From Teams in Grammar Systems to Team Automata

Maurice ter Beek

FMT, CNR–ISTI, Pisa, Italy

Symposium for Erzsébet, ELTE, Budapest, Hungary, September 4th, 2024

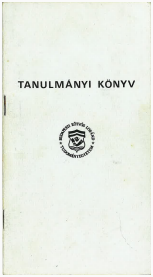
Outline

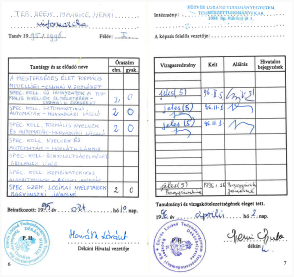
- Teams in Grammar Systems
- Team Automata
- Recent Results
  - **ICTAC20** Compositionality of Safe Communication in Systems of Team Automata
    Extended Team Automata
  - **FM21** Featured Team Automata
  - **FM23** Can we Communicate? Using Dynamic Logic to Verify Team Automata
    Model Check Team Automata
  - **ICTAC23** Realisability of Global Models of Interaction
    Realisable Team Automata
- Closing Words

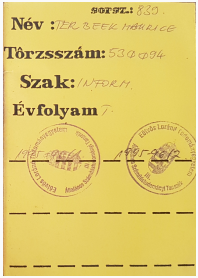
ongoing joint work with **Rolf Hennicker** (LMU, Munich, DE) and **José Proença** (University of Porto, PT)

Teams in Grammar Systems

1995-1996: ELTE + MTA–SZTAKI



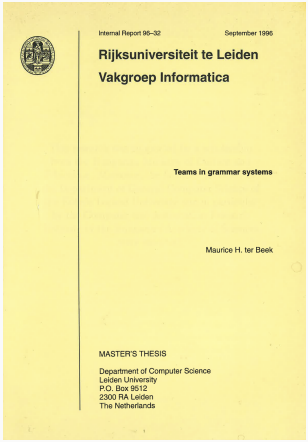




July/August 1996: Grammar Systems (Budapest)

July/August 1996: Grammar Systems (Budapest) + AFL (Salgótarján)

September 1996: MSc thesis (Teams in Grammar Systems)



Internal Report 96–32 September 1996

Rijksuniversiteit te Leiden
Vakgroep Informatica

Teams in grammar systems

Maurice H. ter Beek

MASTER'S THESIS

Department of Computer Science
Leiden University
P.O. Box 9512
2300 RA Leiden
The Netherlands

Dr. Erzsébet Csuhaj-Varjú from the Computer and Automation Research Institute of the Hungarian Academy of Sciences had been found willing to supervise my work in Budapest. With the supervision of Professor Grzegorz Rozenberg and Jetty on distance, failure was excluded. Throughout the year Erzsébet has been of inexpressible help to me. Not only technical problems related to my study were solved by her, but also secondary conditions such as arranging me a room in the Academy have never been a problem. I would like to thank her very much for putting up with me all this time. It has been a year I will think back of for the rest of my life.

1996-1999: Research Output Supervised by Erzsébet

Teams in Grammar Systems: Hybridity and Weak Rewriting *

Maurice H. ter BEEK †

1996-1999: Research Output Supervised by Erzsébet

Teams in Grammar Systems:
Hybridity and Weak Rewriting *

Maurice H. ter BEEK †

Teams in Grammar Systems: Sub-Context-Free Cases

Maurice H. ter BEEK[1]

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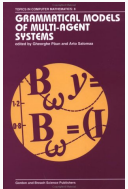

Simple eco-grammar systems with prescribed teams

Maurice H. ter Beek*

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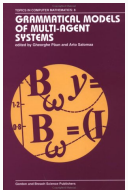

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Hybridity and Weak Rewriting *

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*This research was supported by a scholarship from the Hungarian Ministry of Culture and Education. Moreover, the facilities provided by the Department of General Computer Science of the Eötvös Loránd University and in particular by the Computer and Automation Research Institute of the Hungarian Academy of Sciences were essential.

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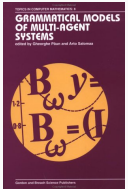

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Acknowledgements

This work has benefited from discussions with and comments and suggestions from E. Csuhaj-Varjú and H.C.M. Kleijn.

2002: ERCIM Fellow @ MTA–SZTAKI

The undersigned herewith accepts the ERCIM fellowship according to the schedule below, under the conditions set by each institution, and under the general conditions as follow:

Duration and Location

The duration of the fellowship will be 18 months, starting 11 March 2002. The fellowship will be divided in 2 successive periods of 9 months, spent in 2 different hosting laboratories.

The first period from 11 March 2002 to 11 December 2002 will be spent at:
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The ERCIM fellowship has allowed me to work in the Computer and Automation Research Institute of the Hungarian Academy of Sciences (MTA-SZTAKI) from 11 March 2002 until 11 December 2002. Throughout this period I was a member of the Research Group on Modelling Multi-Agent Systems (MMS) which is headed by dr. Erzsébet Csuhaj-Varjú. I have closely collaborated with both her and dr. György Vaszil, another member of this group. Furthermore, I have worked with several of the many guests visiting this group during these nine months, viz. dr. Markus Holzer and dr. Victor Mitrana.

