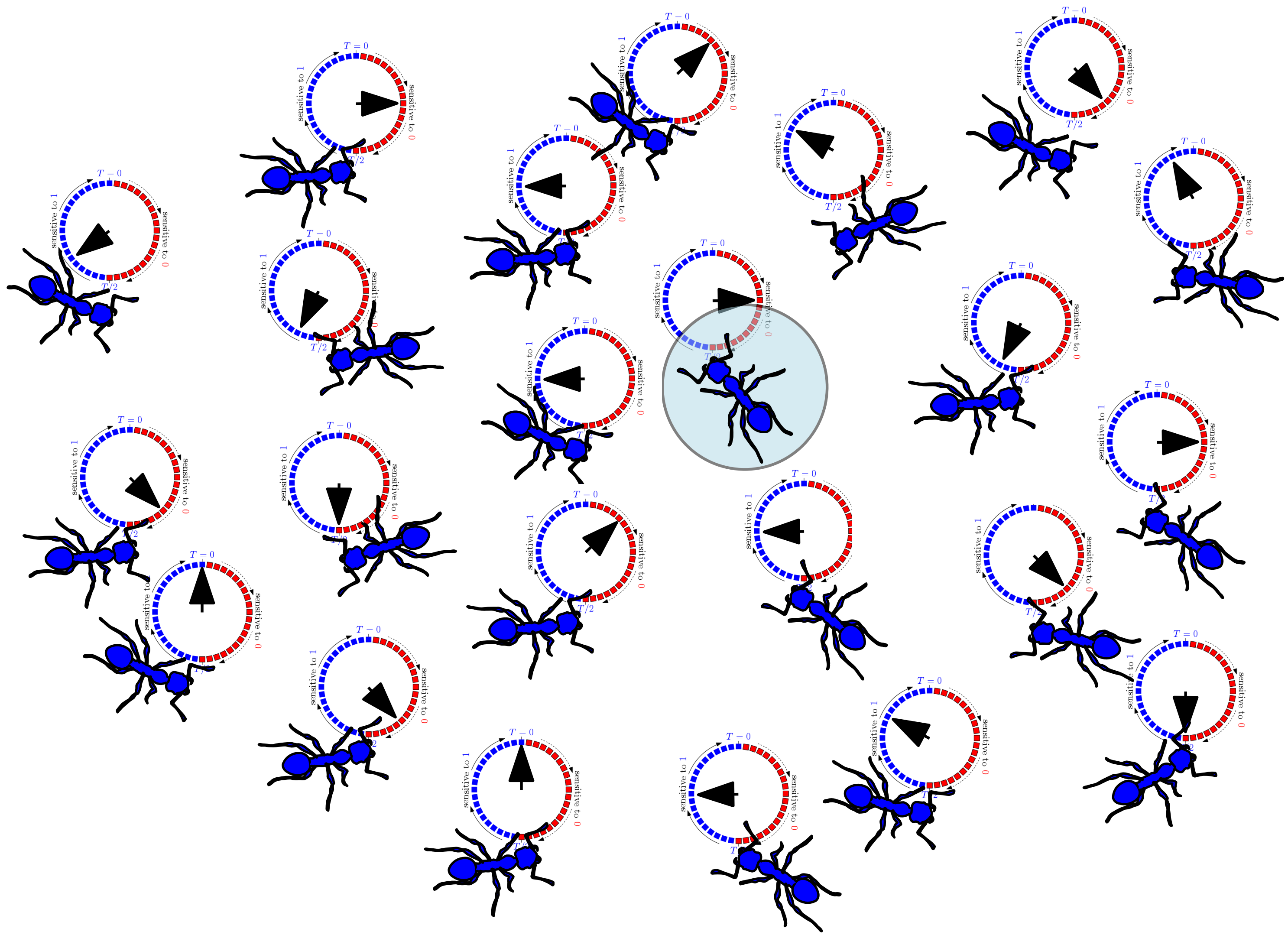


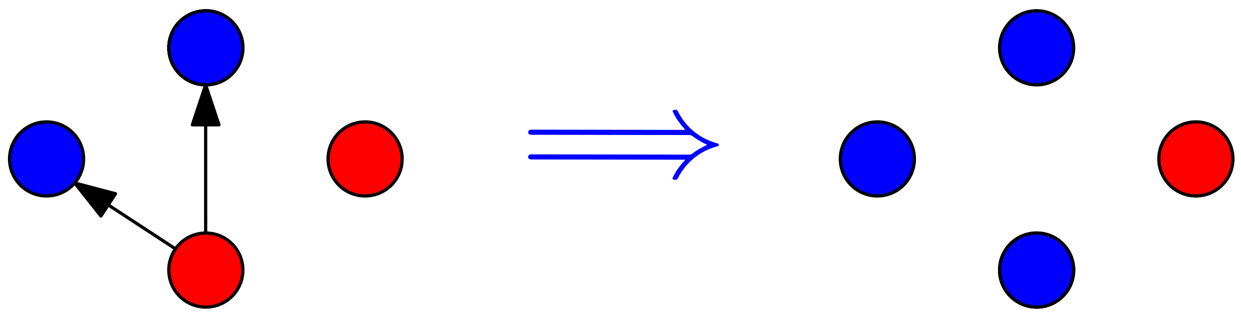


(Self-Stab.) Bit Dissemination vs Synchronization

Self-stablizing algorithms converge from
any initial configuration



Self-Stabilizing Clock Sync. in the $\mathcal{PULL}$ Model



2-Majority dynamics [Doerr et al. '11]. Converge to consensus in $\mathcal{O}(\log n)$ rounds with high probability.

