Teams of Pushdown Automata

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Outline

- background: communication & cooperation in distributed systems
- team automata: foundations & applications
- team pushdown automata
- conclusions & future work

Background

? solid theoretical models for distributed systems

- Computer Supported Cooperative Work
  e.g. groupware systems

- multi-agent technology
  e.g. blackboard systems

- model checking
  e.g. systems specified in Promela

- component-based design

⇒ due to distributive nature: communication & cooperation are key issues!

⇒ need for more types of synchronization than offered by I/O automata, Petri nets, ...

Foundations of Team Automata

Ellis (1997)

"Team Automata for Groupware Systems"

GROUP'97 Int. ACM Conference on Supporting Group Work

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ter Beek, Ellis, Kleijn & Rozenberg (>1999)

"Synchronizations in Team Automata for Groupware Systems"

Computer Supported Cooperative Work: The Journal of Collaborative Computing

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"Team Automata for CSCW"

2nd Int. Colloquium on Petri Net Technologies for Modelling Communication Based Systems

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ter Beek & Kleijn (2003)

"Team Automata Satisfying Compositionality"

FM'03 12th Int. Formal Methods Europe Symposium

Team Automata

- extension of I/O automata, related to Petri nets
  $\Rightarrow$ more types of synchronization!

- model logical architecture of system design

- abstract from concrete data and actions

- describe system behaviour in terms of

  - state-action diagram (automaton)
  - role of actions (input, output, internal)
  - synchronizations (simultaneous execution of common actions)

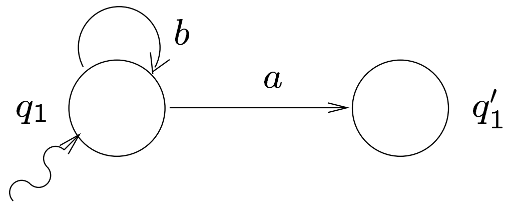
- crux: automata composition!

+ flexible (role of actions, choice of transitions)
+ scalable (modular construction, iteration)
+ extendible (time, probablities, priorities)
+ verifiable (automata-theoretic tools)

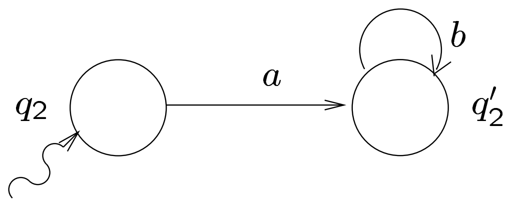
– no tool (yet)

Example Team Automata

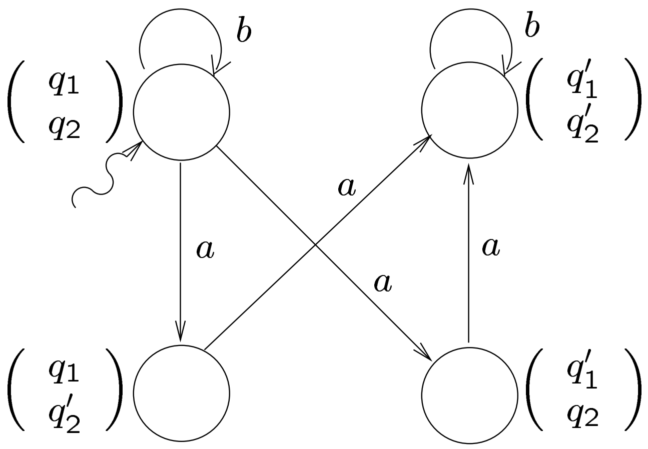
$\mathcal{C}_1$:



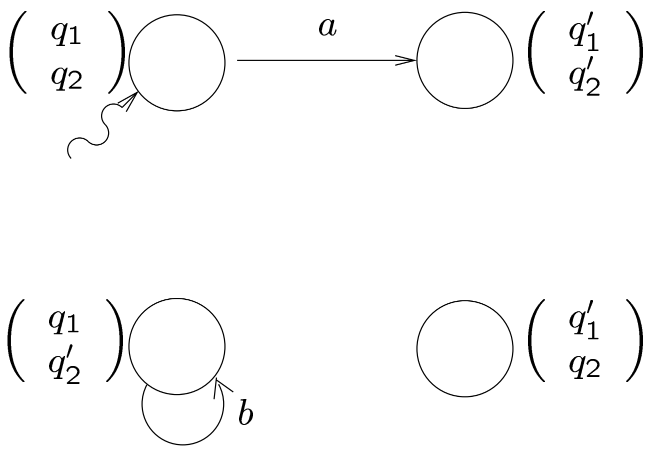
$\mathcal{C}_2$:



$\mathcal{T}^{free}$:



$\mathcal{T}^{ai}$:



$\Rightarrow$ team automata $\mathcal{T}^{free}$ and $\mathcal{T}^{ai}$ over $\{\mathcal{C}_1, \mathcal{C}_2\}$ are defined by choosing their transitions!

Applications of Team Automata

ter Beek, Ellis, Kleijn & Rozenberg (2001)

"Team Automata for Spatial Access Control"

ECSCW'01 7th European CSCW Conference

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ter Beek, Lenzini & Petrocchi (2003)

"Team Automata for Security Analysis of Multicast/Broadcast Communication"

WISP'03 1st Int. Workshop on Issues in Security & Petri Nets

$\Rightarrow$ need for (automated) verification!

Ongoing: verification of team automata design for access control with Spin model checker...

$\Rightarrow$ need for more types of synchronization!

Team Pushdown Automata

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team automata augmented with
pushdown memory (i.e. notebooks)

or *alternatively*

distributed pushdown automata augmented
with
team cooperation
and
level of competence (i.e. cleverness)

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related to:

cooperating pushdown automata
(Hirst & Harel, *JACM*, 1994)

multistack pushdown automata
(Dassow & Mitrana, *JCSC*, 1999)

Team Pushdown Automata at Work

crux:

team cooperation

$\swarrow$ $\searrow$

teams formed
dynamically
according to
the mode of
competence

team members
synchronize on
1) an action &
2) the topmost
symbol on the
pushdown memory

Conclusions

- current focus was on accepting capacity . . .
- team of 3 pushdown automata in $=2$ mode of competence can simulate any two-stack pushdown automata and thus all recursively enumerable languages

Future Work

- characterize the behaviour of team pushdown automata in terms of a synchronized shuffle (variant) of the behaviour of the component pushdown automata
- use team pushdown automata for modelling!