2002: ERCIM Fellow @ MTA–SZTAKI

post-2002: Research Output with Erzsébet

On Competence in CD Grammar Systems*

Maurice H. ter Beek[1,**], Erzsébet Csuhaj-Varjú[2],
Markus Holzer[3], and György Vaszil[2]

post-2002: Research Output with Erzsébet

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ON COMPETENCE IN CD GRAMMAR SYSTEMS WITH PARALLEL REWRITING

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Accepted 4 June 2007
Communicated by H. Bordihn

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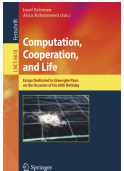

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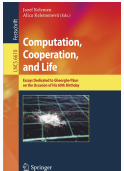
Cooperating Distributed Grammar Systems: Components with Nonincreasing Competence

Maurice H. ter Beek[1], Erzsébet Csuhaj-Varjú[2,*], Markus Holzer[3,**], and György Vaszil[4]

post-2002: Research Output with Erzsébet



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Team Automata

1997-2003: Team Automata

A formalism for interacting component-based systems, whereby multiple sending and receiving actions from concurrent automata can synchronise on certain executions

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First proposed at the 1997 ACM SIGGROUP Conference on Supporting Group Work for modelling components of groupware systems and their interconnections

Formally defined in Computer Supported Cooperative Work (CSCW) — The Journal of Collaborative Computing, in terms of component automata that synchronise

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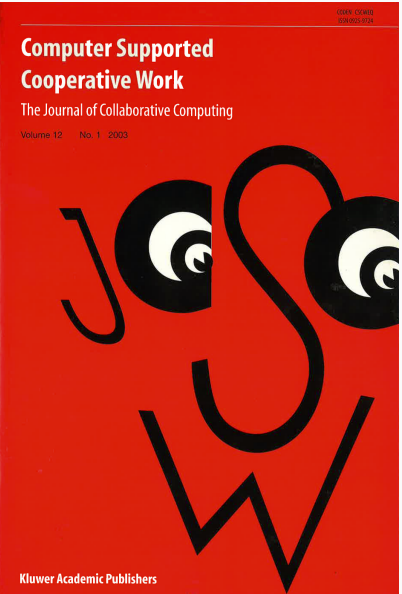
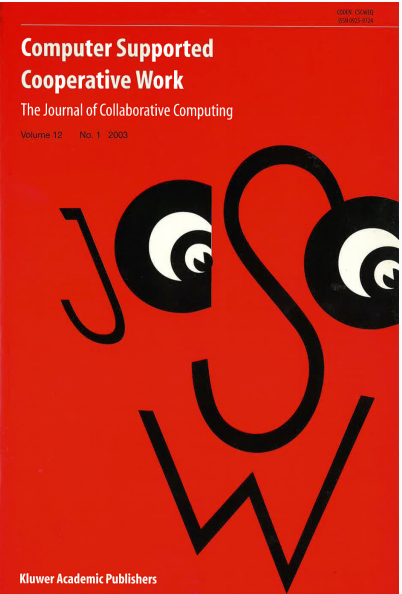
Inspired by Input/Output (I/O) automata, inheriting the distinction between internal and external (input and output) actions used for communication with the environment

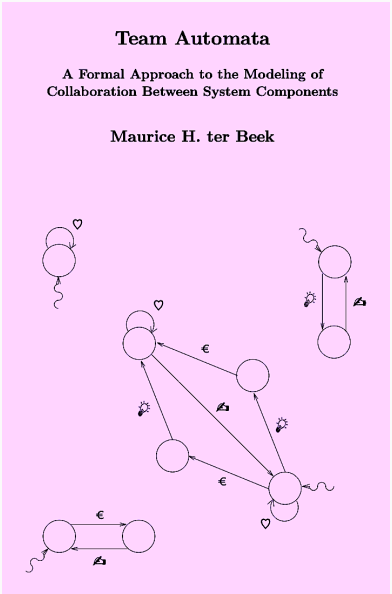
Technically, an extension of I/O automata, imposing hardly any restrictions on the role of actions in components and composition is not limited to the synchronous product

February 2003: CSCW



February 2003: CSCW December 2003: PhD thesis





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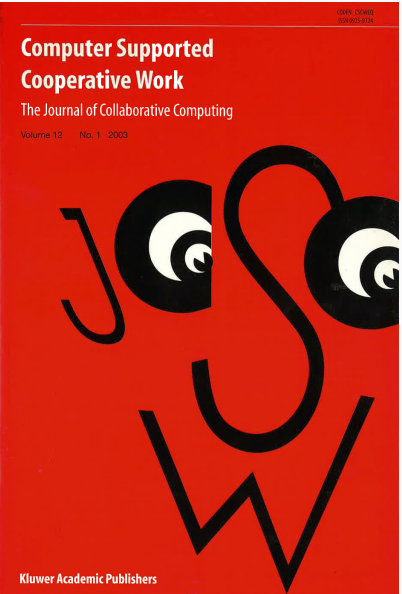
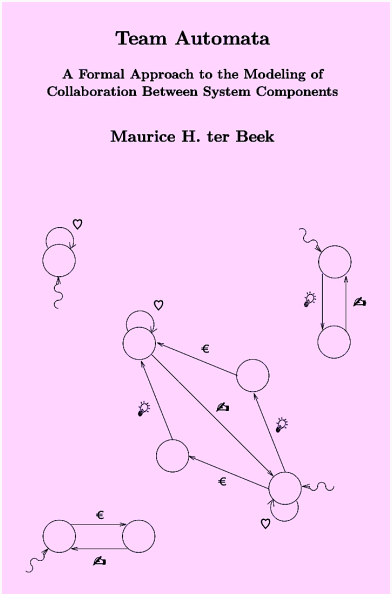