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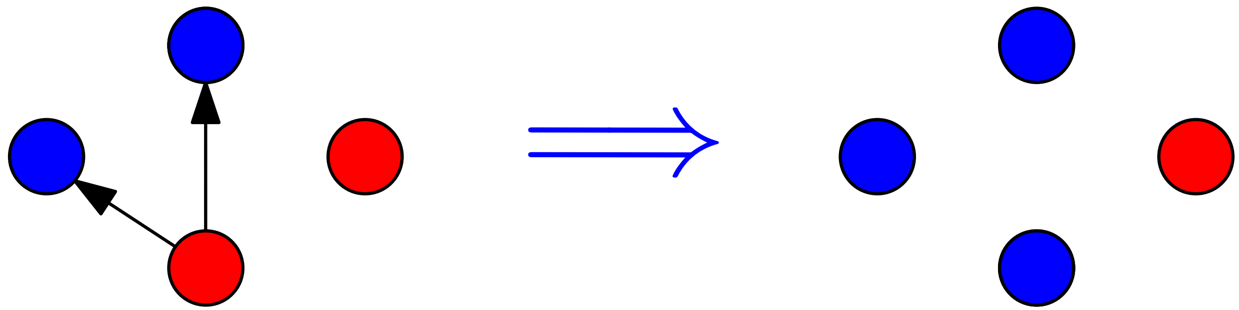

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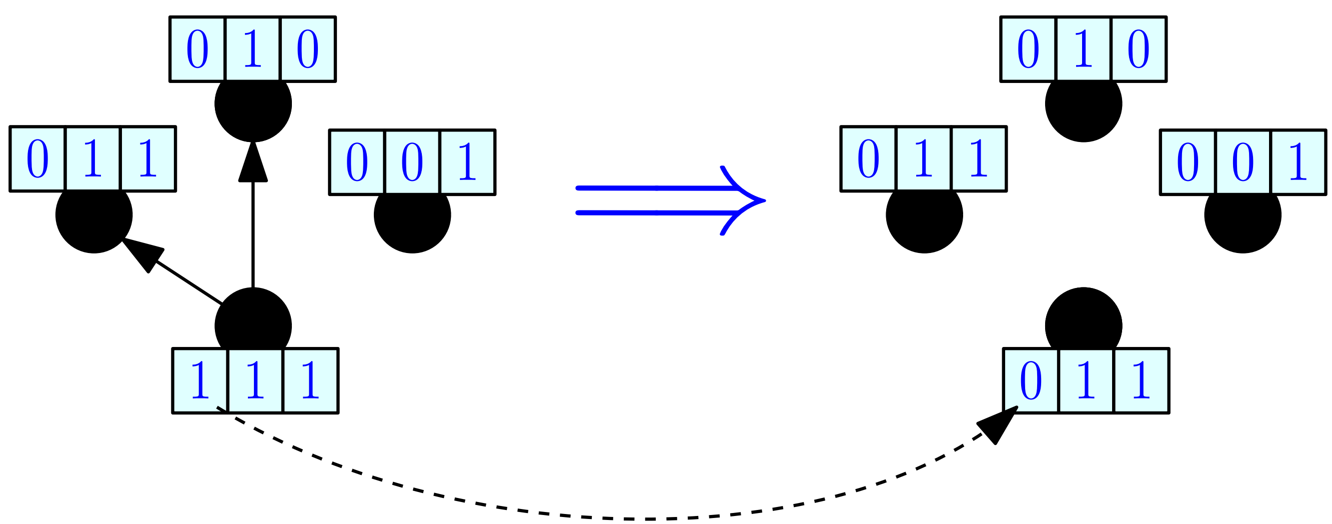

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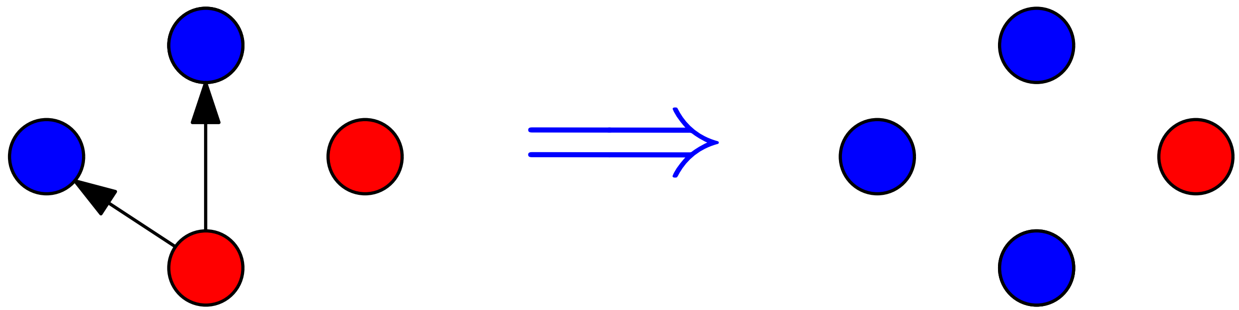

