ASTRA: A Tool for Abstract Interpretation of Graph Transformation Systems

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Graph Transformation Systems

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Start Graph + Set of Rules

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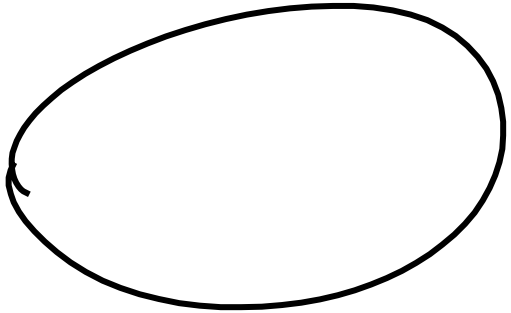
Rule Application: 

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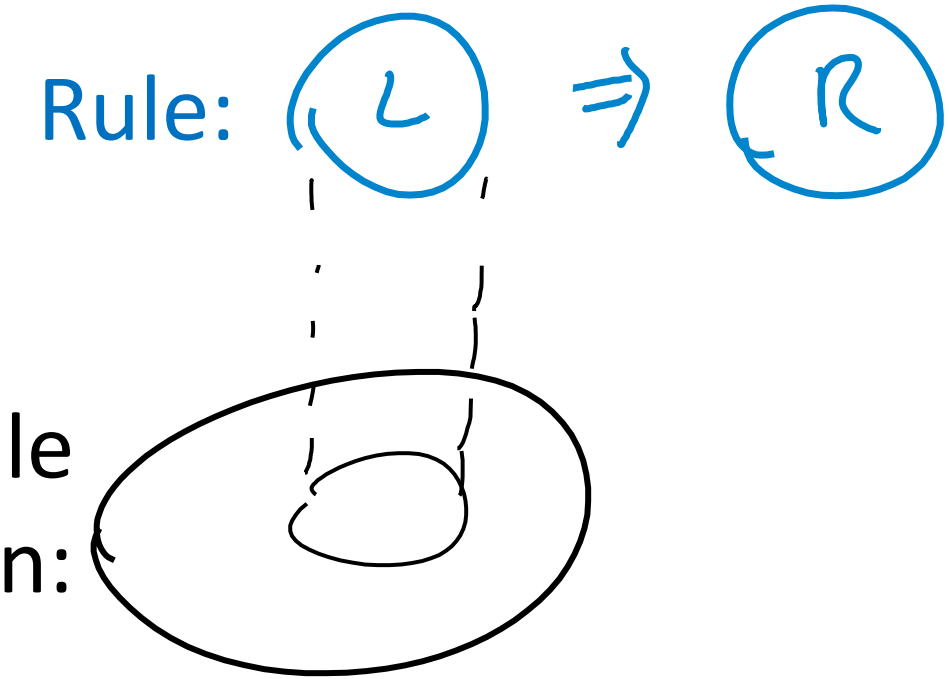

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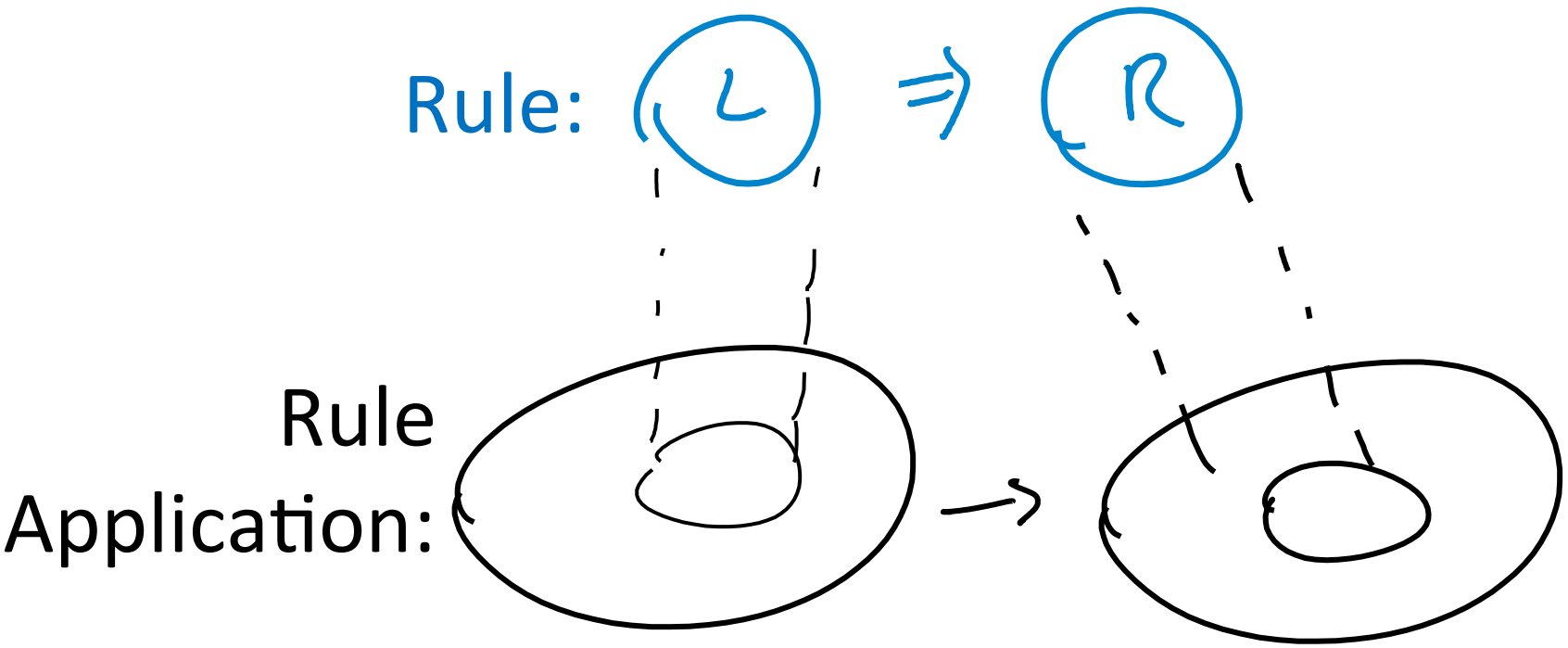
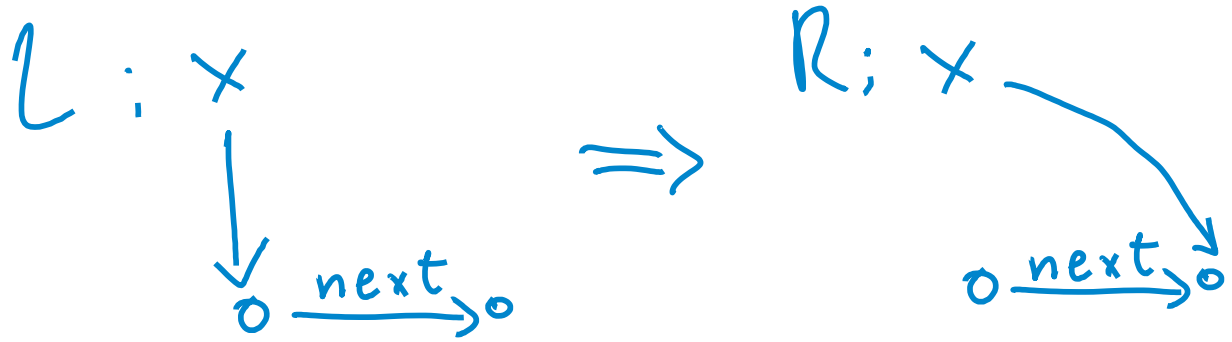
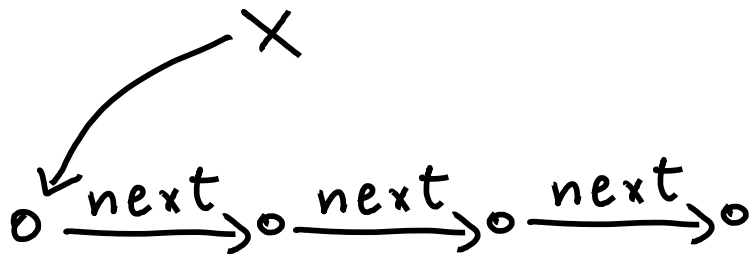