December 2003: PhD thesis + defense



25+ Years: Selected Publications

2023	Realisability of Global Models of Interaction	ICTAC'23
2023	Overview on Constrained Multiparty Synchronisation in Team Automata *	FACS'23
2023	Can we Communicate? Using Dynamic Logic to Verify Team Automata	FM'23
2021	Featured Team Automata	FM'21
2020	Compositionality of Safe Communication in Systems of Team Automata	ICTAC'20
2020	Team Automata@Work: On Safe Communication	COORDINATION'20
2017	Communication Requirements for Team Automata	COORDINATION'17
2016	Conditions for Compatibility of Components: The Case of Masters and Slaves	ISoLA'16
2014	On Distributed Cooperation and Synchronised Collaboration	JALC
2013	Compatibility in a multi-component environment *	TCS
2012	Vector Team Automata	TCS
2010	Team Automata Based Framework for Spatio-Temporal RBAC Model *	BAIP'10
2009	Associativity of Infinite Synchronized Shuffles and Team Automata	Fundam. Inform.
2008	Extending Team Automata to Evaluate Software Architectural Design *	COMPSAC'08
2008	A calculus for team automata	ENTCS
2007	A Review on Specifying Software Architectures Using Extended Automata-Based Models *	FSEN'07
2006	Modelling a Secure Agent with Team Automata *	ENTCS
2006	A Team Automaton Scenario for the Analysis of Security Properties in Communication Protocols	JALC
2005	Team Automata for Security – A Survey –	ENTCS
2005	Modularity for Teams of I/O Automata	IPL
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2003	Synchronizations in Team Automata for Groupware Systems	CSCW
2002	Towards Team-Automata-Driven Object-Oriented Collaborative Work *	LNCS
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1997	Team Automata for Groupware Systems	GROUP'97

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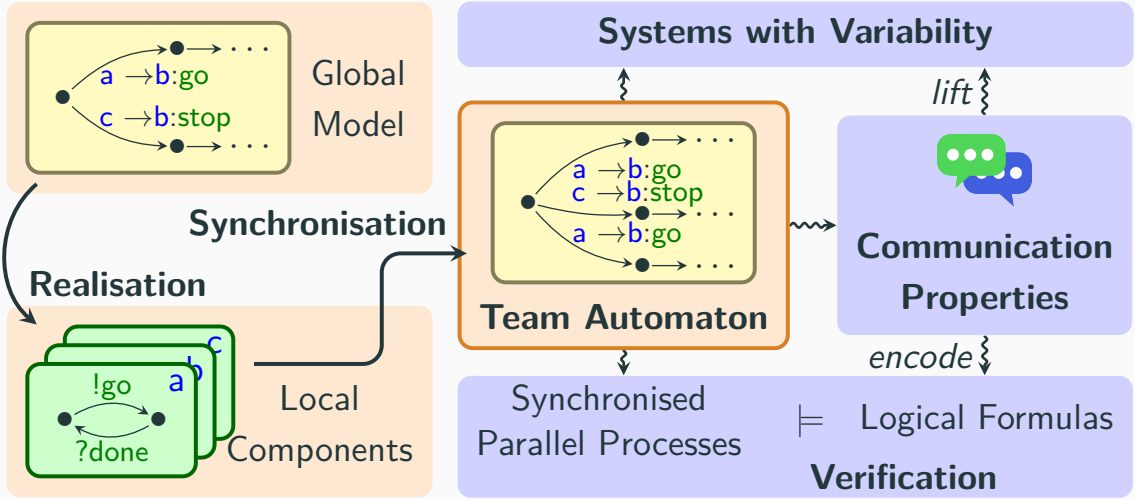
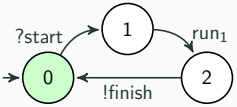

Systems with Variability
a →b:go
c →b:stop
Global Model
Synchronisation
Realisation
lift
a →b:go
c →b:stop
a →b:go
Team Automaton
Communication Properties
encode
!go
?done
Local Components
Synchronised Parallel Processes
⊨ Logical Formulas
Verification

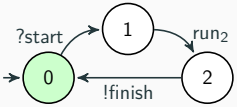
Extended Team Automata

Team Automata by Example

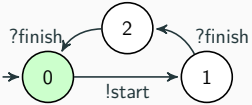
Team Automata: **not all system transitions are meaningful!**



$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

[COORDINATION'17,'20] [ICTAC'20,'23]

Team Automata by Example

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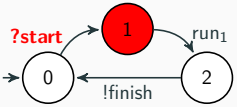

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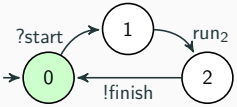
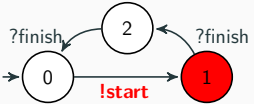


$\mathcal{R}unner_2$



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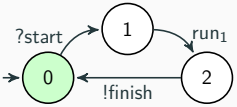

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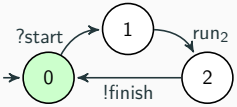
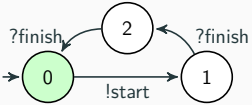


$\mathcal{R}unner_2$



Controller

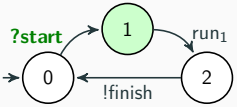
Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

