



Fifth  
Framework  
Programme



Research  
Training Networks

# Systems for Integrated Computation and Deduction



The CALCULEMUS IHP Training Network  
**HPRN-CT-2000-00102**

**Christoph Benzmüller and Jörg Siekmann**

Saarland University and German Research Centre for AI (DFKI)



# Presentation Outline

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- Part A: Scientific Impact
- Part B: Networking Aspects
- Part C: Training Aspects
- Part D: Financial Aspects
- Part E: Revision of Contract



# Part A:

# Scientific Impact



# CALCULEMUS: Overview

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0. History and Prehistory of the Field
1. The Sociology of the Community
2. CAS & DS
3. Economic and Industrial Interest in this Academic Field



# History and Prehistory of the Field

Idea:



Mechanisation of Reasoning

(1) Automation of (deductive) Reasoning

(2) Computer Algebra



# The Sociology of the Community

## (1) Automated Reasoning

CADE

(since 1974/76)

**first + seminal papers in:**

nonmonotonic reasoning  
reasoning maintenance systems  
logic programming  
rewriting systems  
unification theory  
abduction (systems)  
inference systems for NL  
probabilistic systems  
logic-based diagnosis  
deduction≡ planning  
program synthesis  
constraints (and LP)  
logical frameworks  
deduction for PV  
...





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- logical frameworks
- deduction for PV

...

Spin-off Conferences

- RTA
- Tableaux
- Unification
- (KR)
- CAV
- (Lics)
- \*LP\*
- ...



# The Sociology of the Community

## (1) Automated Reasoning



- About a dozen Workshops:
  - Proof Presentation
  - User Interfaces for TPs
  - First-Order TP
  - CALCULEMUS
  - ...

**CADE**  
(since 1974/76)  
**first + seminal papers in:**

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...



- Spin-off Conferences
- RTA
  - Tableaux
  - Unification
  - (KR)
  - CAV
  - (Lics)
  - \*LP\*
  - ...



# The Sociology of the Community

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## (2) Computer Algebra

The Beginning: ■ AI and Mathematics



# The Sociology of the Community

## (2) Computer Algebra

The Beginning: ■ AI and Mathematics

- ISSAC (Intern. Symp. on Symbolic and Algebra Computation)
- ACA (Application of Computer Algebra)
- AISC (AI and Symbolic Computation)
- MEGA (Commutative Algebra)
- CASC (Computer Algebra in Scientific Computing)

Now:

- Intern. Congress of Mathematical Software
- RWCA (Rhein Workshop on Computer Algebra)
- GAMM (special section on CAS)
- Computer Algebra Tagung (in Germany and also most other countries)

PLUS: dozens of workshops



# The Sociology of the Community

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(3) Logic:

→ see: IFCoLog

("The International Federation for Computational Logic")

(4) Mathematics

(5) Computer Science: Formal Methods



# CAS & DS: The Map

$DS \subseteq CAS:$

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$CAS \equiv DS:$



# CAS & DS: The Map

$DS \subseteq CAS:$

- - THEOREMA  $\subseteq$  *Mathematica*
- - HR uses OTTER for MAPLE

$CAS \subseteq DS:$

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$CAS \subseteq DS:$

- tight coupling:
  - T-unification, constraint resolution, T-resolution
- loose coupling:
  - reflection approach as used in Coq
  - proof planning ( $\lambda Clam$ ,  $\Omega MEGA$ )

$CAS \equiv DS:$



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$CAS \subseteq DS:$

- tight coupling:
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- loose coupling:
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$CAS \equiv DS:$

- protocol, e.g. á la Calmet
- common interface:
  - top down: OMRS, MathWeb-SB, LBA, MathBroker
  - bottom up: CCR, MathSat

1. Who Wants To Use Integrated Proving and Computer Algebra Systems?
2. ... and what for?

Support for:

- Mathematical Assistant Systems
  - in Mathematics
  - in Education: Maths Tutor System
- Program Verification/Model Checking
  - Mobile Computing and Telecommunication
  - Integrated Systems
  - Dependable, high-risk Systems