Example: List Traversal

Rule:





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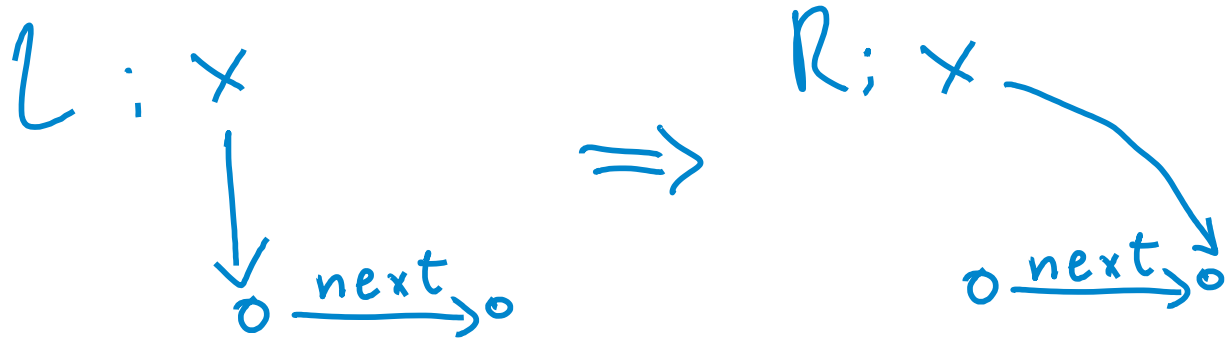

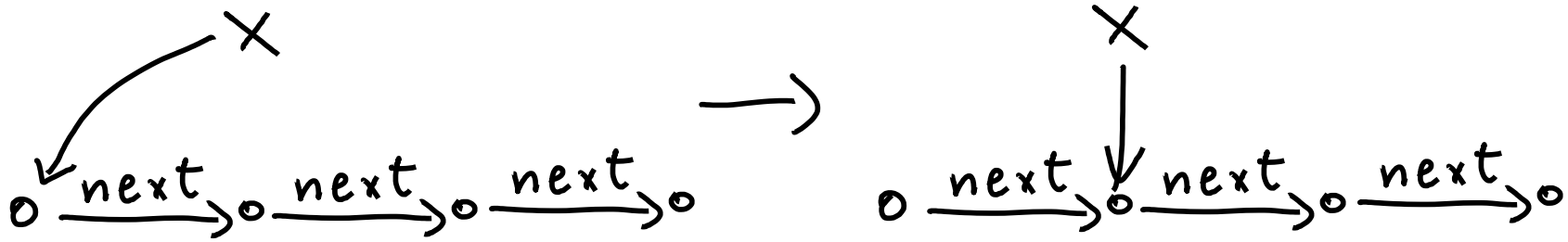

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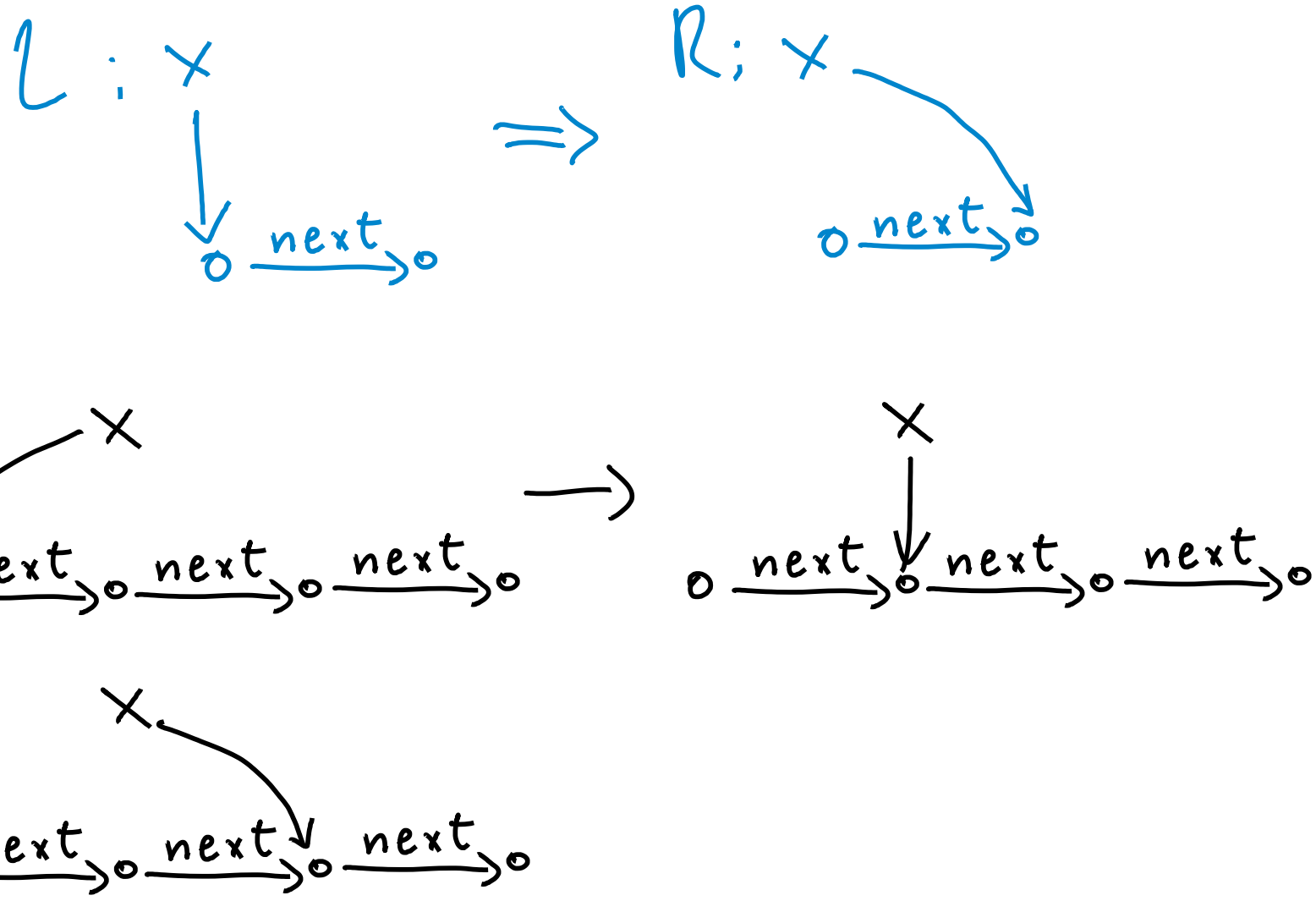