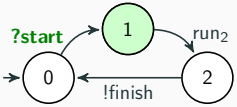
[COORDINATION'17,'20] [ICTAC'20,'23]

Team Automata by Example

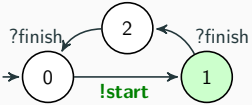
Team Automata: **not all system transitions are meaningful!**



$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

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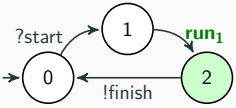
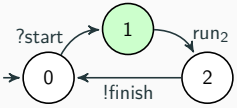


$\mathcal{R}unner_1$



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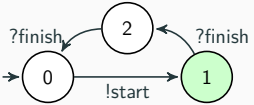

Controller

Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

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Team Automata by Example

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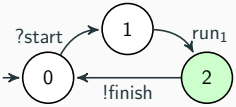
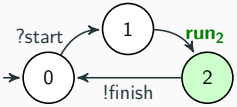
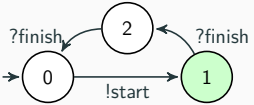


$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

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Team Automata by Example

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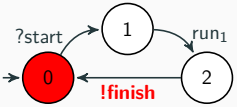
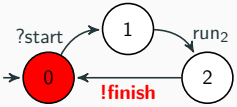
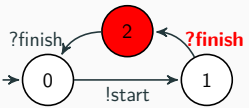


$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

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Team Automata by Example

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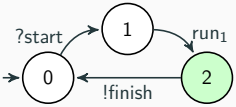
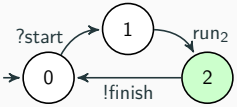
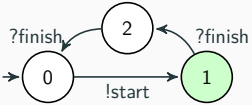


$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

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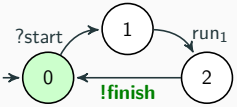
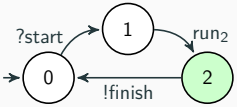
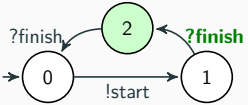


$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

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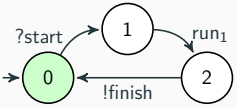
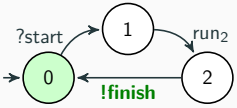
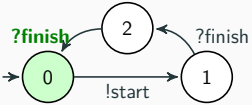


$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Team Automata

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

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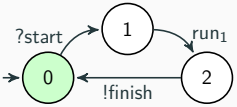
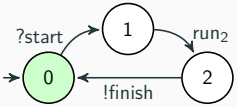
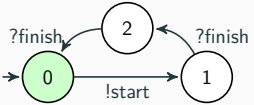
Extended Team Automata: Constrained Multiparty Synchronisations



$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

Extended TA synchronisations

[CSCW'01'03] [FM'03,'21,'23] [TCS'12'13]

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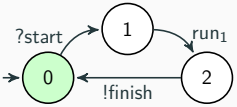
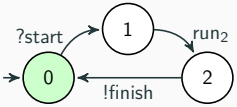
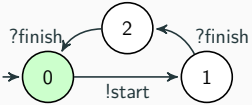
Extended Team Automata: Constrained Multiparty Synchronisations



$\mathcal{R}unner_1$



$\mathcal{R}unner_2$



Controller

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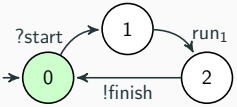
[COORDINATION'17,'20] [ICTAC'20,'23]

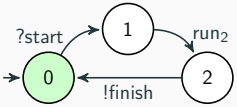
multiparty

Ctr $\rightarrow \{R1, R2\}$: start

Extended Team Automata: Constrained Multiparty Synchronisations



$\mathcal{R}unner_1$



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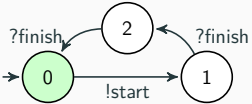

Controller

Extended TA synchronisations

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[COORDINATION'17,'20] [ICTAC'20,'23]

multiparty

Ctr $\rightarrow \{R1, R2\}$: start

constrained

start: $1 \rightarrow 2$

finish: $1 \rightarrow 1$

Recent Results

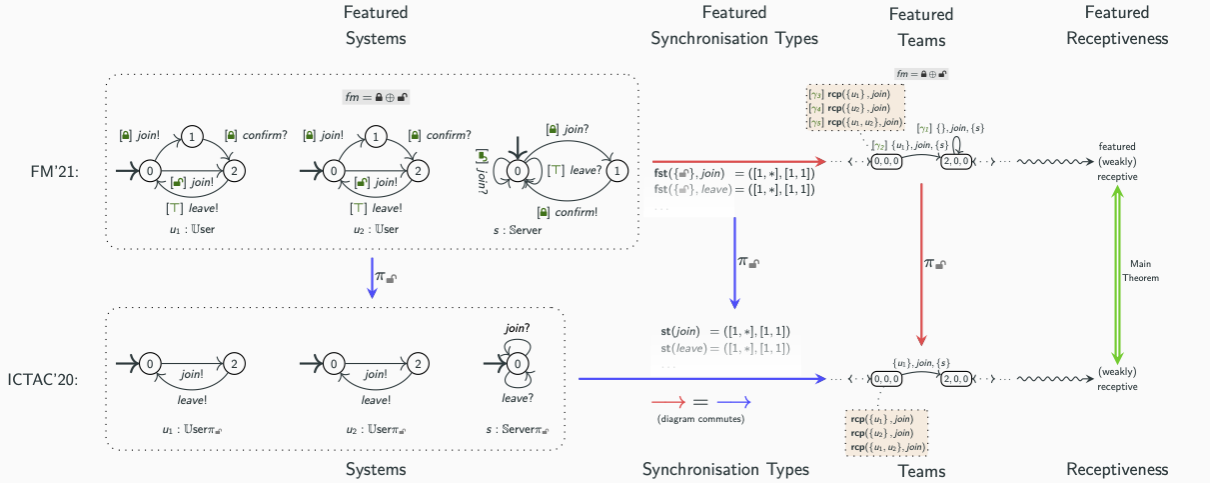
Featured Team Automata

Featured Extended Team Automata (fETA)