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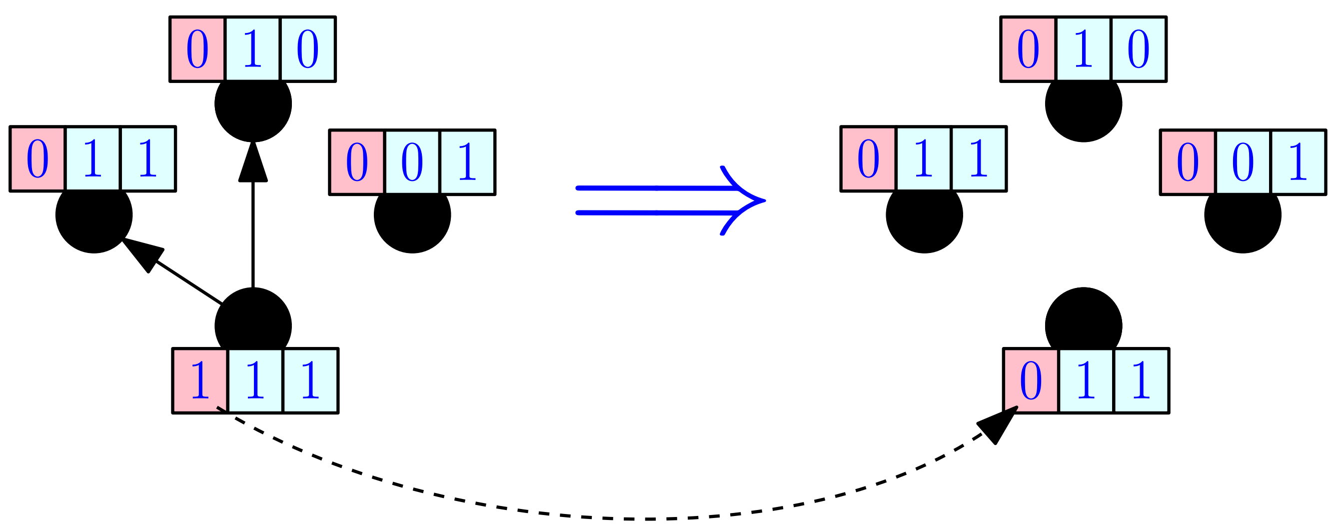

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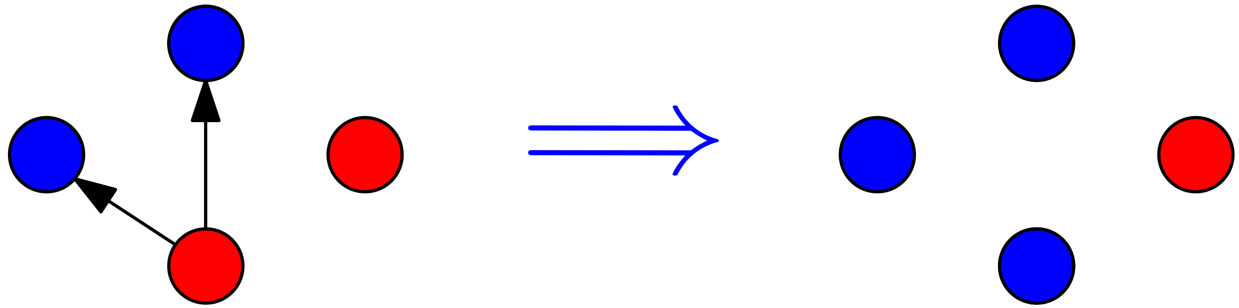