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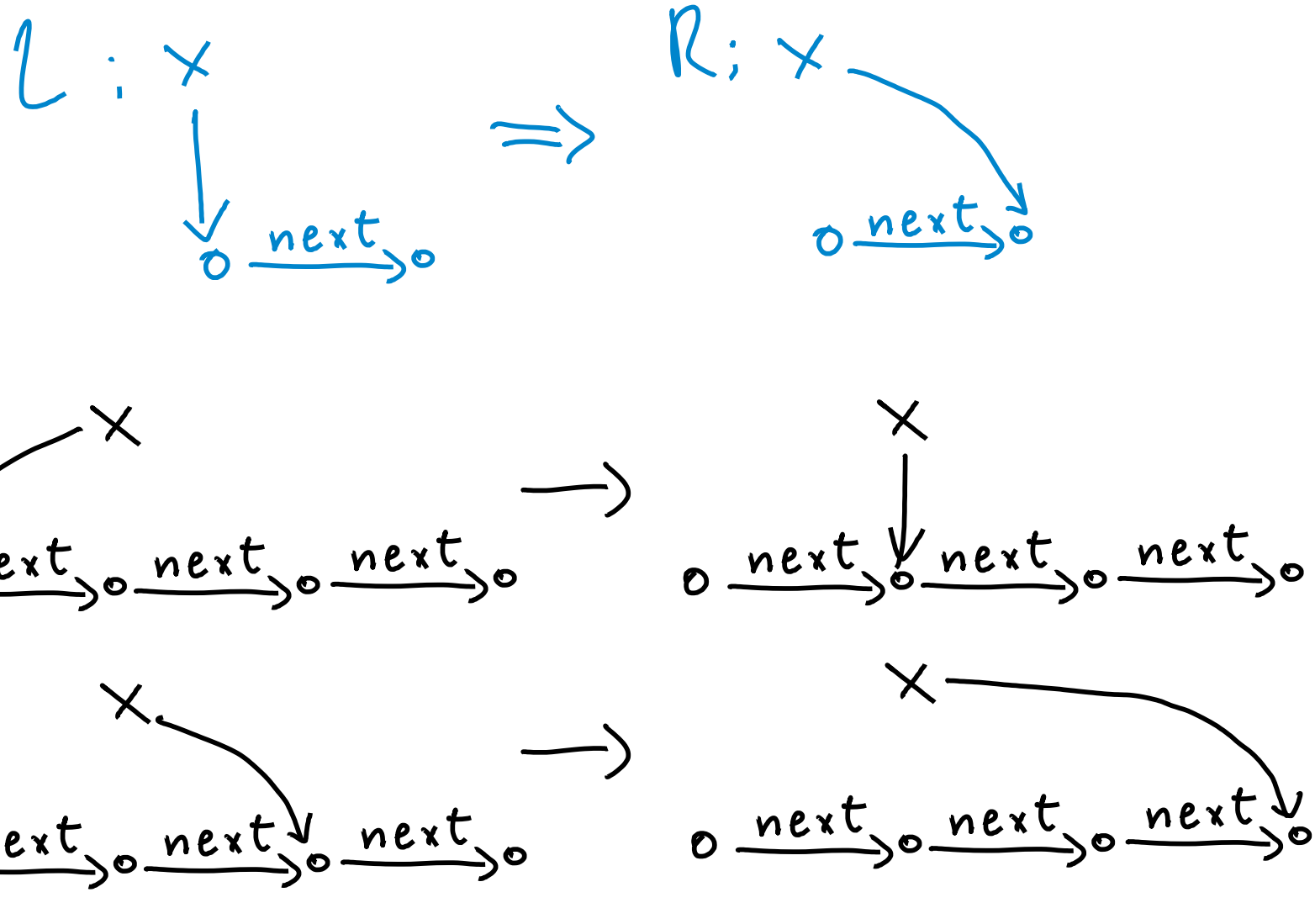

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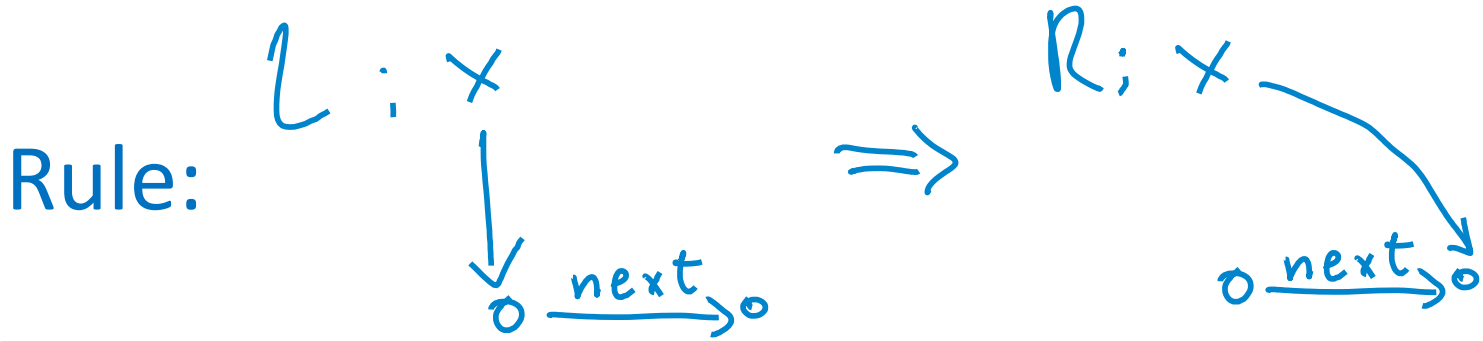
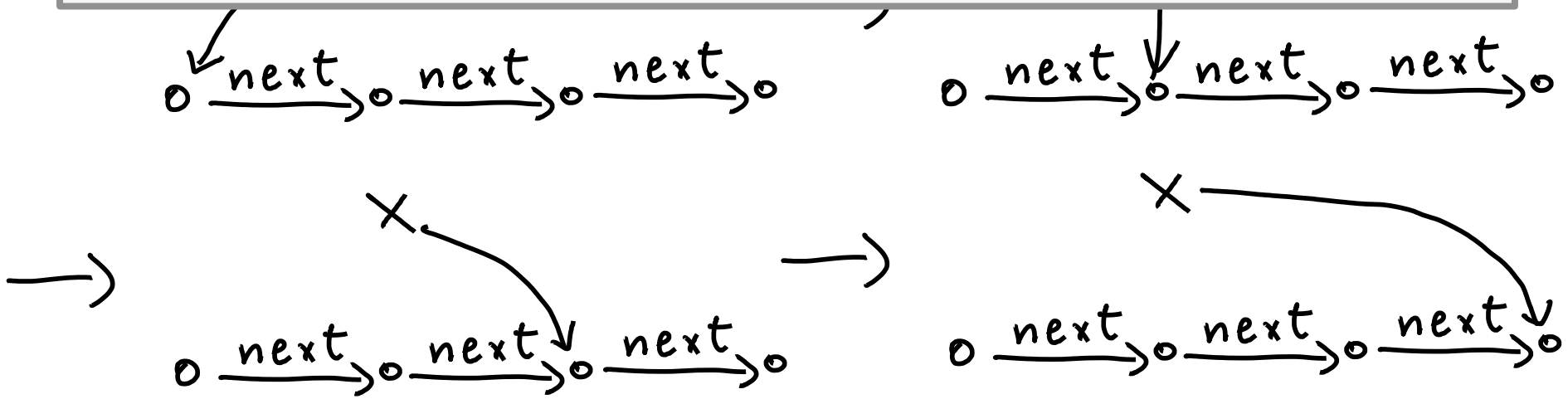