Safe communication: receptiveness (*no message loss*) & responsiveness (*no indefinite waiting*)

Featured Extended Team Automata (fETA)

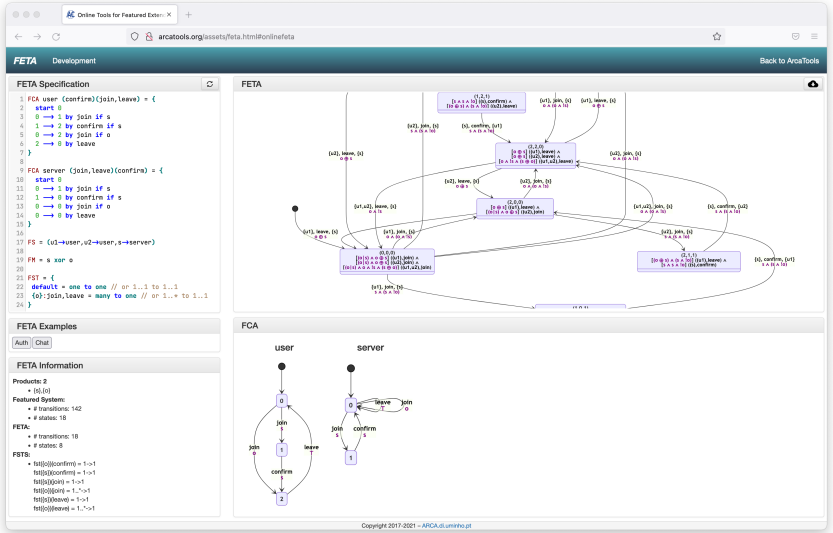
Safe communication: receptiveness (*no message loss*) & responsiveness (*no indefinite waiting*)



Online Prototype: `http://arcatools.org/feta`

- Specify
- Generate*
- Visualise
- Statistics

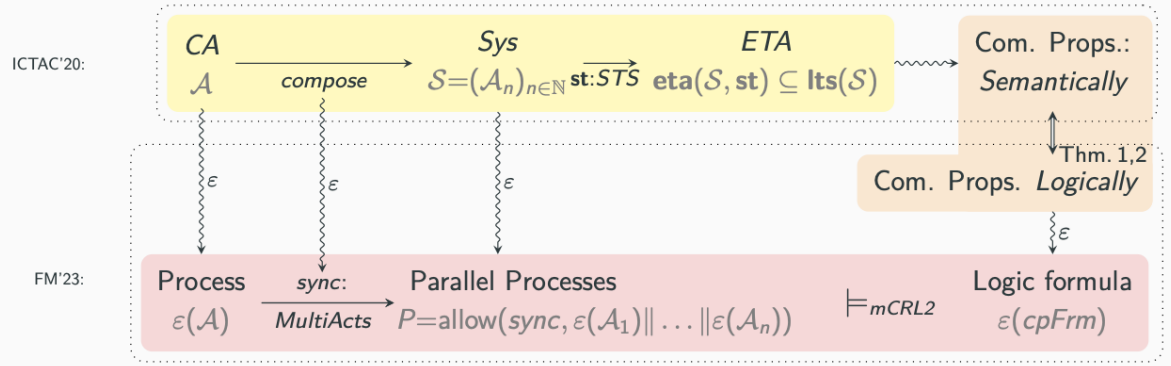
*SAT solver to solve *fm*



Model Check Team Automata

Using Dynamic Logic to Verify Team Automata

Com. Props.: receptiveness (*no message loss*) & responsiveness (*no indefinite waiting*)



mCRL2 analysing system behaviour

Online Prototype: https://github.com/arcalab/team-a

ETA Specification

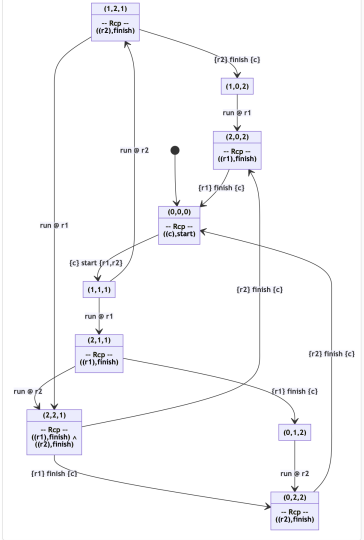
```
1  //Race example
2  CA runner (start)
3          (finish) = {
4    start 0
5    0 --> 1 by start
6    1 --> 2 by run
7    2 --> 0 by finish
8  }
9  CA controller (finish)
10                 (start) = {
11   start 0
12   0 --> 1 by start
13   1 --> 2 by finish
14   2 --> 0 by finish
15 }
16 S = (r1:runner, r2:runner,
17      c:controller)
18 STS = {
19   default = 1 to 1
20   start = 1 to 2
21 }
```