# CAS & DS

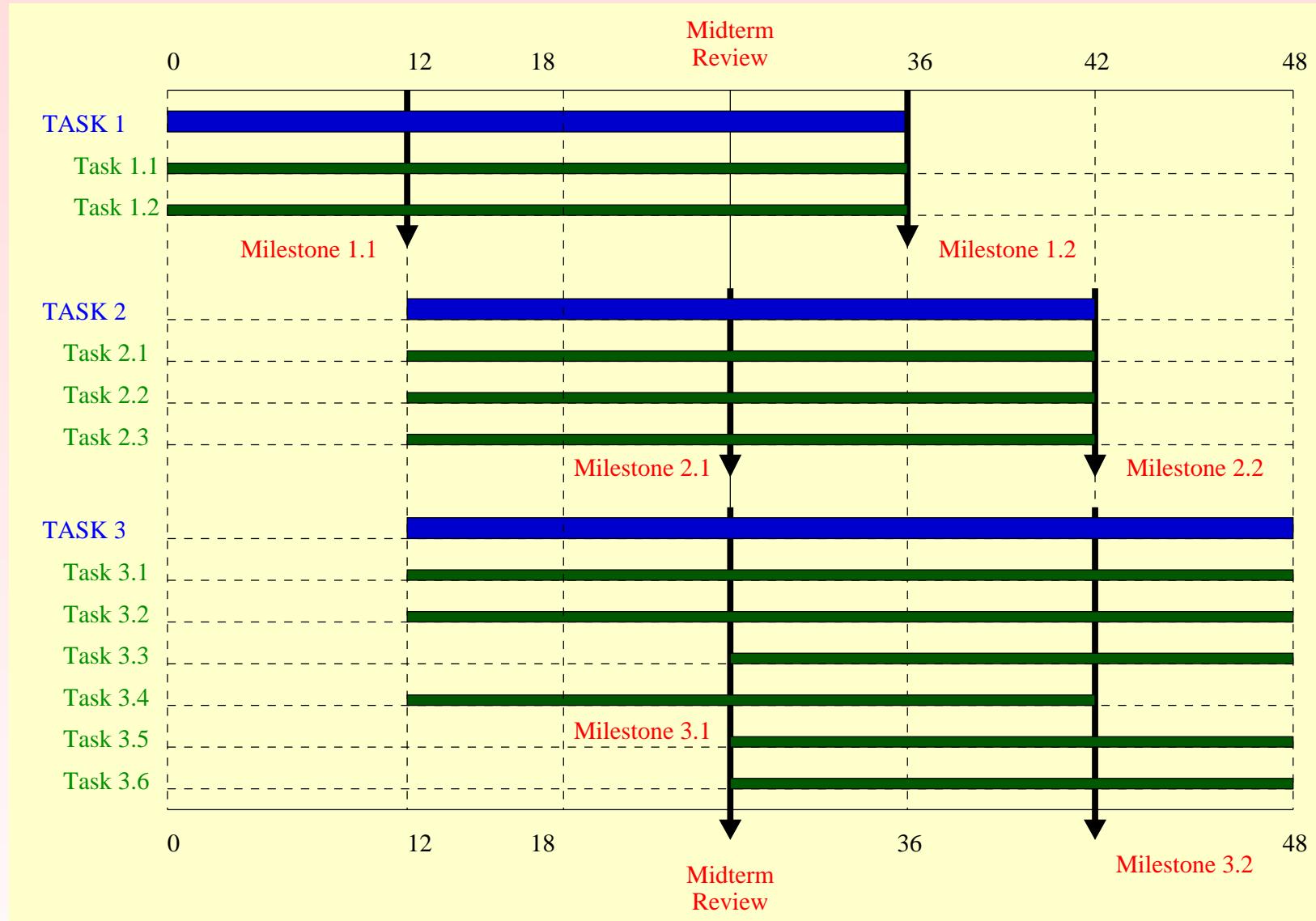
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Support for:

- Security (+Safety) on the Internet
  - Electronic Money Transfer
  - Protocol Verification
  - Electronic Market Places: Mobile Agents
  - Inference Engines for the Semantic Web
- Military Applications



# Schedule: ANNEX I



# Part B:

# Networking Aspects

# Networking

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## Why is networking required?