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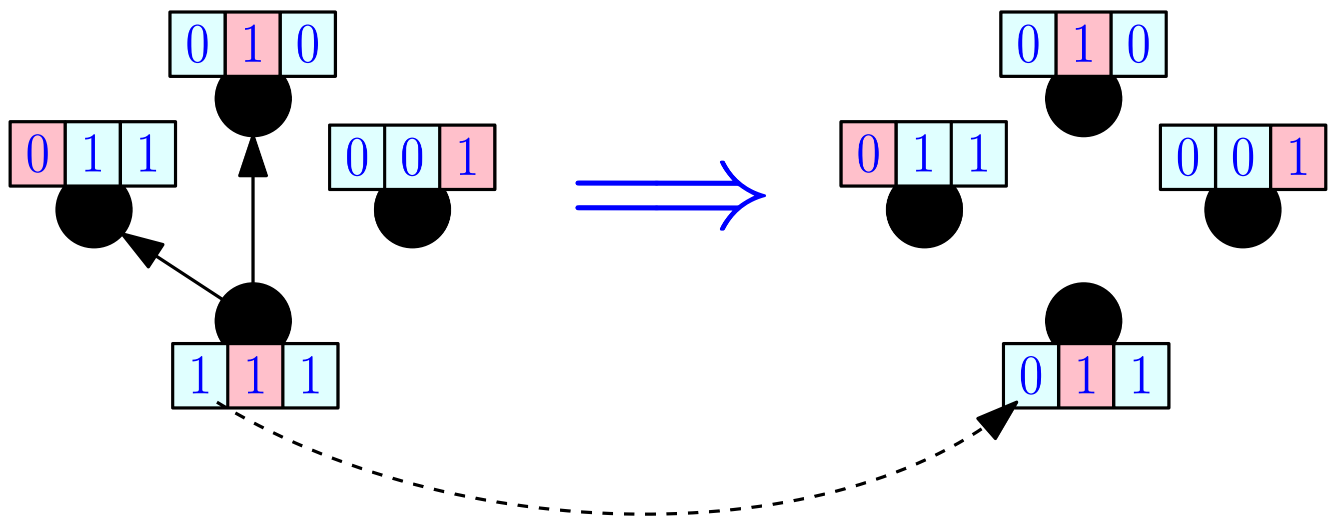

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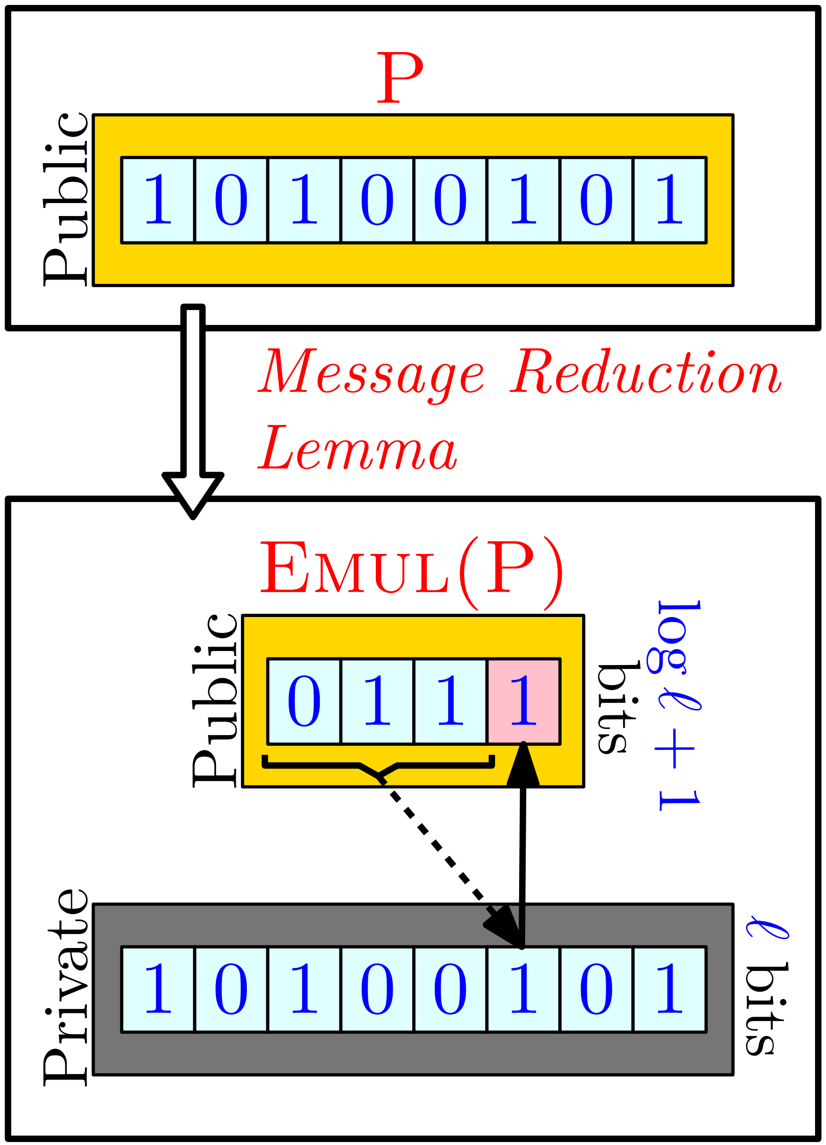