Race example

ETA Examples

Simple | Race | Chat

ETA diagram



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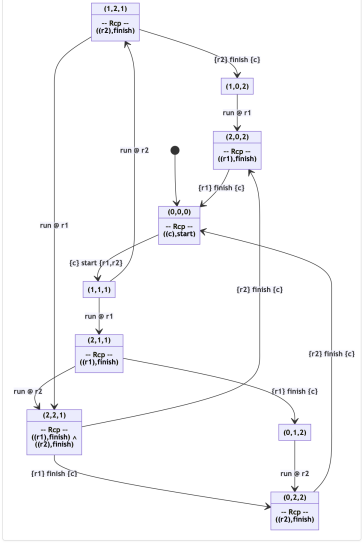
Race example

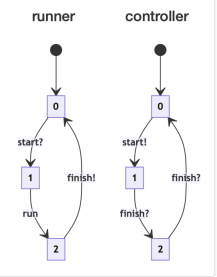
ETA Examples

Simple | Race | Chat

ETA diagram



CA



Online Prototype: `https://github.com/arcalab/team-a`

Communication Properties' Characterisation in mCRL2

Receptiveness:

```
[ (r1_finish|c_finish + r2_run + c_start|r1_start|r2_start + r2_finish|c_finish + r1_run)* ](
  ((<c_start> true)  =>  (<c_start|r1_start|r2_start> true)) &&
  ((<r1_finish> true)  =>  (<r1_finish|c_finish> true)) &&
  ((<r2_finish> true)  =>  (<r2_finish|c_finish> true))
)
```

Responsiveness:

```
[ (r1_finish|c_finish + r2_run + c_start|r1_start|r2_start + r2_finish|c_finish + r1_run)* ](
   (<c_finish +
     r1_start|r2_start> true)
   =>
   (<r1_finish|c_finish +
     c_start|r1_start|r2_start +
     r2_finish|c_finish> true)
)
```

Weak Receptiveness:

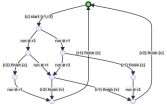
```
[ (r1_finish|c_finish + r2_run + c_start|r1_start|r2_start + r2_finish|c_finish + r1_run)* ](
  ((<r1_finish> true)  =>  (<(r2_run+r2_finish|c_finish)* . r1_finish|c_finish> true)) &&
  ((<r2_finish> true)  =>  (<(r1_finish|c_finish+r1_run)* . r2_finish|c_finish> true)) &&
  ((<c_start> true)  =>  (<(r2_run+r1_run)* . c_start|r1_start|r2_start> true))
)
```

Weak Responsiveness:

```
[ (r1_finish|c_finish + r2_run + c_start|r1_start|r2_start + r2_finish|c_finish + r1_run)* ](
   (<c_finish +
     r1_start|r2_start> true)
   =>
   (<(r2_run+r1_run)* . r1_finish|c_finish +
     c_start|r1_start|r2_start +
     (r2_run+r1_run)* . r2_finish|c_finish> true)
)
```

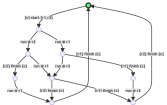
View mCRL2 evidence

Receptiveness: true

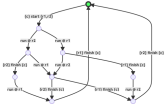


Responsiveness: false

Weak Receptiveness: true



Weak Responsiveness: true

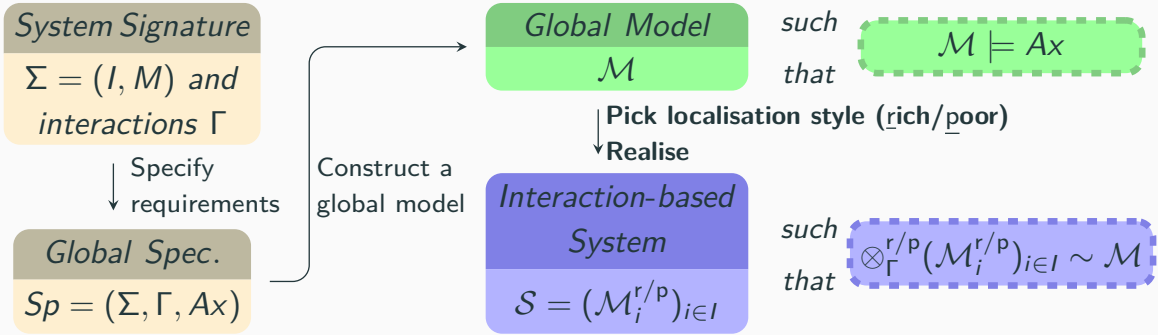


Realisable Team Automata

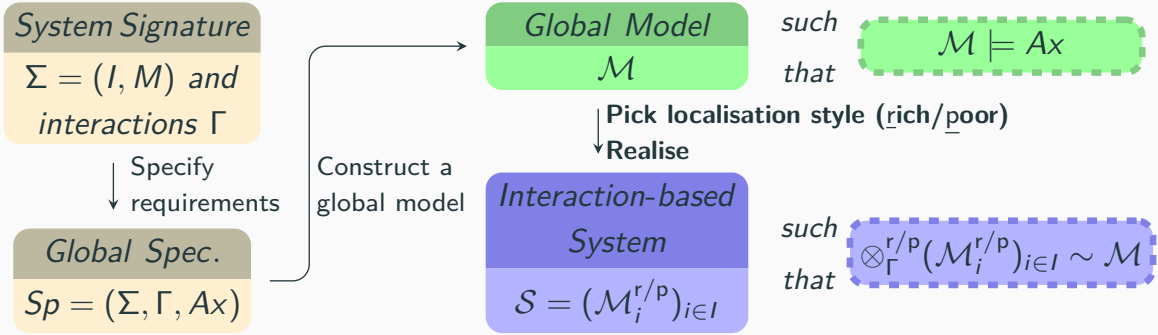
Challenge

How to check if a global (team) model is realisable and, if it is, how to synthesise a realisation?