Semantics of Graph Transformation System =

All graphs reachable from start graph via rule applications



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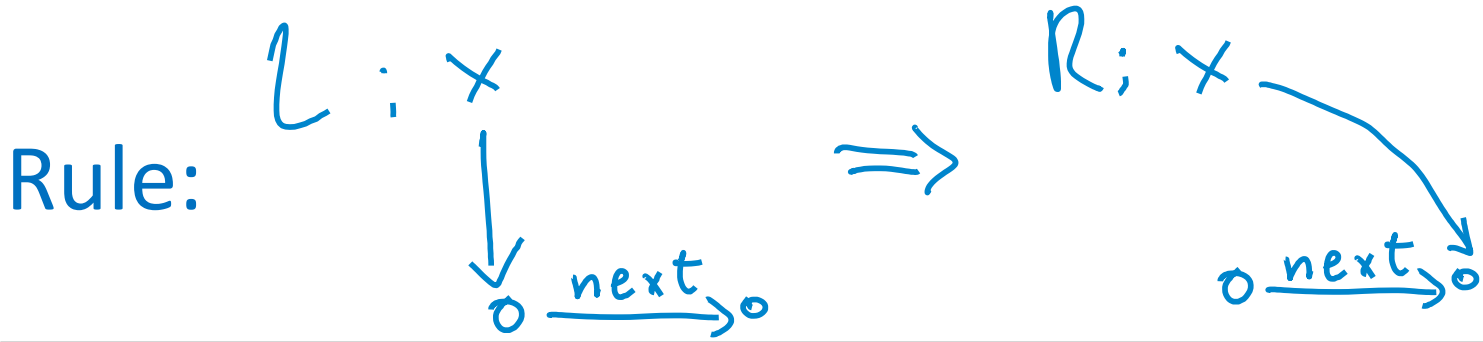

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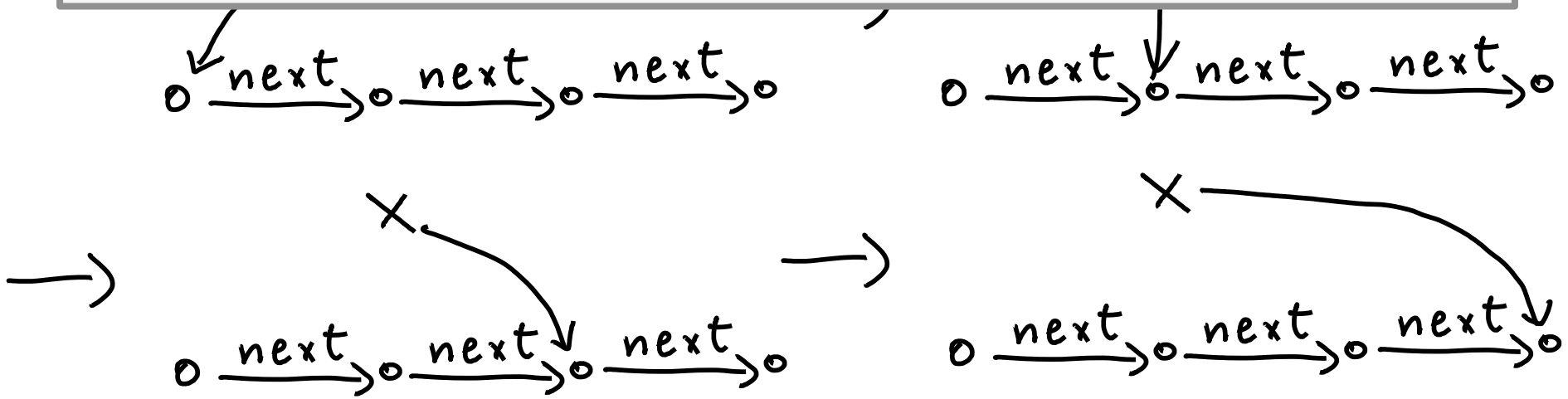

Graph Transformation

Useful to model many kinds of computations:

- dynamic message-passing systems,
- biological processes,
- business processes,
- heap-manipulating programs, etc.

Our Main Area of Application: Dynamic Message-Passing Systems

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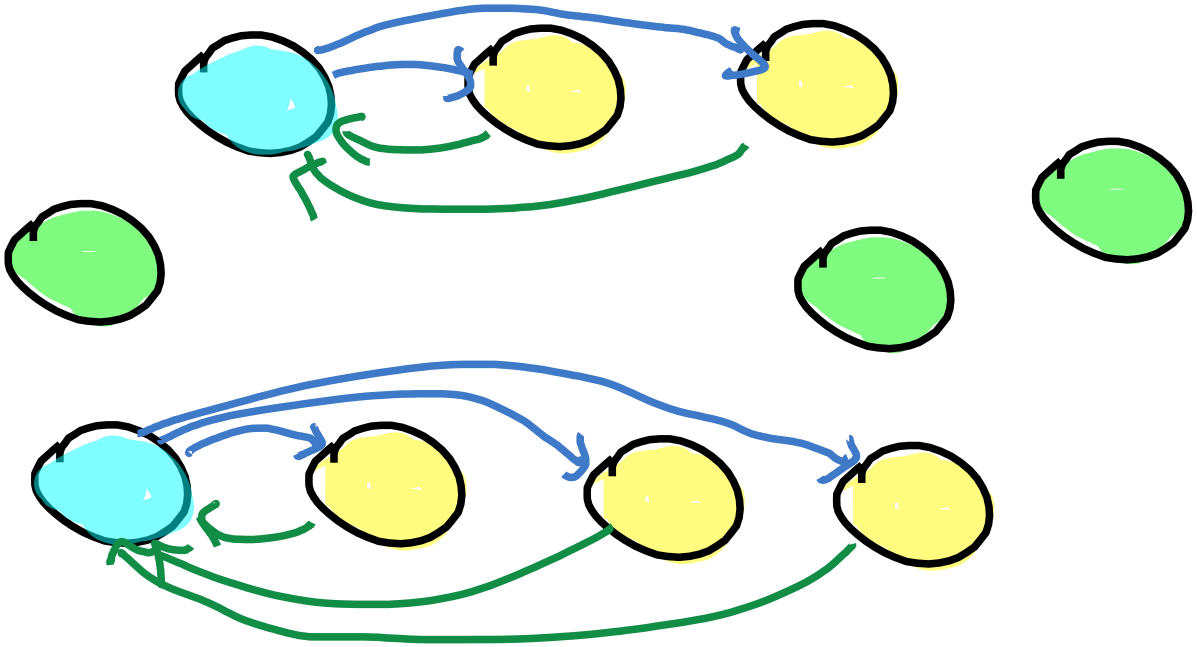
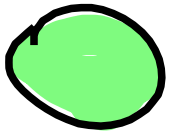
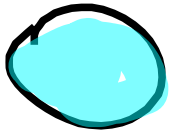
Characteristics:

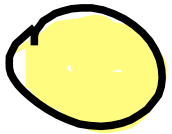
- Unbounded number of concurrent processes
- Processes dynamically construct and destruct communication topologies
- Each process executes a finite state protocol; makes transitions based on its local view of the system state