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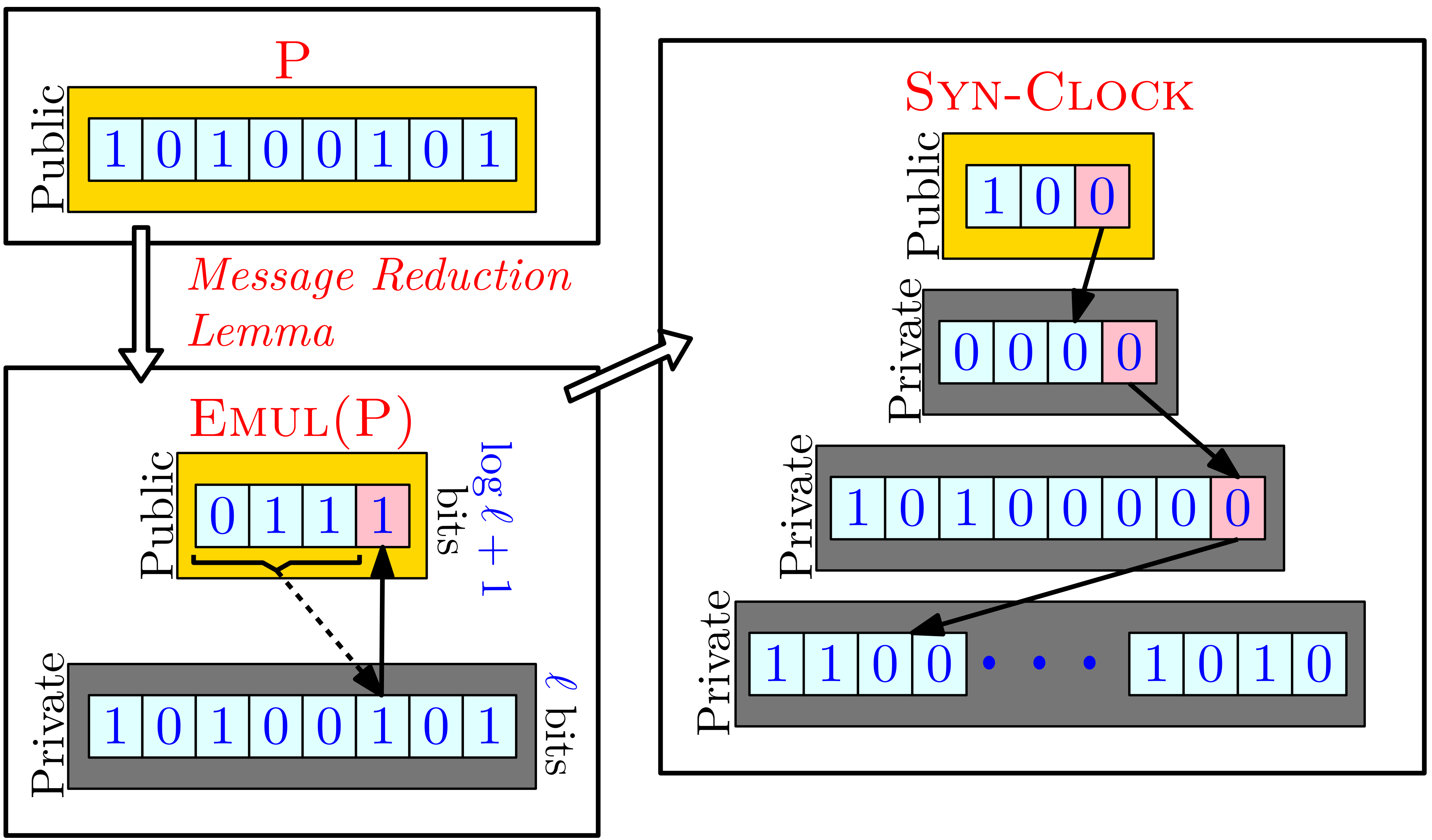

Results

Theorem (Clock Syncronization).
SYN-CLOCK is a *self-stabilizing* clock synchronization protocol which synchronizes a clock modulo T in $\tilde{\mathcal{O}}(\log n \log T)$ rounds w.h.p. using 3-bit messages.

Theorem (Self-Stabilizing Bit Dissemination).
There is a *self-stabilizing* Bit Dissemination protocol which converges in $\tilde{\mathcal{O}}(\log n)$ rounds w.h.p using 3-bit messages.

Self-Stab. Bit Diss. with 1 bit: a Candidate

BFS(f, s). Agents can *boosting*, $1/0$-*frozen* or $1/0$-*sensitive*.

- *Boosting*: Update their opinion with majority of their bit and the 2 bits they pull. If they see only agents of color c for s rounds, they become c-*sensitive*.
- c-*sensitive*: Turn into c-*frozen* if see value c.
- c-*frozen* keep value c for f rounds before becoming *boosting*.