Contributions ICTAC'23



Contributions ICTAC'23

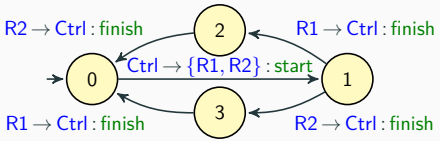


rich (à la multi-party session types, choreography languages) $i \to j : m \Rightarrow$ local output action $i\,j\,!\,m$ for i and local input action $i\,j\,?\,m$ for j

poor (à la component-based I/O development, loose coupling) $i \to j : m \Rightarrow$ local output action $!m$ for i and local input action $?m$ for j

Example

$$\Gamma_{\text{Race}} = \left\{ \begin{array}{l} \text{Ctrl} \to \{\text{R1}, \text{R2}\} : \text{start}\,, \\ \text{R1} \to \text{Ctrl} : \text{finish}\,, \\ \text{R2} \to \text{Ctrl} : \text{finish} \end{array} \right\}$$



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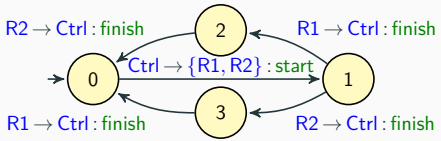
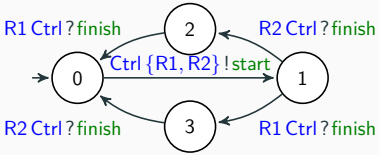
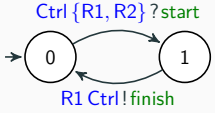
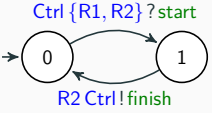
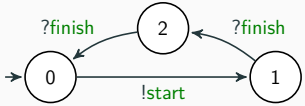
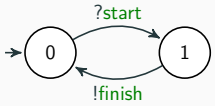
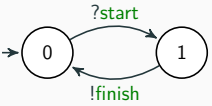
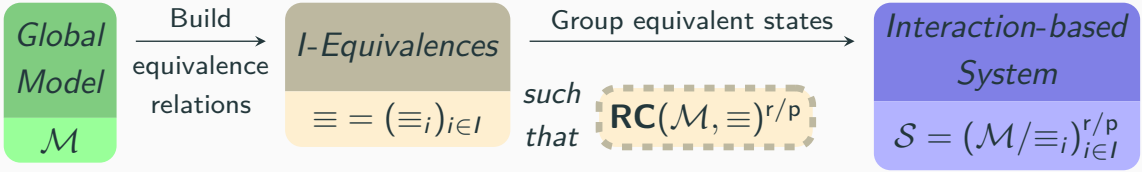
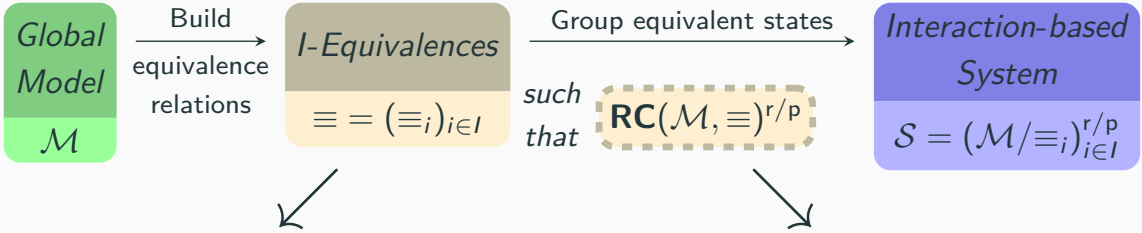


Localisation	Local Ctrl	Local R1	Local R2
Rich			
Poor			

Check Realisability and System Synthesis



Check Realisability and System Synthesis



I. Castellani, M. Mukund, and P.S. Thiagarajan, Synthesizing Distributed Transition Systems from Global Specifications @ FSTTCS'99

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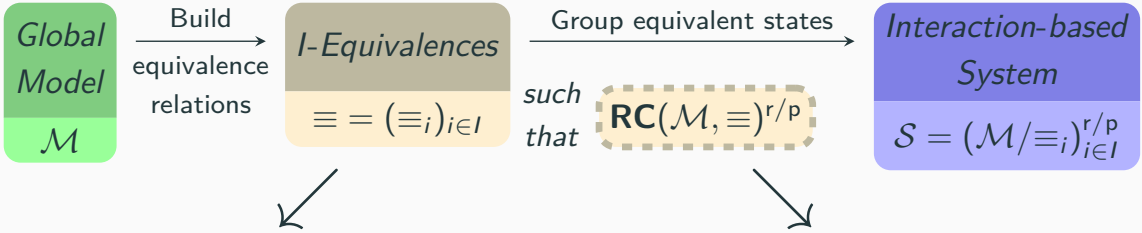

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Theorems 2/3

If $RC(\mathcal{M}, \equiv)^{r/p}$ holds, then $\mathcal{M} \sim \otimes_{\Gamma}^{r/p}((\mathcal{M}/\equiv_i)^{r/p})_{i \in I}$