Example: Car Platooning



Free Agent = 

Platoon Leader = 

Follower = 

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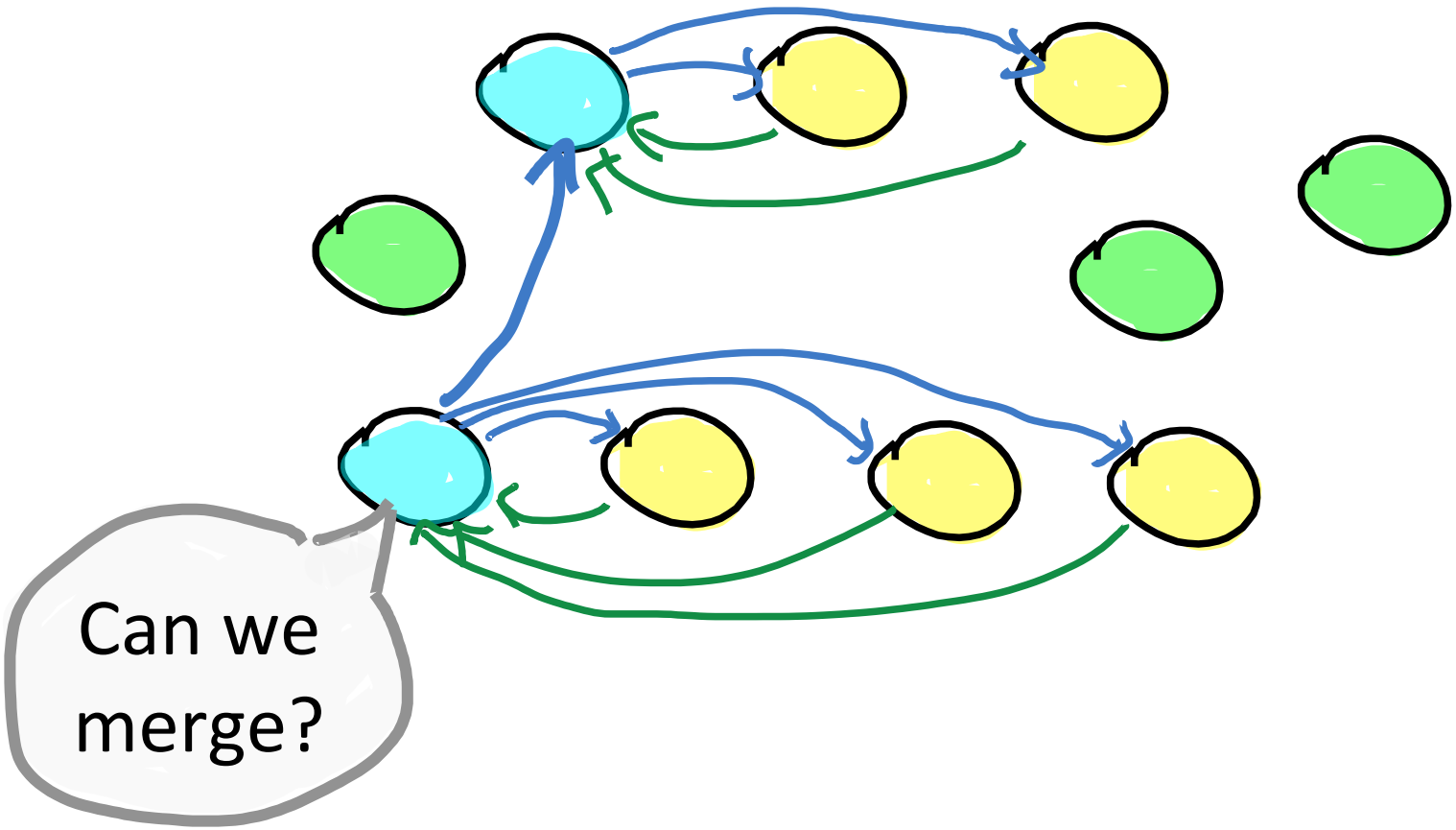

Free Agent = Platoon Leader = Follower =

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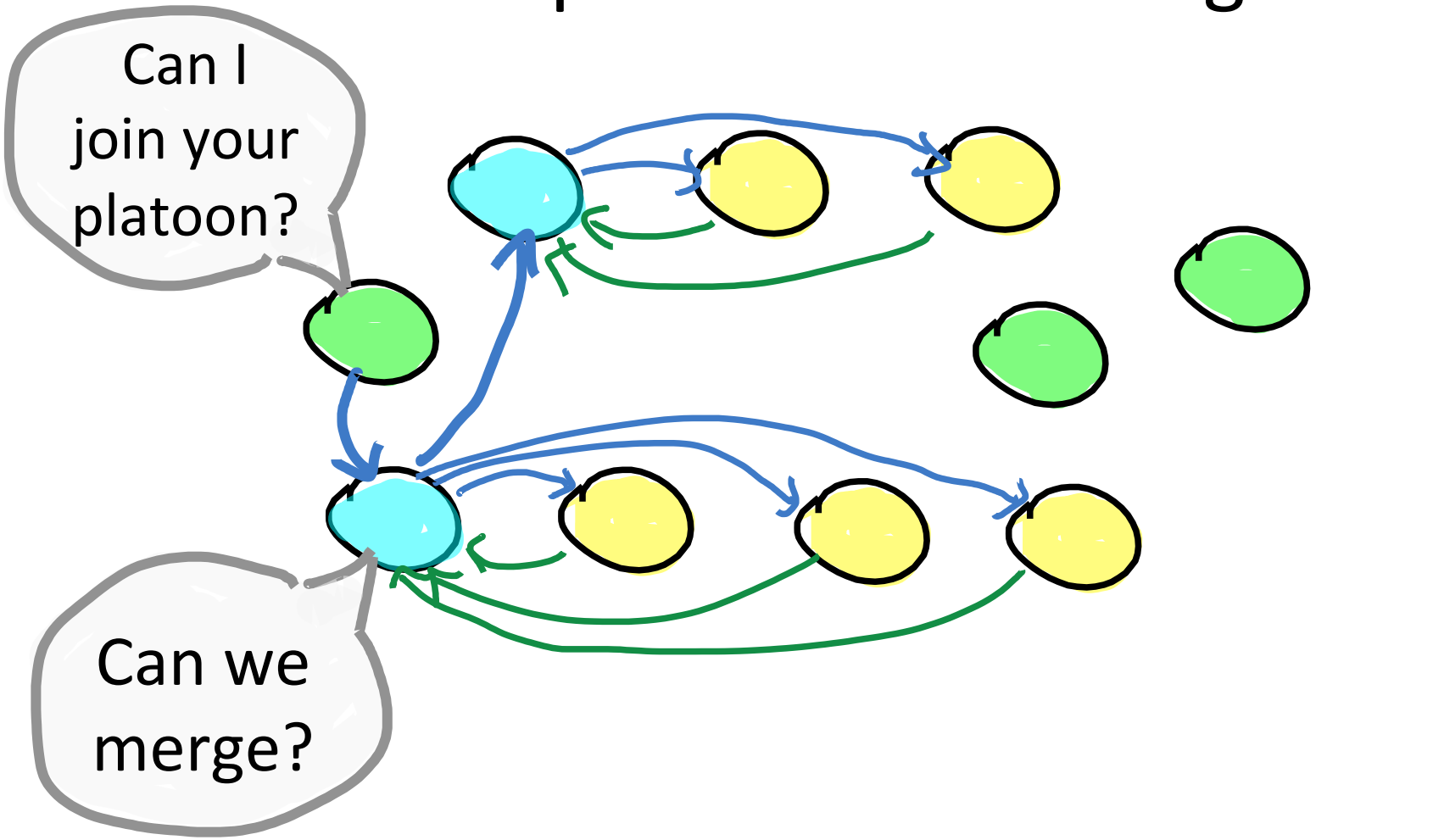