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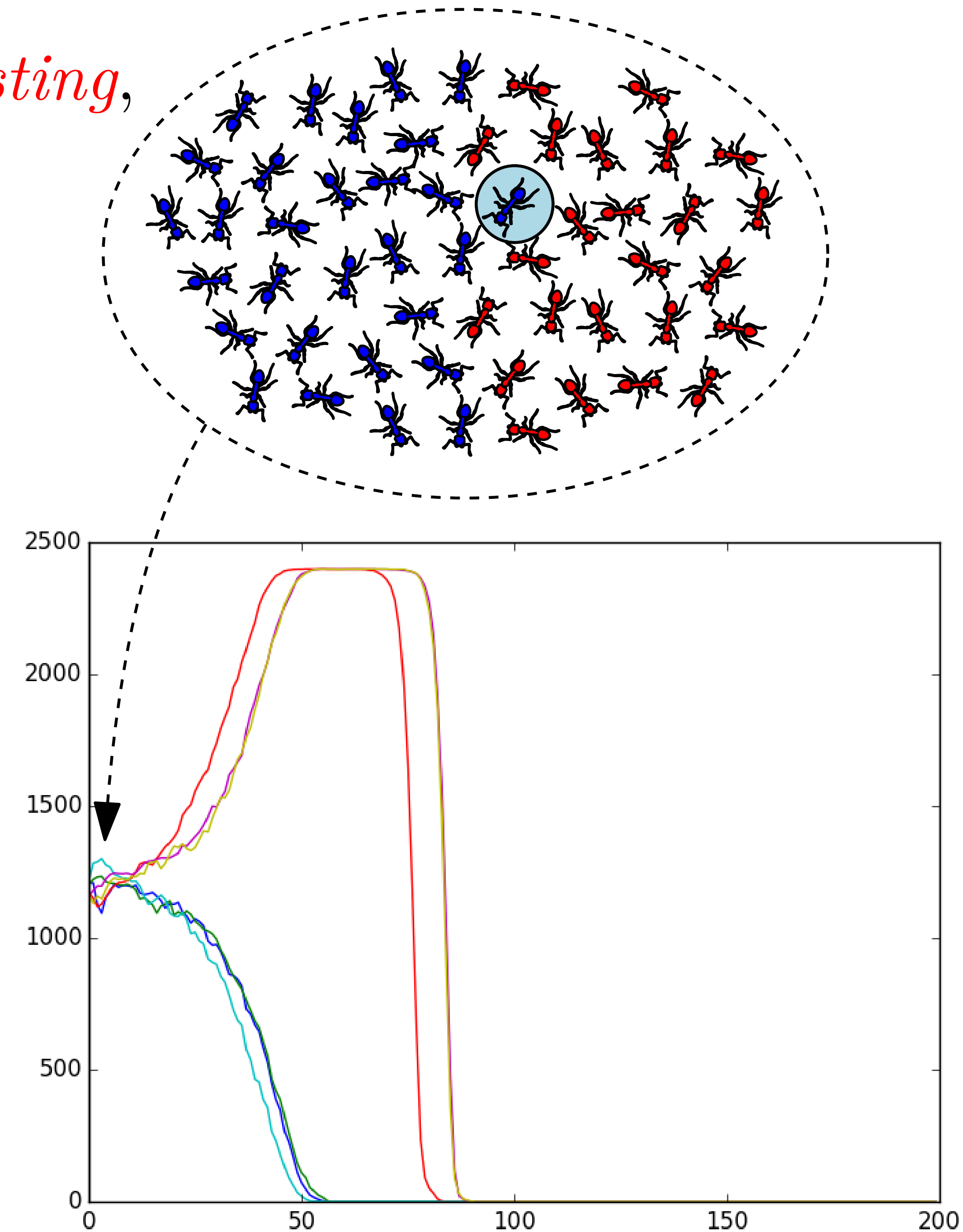