# Networking

## Why is networking required?

- expertise from several areas required: *Deduction Systems, Computer Algebra Systems, Mathematics, Artificial Intelligence, Formal Methods, etc.*



# Networking

## Why is networking required?

- expertise from several areas required: *Deduction Systems, Computer Algebra Systems, Mathematics, Artificial Intelligence, Formal Methods, etc.*
- Minimize system development efforts
- Recruitment and training of young researchers
- Training of senior researchers
- Training of industry and training by industry
- Dissemination of research results



# Network Partners



**USAAR** Jörg Siekmann, Christoph Benzmüller, Serge Autexier



**UED** Alan Bundy, Ewen MacLean



**UKA** Jacques Calmet, Regine Endsuleit



**RISC** Bruno Buchberger, Wolfgang Windsteiger, Tudor Jebelean



**TUE** Arjeh Cohen, Henk Barendregt, Herman Geuvers  
Freek Wiedijk



**ITC-IRST** Fausto Giunchiglia, Roberto Sebastiani, Alessandro Cimatti,  
Marco Bozzano



**UWB** Andrzej Trybulec, Czeslaw Bylinski, Grzegorz Bancerek



**UGE** Alessandro Armando, Enrico Giunchiglia



**UBIR** Manfred Kerber, Volker Sorge



# Major Network Events

- Symposium in St. Andrews, Scotland, August, 2000.
- Symposium in Siena, Italy, June, 2001.
- Network Meeting in Genova, Italy, February, 2002.
- Symposium in Marseilles, France, July, 2002.
- Autumn School, Pisa, Italy, September, 2002.
- MTR Meeting in Saarbrücken, Germany, March, 2003.

## Upcoming

- Symposium in Rome, Italy, September, 2003.
- Symposium in Cork, Ireland, August, 2004.



# Other Events

With involvement of network partners:

- yearly CIAO Workshops: USAAR/DFKI, UED, UGE, ITC-IRST, UBIR
- CALCULEMUS/MONET Workshop, Linz, November, 2002: RISC, USAAR, ITC-IRST, TUE
- $\Omega$ MEGA Tutorial at UBIR, 2002: USAAR and UBIR
- FLOC 2002 Workshop in Copenhagen, Denmark, 2002.
- THEOREMA- $\Omega$ MEGA Meeting at RISC in May 2003

Furthermore:

- Involvement in MKM (Mathematical Knowledge Management) Meetings: Linz, October, 2001 and Bologna/Bertinoro, February, 2003
- Special CALCULEMUS session at Workshop Mathematics in the Semantic Web, Eindhoven, May 2003



# Dissemination of Results

## Proceedings of CALCULEMUS Symposia

- M. Kerber and M. Kohlhase, editors. CALCULEMUS-2000. AK Peters
- S. Linton and R. Sebastiani, editors. CALCULEMUS-2001.
- J. Calmet, et al. CALCULEMUS-2002, LNAI 2385. Springer
- O. Caprotti and V. Sorge, editors. CALCULEMUS-2002-Work-in-Progress.

## Special Issues in Journal of Symbolic Logic:

- T. Recio and M. Kerber, editors. JSC 32(1/2), 2001.
- A. Armando and T. Jebelean, editors, JSC 32(4), 2001
- S. Linton and R. Sebastiani, editors. JSC 34(4), 2002.

## Proceedings of CALCULEMUS Autumn School

- C. Benzmüller and R. Endsuweit, editors. Autumn School 2002: Course Notes (Part I-III)
- J. Zimmer and C. Benzmüller, editors. Autumn School 2002: Student Poster Abstracts

## Proceedings of Workshops

- S. Colton and V. Sorge, editors. FLOC-2002 Workshop.



# Joint Publications (after 08/2000)

	Joint Publications	All Publications
Refereed Papers		
- Journals	7	> 22
- Proceedings/Books	33	> 54
Technical Reports	4	> 13
PhD Thesis		> 3
Others		> 4
Total	44	> 96

Source: The CALCULEMUS Midterm Report



# Joint Systems and Applications

System, Language, Software	Developed/used at the following nodes
OMDoc	USAAR,UBIR,UED,UWB
MathWeb	USAAR,UBIR,UGE,UED
$\Omega$ MEGA	USAAR,UBIR
MIZAR	UWB,TUE
MathSat	ITC-IRST,UWB

Application	performed by the following nodes
Irrationality of $\sqrt{2}$	TUE,USAAR,UWB,RISC
Exploration of Residue Classes	USAAR,UBIR,UED
Permutation Groups	USAAR,UBIR,TUE
Zariski Spaces	UBIR,UED
Hybrid Systems	USAAR,UGE,UED
Correct Functions in MAPLE	UKA,UED,UGE
Security Protocols	UED,UGE,ITC-IRST
Model Checking for Real-Time Systems	ITC-IRST,UWB



# Organisation and Management

- Team at USAAR:

- Christoph Benzmüller (since 2001)
- Corinna Hahn (Eurice GmbH)
- Jörg Siekmann

supported by YVRs and  $\Omega$ MEGA group at USAAR

- Researchers in charge at the individual sites:

- Head of Nodes
- Marco Bozzano, Ewen McLean, Herman Geuvers, Volker Sorge, Freek Wiedijk, Wolfgang Windsteiger,  
....