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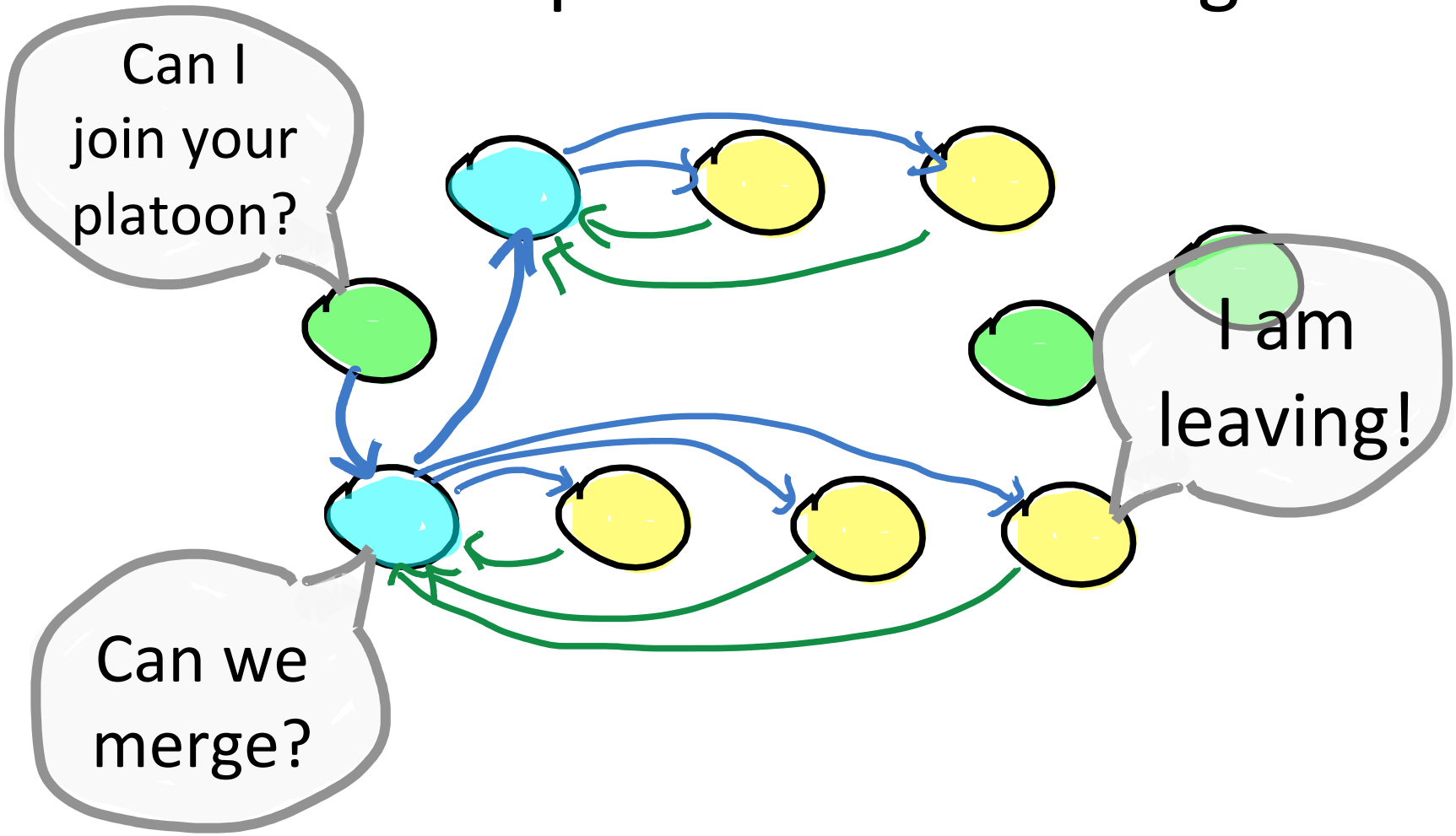

Free Agent =

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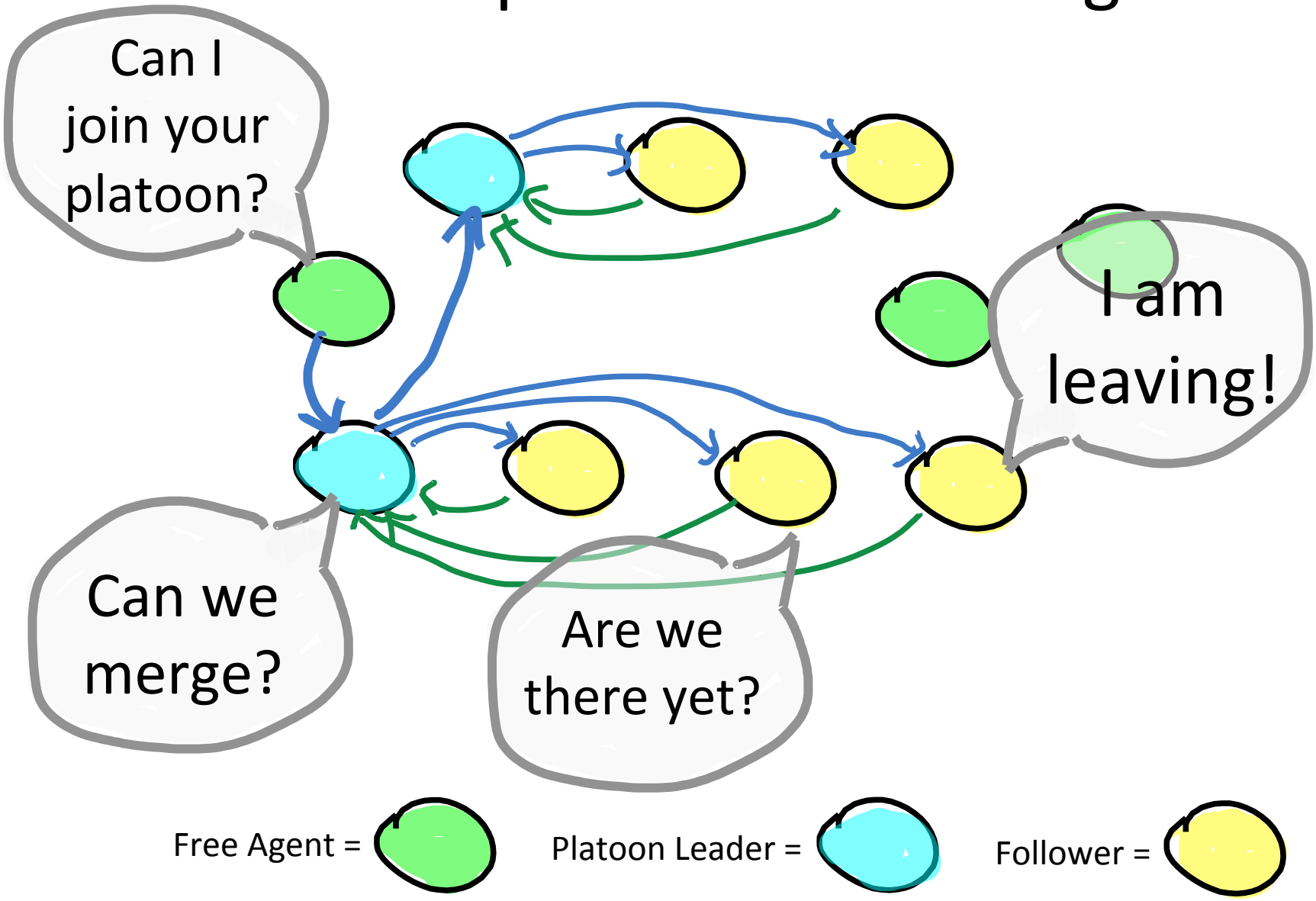