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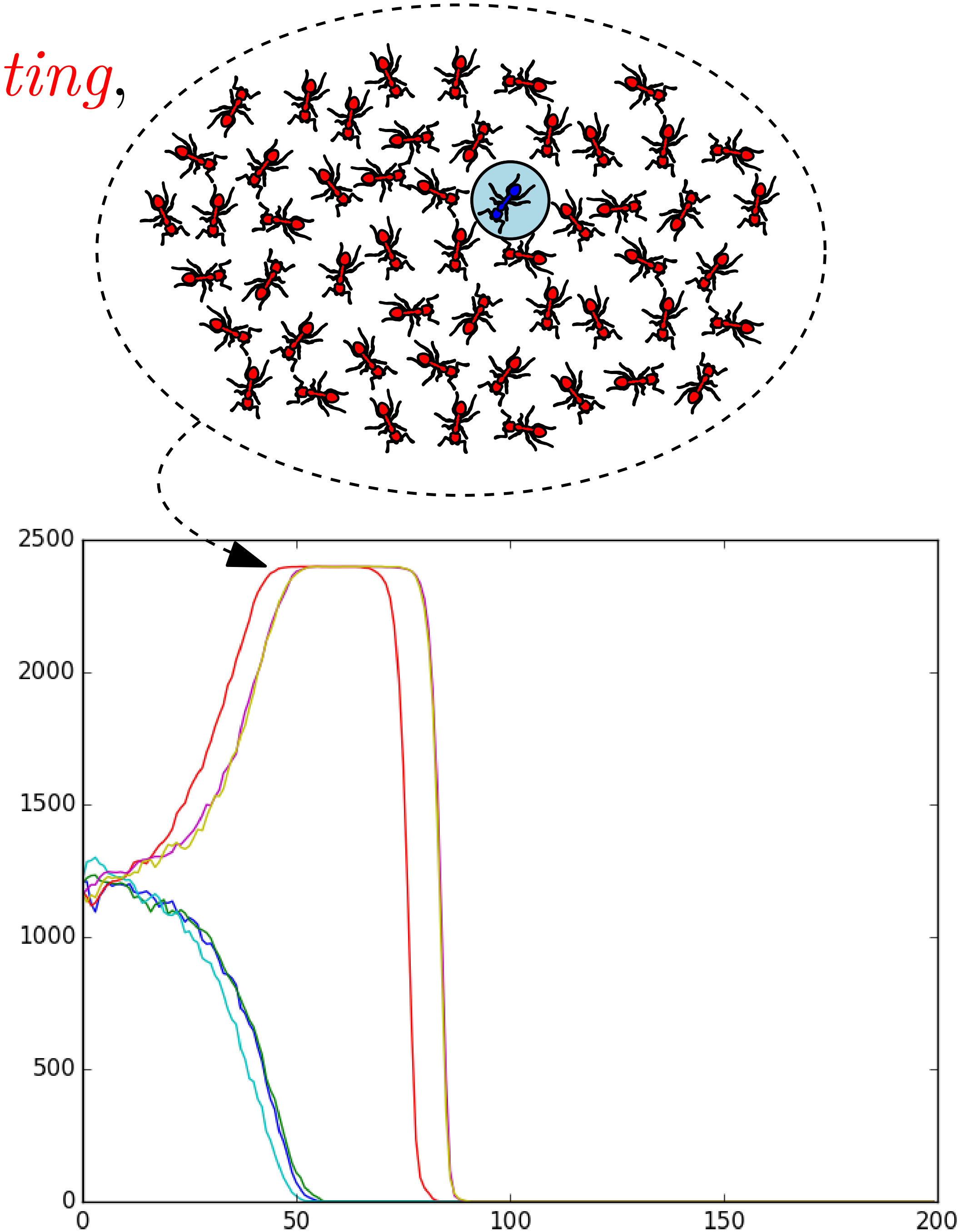

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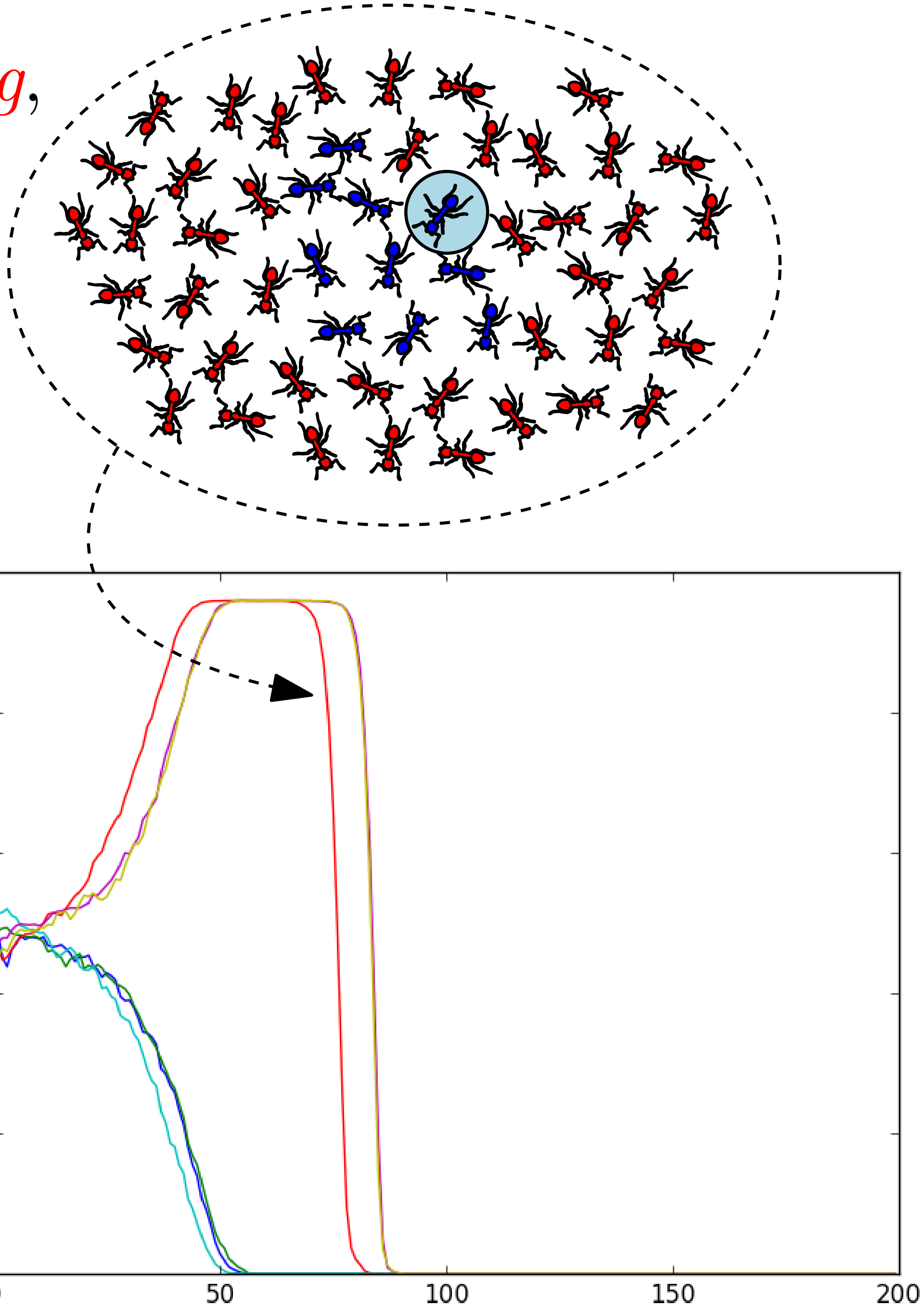