# Communication Means

e-mail	<a href="mailto:calculemus-ihp@ags.uni-sb.de">calculemus-ihp@ags.uni-sb.de</a>	Network Researchers and YVRs
	<a href="mailto:calculemus-ihp-steering@ags.uni-sb.de">calculemus-ihp-steering@ags.uni-sb.de</a>	Network Steering Committee
	<a href="mailto:calculemus-autumn-school@eurice.de">calculemus-autumn-school@eurice.de</a>	Autumn School Organisation Team
	<a href="mailto:calculemus2002school@ags.uni-sb.de">calculemus2002school@ags.uni-sb.de</a>	Autumn School Participants
Web	<a href="http://www.eurice.de/calculemus/">www.eurice.de/calculemus/</a>	Network Homepage
	<a href="http://www.eurice.de/calculemus/autumn-school/">www.eurice.de/calculemus/autumn-school/</a>	Autumn School Homepage
Web	<a href="http://www.win.tue.nl/~smurray/calculemus/eut.html">www.win.tue.nl/~smurray/calculemus/eut.html</a>	Partner Nodes
	...	
	Further Task Report Web-sites	
	...	
CVS	<u><a href="#">Concurrent Version Control System</a></u> repository maintained by USAAR and UBIR ( <a href="http://www.ags.uni-sb.de/~chris/calculemus-cvs/">www.ags.uni-sb.de/~chris/calculemus-cvs/</a> )	Joint Document Development

# Part C: Training Aspects



# Network YVRs

Participant	Young Visiting Researchers (so far)
USAAR	Andrew Adams, Corrado Giromini, Pasquale De Lucia, Markus Moschner Silvio Ranise
UED	Corrado Giromini, Luca Compagna, Jürgen Zimmer, Julien Musset, <i>Rafael Accorsi</i>
UKA	Simon Colton, Jesus Maria Aransay Azofra, <i>Julien Musset</i> , Vincent Lefévre, <i>Arno Wagner</i>
RISC	Adrian Craciun, <i>Laura Kovacs</i> , <i>Camelia Kocsis</i>
TUE	Scott Murray, Markus Rosenkranz, Mariusz Giero
ITC-IRST	Artur Kornilowicz, Gilles Audemard, <i>Daniel Sheridan</i>
UWB	Josef Urban, Hazel Duncan, Markus Moschner
UGE	Jürgen Zimmer, Sorin Stratulat, Pierre Ganty
UBIR	Martin Pollet, Andreas Meier



# Network YVRs

Participant	YVR-Deliverable (months)			YVRso far (months)		
	PreDoc (a)	PostDoc (b)	Total (a+b)	PreDoc (c)	PostDoc (d)	Total (c+d)
USAAR	18	15	33	22	5	27 ( <i>&gt; 6</i> )
UED	26	16	42	19	0	19 ( <i>17</i> )
UKA	24	15	39	6	3	9 ( <i>11</i> )
RISC	18	13	31	17	0	17 ( <i>&gt; 14</i> )
TUE	24	14	38	2	12	14 ( <i>10</i> )
ITC-IRST	26	17	43	1.5	21.5	23 ( <i>18</i> )
UWB	12	3	15	8	3	11 ( <i>&gt; 4</i> )
UGE	11	8	19	12	5	17 ( <i>&gt; 6</i> )
UBIR	8	8	16	8	0	8 ( <i>3</i> )
<b>TOTAL</b>	167	109	<b>276</b>	95.5	49.5	<b>145 + (89)</b>