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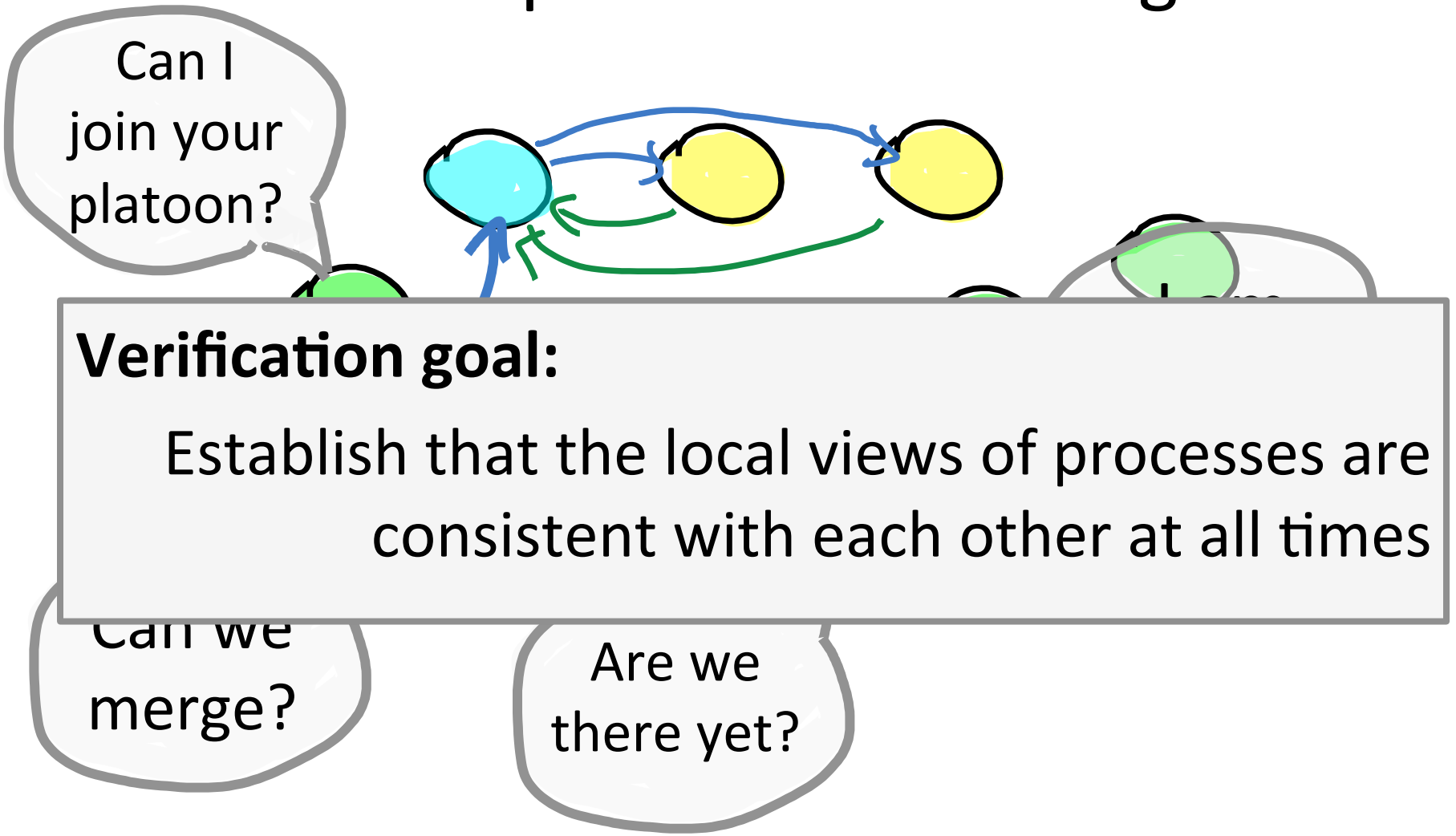
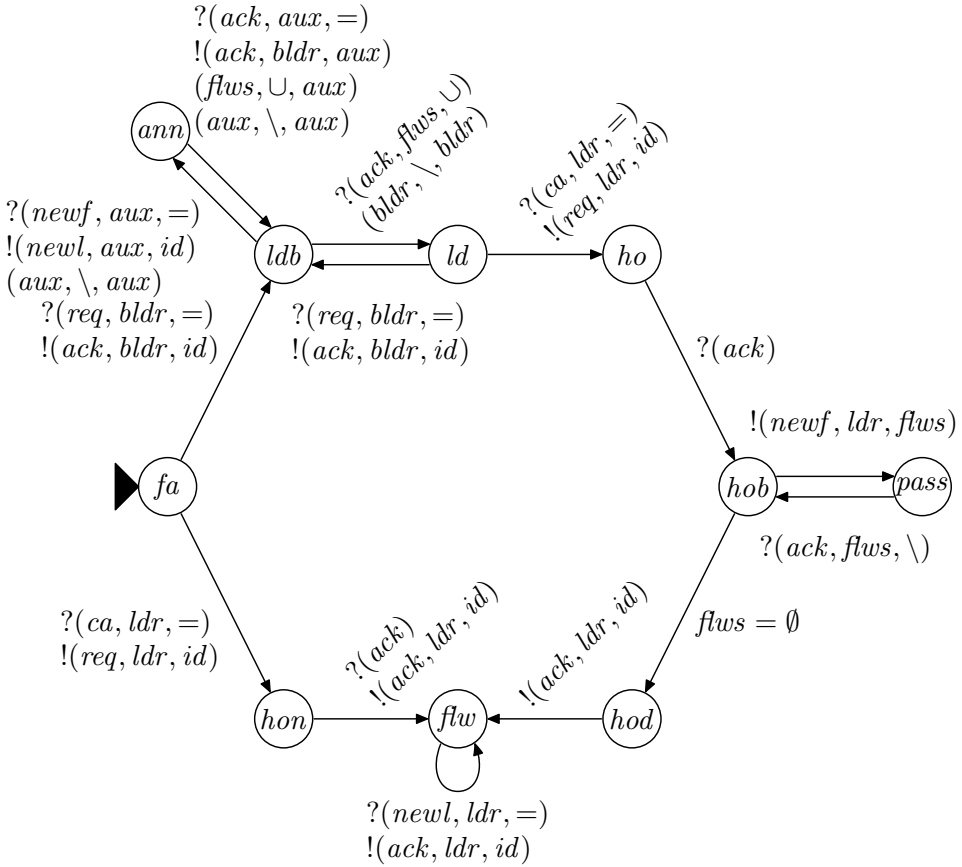


Example:

Merge Protocol from Car Platooning

All processes concurrently execute the following protocol + new processes may appear arbitrarily:



Example:

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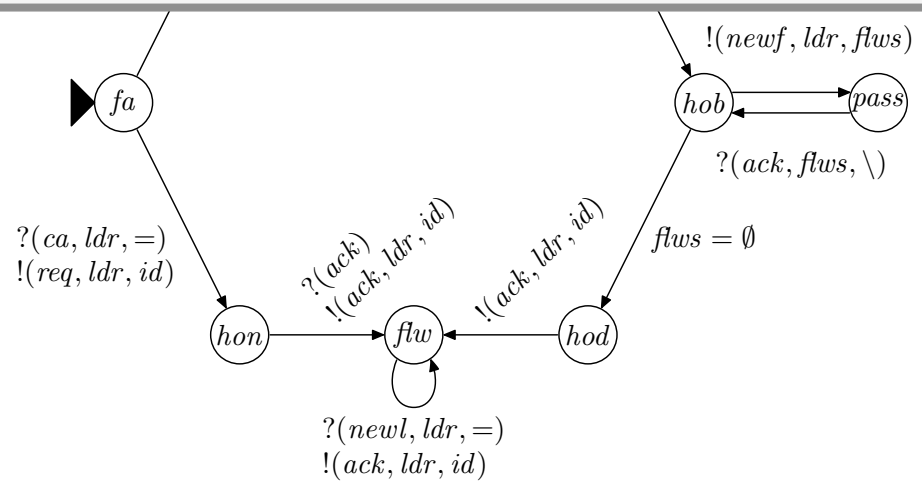
All processes concurrently execute the following protocol + new processes may appear arbitrarily:

Simple translation into graph transformation system:

- One rule for each transition in the automaton
- One rule for process creation



Cluster Abstraction

Assumption:

Protocols designed by humans establish invariants that are “local in nature”.