Novelty

1. Realisations of global models with arbitrary multi-interactions supporting any kind of synchronous communication between multiple senders and multiple receivers
2. Correctness notion for realisation based on bisimulation rather than isomorhism, so allowing to deal with non-determinism
3. To construct realisations we consider, and analyse, two different localisation styles: rich and poor local actions
4. A prototypical tool Ceta checks the realisability conditions and, if they are satisfied, generates local quotients and hence realisations

`https://github.com/arcalab/choreo/tree/ceta`

`https://lmf.di.uminho.pt/ceta`

Online Prototype: `https://lmf.di.uminho.pt/ceta`

Choreographic Extended Team Automata

Choreography

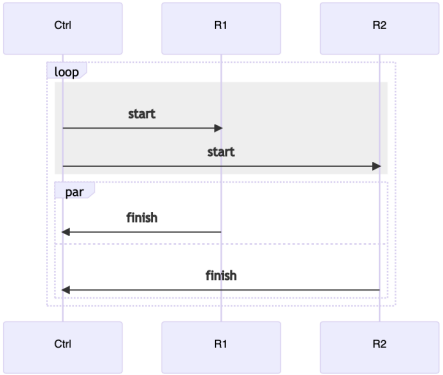
```
1 // Race example
2 (
3  (Ctrl->R1,R2: start);
4  (R1->Ctrl:finish ||
5   R2->Ctrl:finish)
6 )*
```

A controller starts 2 runners at the same time, and receives a finish message from each runner at a time.

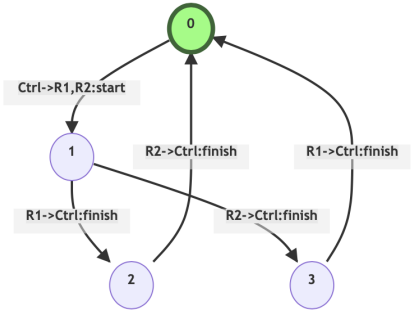
Examples

Race (simple) | Race (R1-first) | Race (once, simple) | Toss | Gossip (bad) | Gossip (good) | Cast-v1 | Cast-v2 | ab+cb+ca | ab;ac | ab|ac | ab;cd | ab|cd

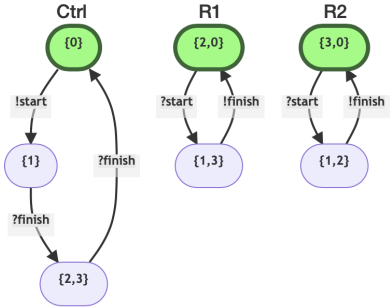
Sequence Diagram



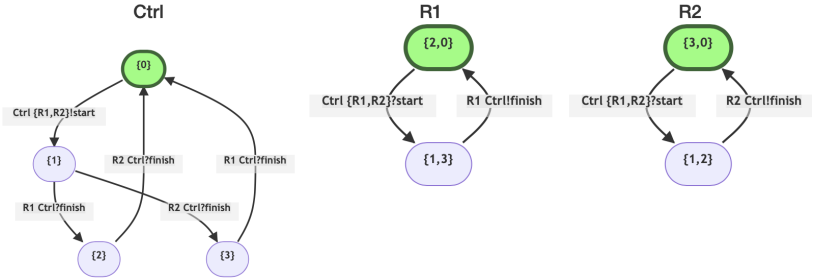
LTS: Global S-Choreo



LTS (poor actions): Local Quotients (Component Automata)



LTS (rich actions): Local Quotients (NOT Component Automata)



Future Work

Team automata with asynchronous communication?

Closing Words

Closing Words from ERCIM News

It has been a true pleasure to work with Erzsi on the ERCIM News editorial board for about 20 years, from 1995 to 2015. Her sharp scientific insight greatly contributed to the quality of ERCIM News, playing a key role in its ongoing success and enduring popularity.
I wish Erzsi a wonderful retirement filled with joy and happiness,

Peter

Closing Words from ERCIM News and from Leiden

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Dear Erzsébet,
first of all congratulations with your achievements and your contributions to theoretical computer science. It has always been a pleasure to see you at conferences, workshops, and of course in Leiden. Thank you for your friendliness and wishing you a happy relaxed retirement with pleasant new endeavours.

Jetty

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Jetty

Dear Erzsi,
Congratulations on your 70th birthday. The theory group in Leiden (distributed by now) holds very nice memories of stimulating and rewarding contacts with you, in Leiden, Hungary and at many scientific meetings in many countries. Also, best wishes for a relaxed, satisfying and productive retirement period of your life.

Hugs, Grzegorz

Thanks for your Attention!

Köszi Erzsi!

Realisability Condition RC($\mathcal{M}, \equiv$): Sufficient But Not Necessary

Global model $\mathcal{M}$ does not satisfy **RC**($\mathcal{M}, \equiv$), but $\mathcal{S} = \{\mathcal{M}_{\mathsf{p}}, \mathcal{M}_{\mathsf{q}}, \mathcal{M}_{\mathsf{r}}\}$ does realise $\mathcal{M}$:

global $\mathcal{M}$	local $\mathcal{M}_{\mathsf{p}}$	local $\mathcal{M}_{\mathsf{q}}$	Local $\mathcal{M}_{\mathsf{r}}$	**ta**($\mathcal{S}$, **st**)