# Training Programme

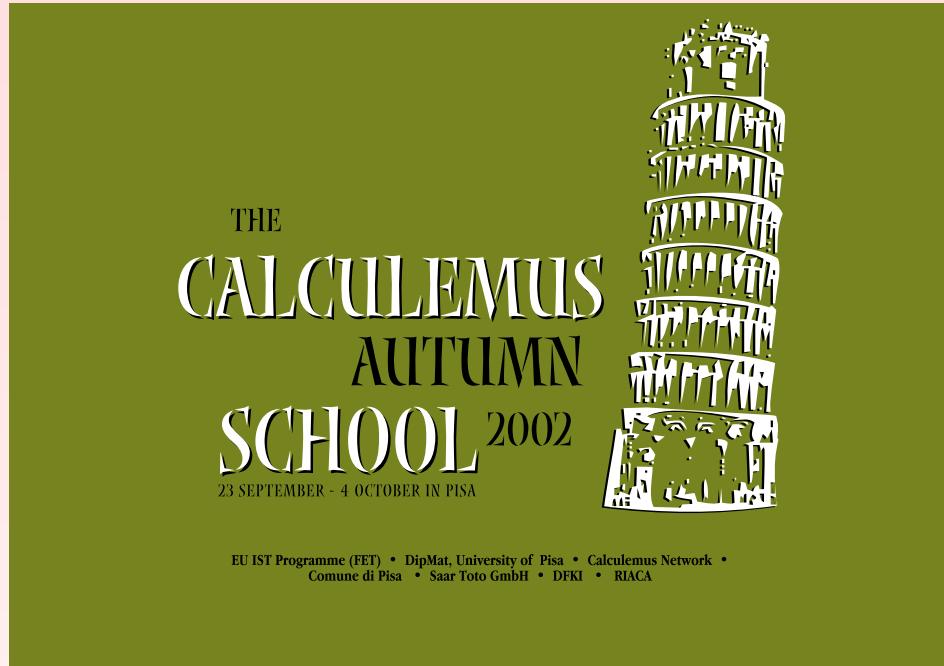
The training measures of the Network include:

1. The CALCULEMUS Autumn School
2. Training at an Individual Level at the Network Nodes
3. Local Courses, Workshops, Talks, and Seminars
4. Exchange of YVRs between Network Nodes
5. Participation in Network Meetings
6. Industry Internships

Not a big difference between PreDocs and PostDocs



# The CALCULEMUS Autumn School



## Organising Committee

Christoph Benzmüller, USAAR (Chair)  
Regine Endsuleit/Clemens Ballarin, UKA (Chair)  
Carlo Traverso, Uni Pisa (Local Organizer)  
Jörg Siekmann, USAAR  
Jacques Calmet, UKA  
Corinna Hahn, EPO/ Eurice GmbH





# The CALCULEMUS Autumn School

The first training event with the main experts from the involved fields

- 75 participants (approx. 30 from Network): Undergrads, PreDocs, PostDocs, Researchers, Lecturers
- 26 lecturers



## Associated Events:

- OPENMATH workshop
- MKM Network kick off meeting
- CALCULEMUS task force meetings



# The CALCULEMUS Autumn School

- Introductory and Overview Courses
- Advanced Topics
- Evening Talks
- Student Sessions
- System Demonstration
- Experimentation with Systems



Evaluation of School showed:

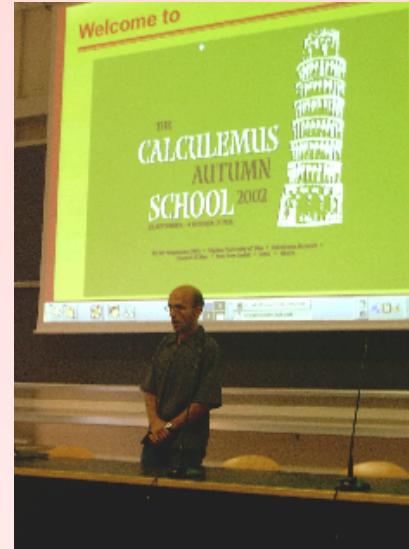
- the concept/format of the school was well chosen
- overall success of the event



# The CALCULEMUS Autumn School

The story with the teachers ...