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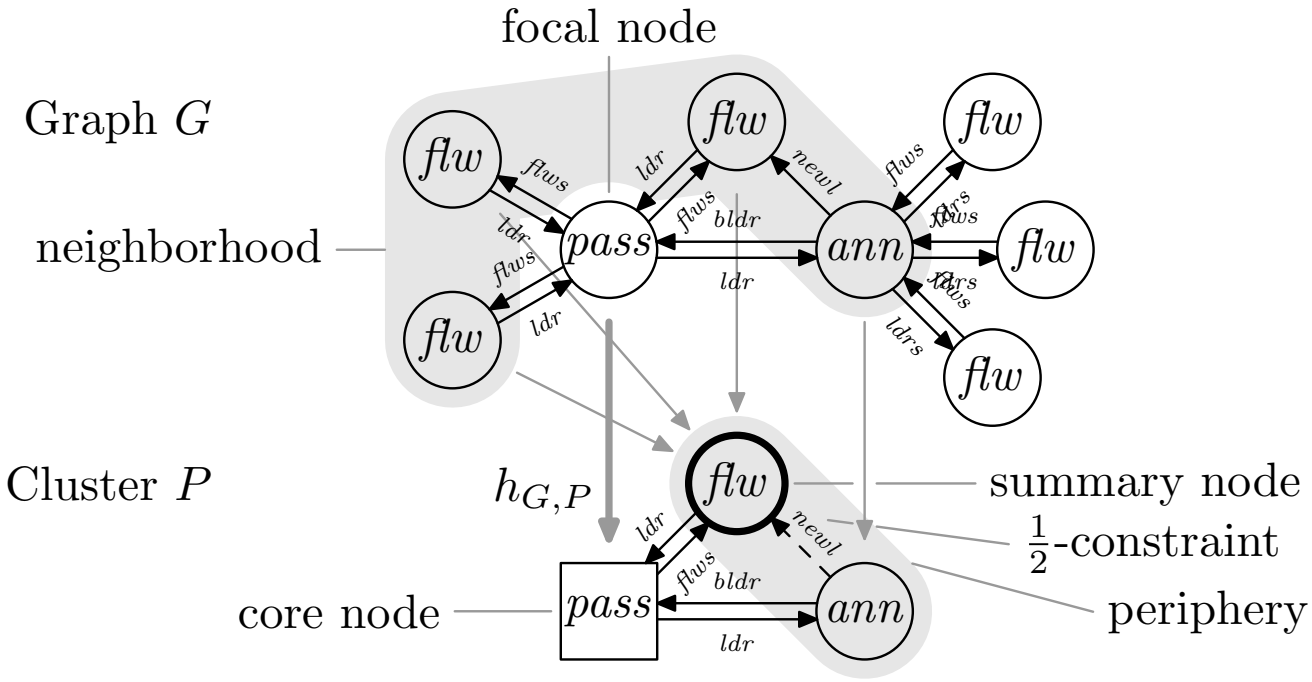
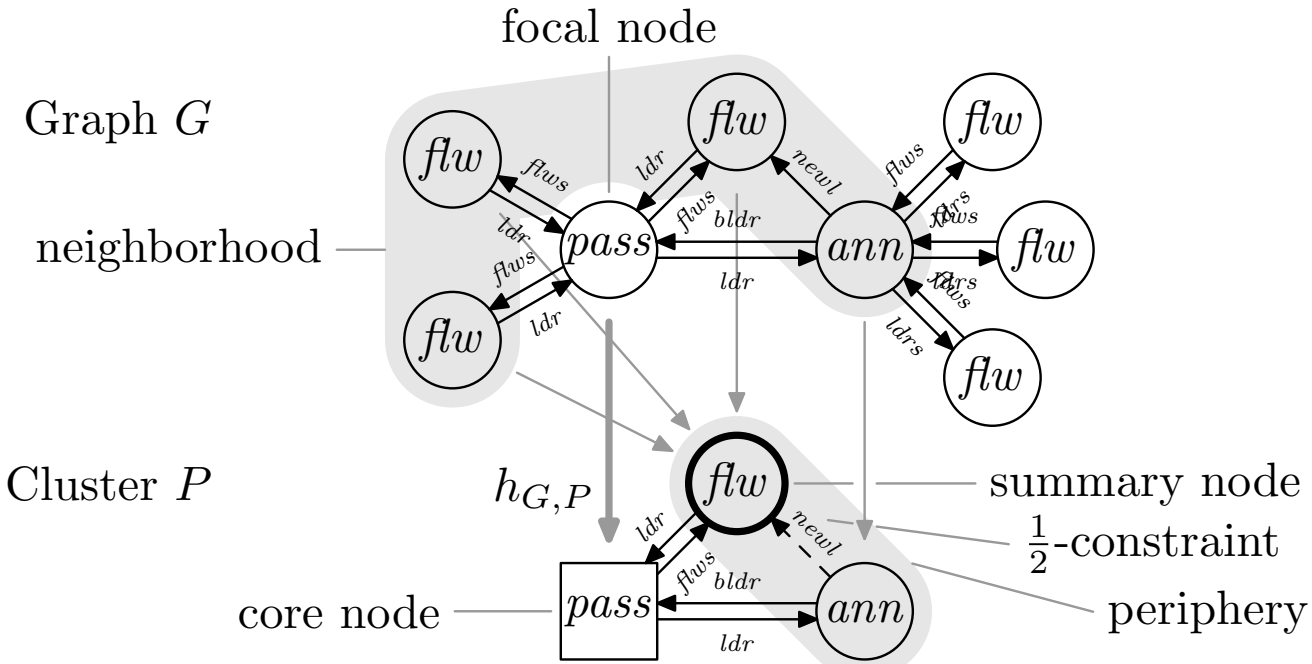
Cluster Abstraction:

Maintain for each process only its immediate environment.

Cluster Abstraction: Example



Cluster Abstraction: Example



Challenge:

Computing (best) abstract transformer for cluster abstraction

See [VMCAI 2015] for more details.

Astra 2.0

Implements cluster abstraction

- Input: Graph Transformation System S
- Output: Set of clusters overapproximating semantics of S

Free Software, available here:

http://www.rw.cdl.uni-saarland.de/~rtc/astra/

Some Experimental Results

Benchmark	**# clusters**	**# it.**	**time**	**v?**
Sync. leader-controlled merge	22509	135	9m	y
Sync. follower-controlled merge	24957	144	22m	y
Async. leader-controlled merge	142326	202	13136m	y
Async. follower-controlled merge	58023	157	3972m	y

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Firewall	31	5	0m	y
Firewall 2	45525	7	0m	n
Public/private servers	239	10	0m	y
Dining philosophers	41	7	0m	*
Resources	32	4	0m	y
Mutual exclusion	308	17	1m	y
Euler walks	18	3	0m	*
Linked list	7	3	0m	y
Circular buffer	152	17	3m	*
Red-black tree	263	11	10m	y
AVL tree	1876	38	757m	y

Now: Tool Demo