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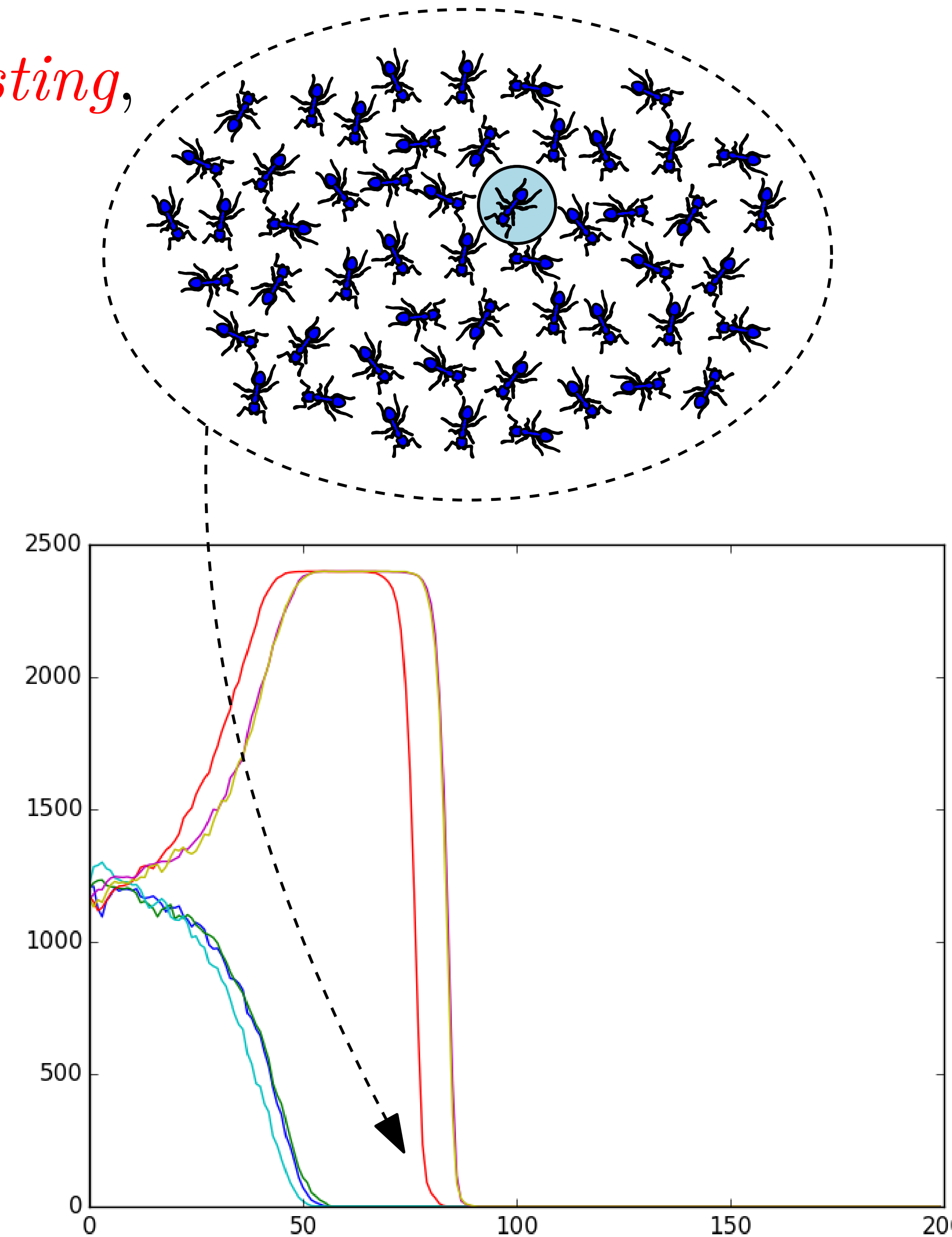

Thank You!