- with big effort: 26 Comenius grants
- hired a student for advertisement
- very few registrations
- ... finally course skipped



Evaluation of Autumn School:

- the concept/format of the School was well chosen
- good – very good overall rating



# Training: Two YVR Examples

We illustrates the networks training practice at hand of the following two Young Researchers:



Corrado Giromini



Jürgen Zimmer



# Training: Two YVR Examples



UGE



USAAR



UED



- Corrado: Masters at UGE
- Jürgen: Masters at USAAR



# Training: Two YVR Examples



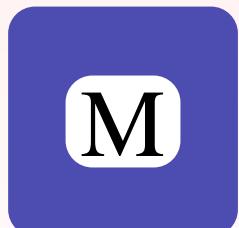
UGE



USAAR



UED



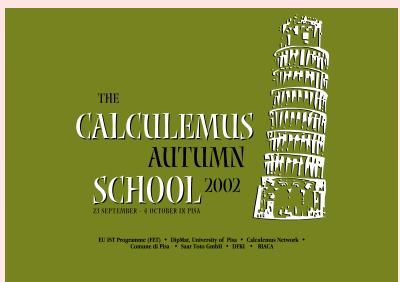
- Corrado and Jürgen at UGE:
  - Joint work on MathWeb-SB and LBA
  - Supervised by A. Armando
- Joint publication



# Training: Two YVR Examples



UGE



USAAR



UED



- Corrado trained at USAAR and DFKI
  - supervised by C. Benzm. / A. Nonnengart
- Jürgen trained at UED
  - supervised by A. Bundy / L. Dennis
- Joined publications at both sides



# Training: Two YVR Examples



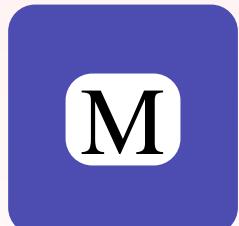
UGE



USAAR



UED



- Corrado at trained UED / company M
  - DFKI involved (A. Nonnengart visits M)
- Jürgen back at USAAR: PhD studies
  - other training measures, e.g. at RISC



# Training: Two YVR Examples



UGE



UED



USAAR



- Corrado and Jürgen at USAAR
  - organisation and participation at MTR
- Feedback to USAAR/DFKI on work at M by Corrado



# Training: Two YVR Examples



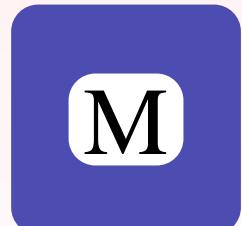
UGE



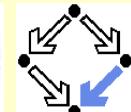
USAAR



UED



- Corrado: PhD between UGE-USAAR-UED?
- Jürgen trained at company M and UED
  - PhD work between USAAR-UED
- others involved ...



...



# Career Impact of Network

- Simon Colton: Lecturer at Imperial College, London, UK
- Silvio Ranise: Inria Researcher of Nancy, F
- Volker Sorge: Lecturer at University of Birmingham, UK
- Sorin Stratulat: Lecturer at University of Metz, Metz, F
- Gilles Audemard: Assistant Professor at Université D'Artois, Lens, F
- Artur Kornilowicz: Assistant Professor at UWB, P
- ... more to come ...



# Training by Industry Internships

- Corrado Giromini — telecommunication company near Edinburgh, UK
- Jürgen Zimmer — same company
- Andreas Meier — car supplier near Stuttgart, D
- Luca Compagna — electronic group near Munich, D
- further internships are planned by RISC and ITC-IRST

Bidirectional information flow:

- current industrial environment
- network potentials in industry



# Training by Industry Internships

- Only selective industry internships: there should be a potential benefit for both sides
- No internships for YVRs without background knowledge about the network

... another training measure: myself as coordinator

# Part D:

# Financial Aspects

# Financial Aspects

Participant	Cost Categories (spent to date, in thousands €)				Estimated Eligible Costs (foreseen in the contract, in thousands €)			
	Personnel	Networking	Overheads	Total	Personnel	Networking	Overheads	Total
USAAR	91	54	29	174	92	56	29	179
UED	39	8	9	57	73	20	18	112
UKA	31	12	8	52	97	23	24	144
RISC	28	24	10	63	77	20	19	117
TUE	48	4	10	63	86	20	21	128
ITC-IRST	70	6	15	91	92	22	22	137
UWB	11	15	5	32	14	22	7	43
UGE	42	18	12	73	42	11	10	64
UBIR	39	11	10	61	31	10	8	50
<b>Totals</b>	402	156	111	<b>671</b>	608	208	163	<b>979</b>

→ neither overspending nor strongly underspending (taking the 6 months delay into account)

# Part E:

# Revision of Contract



# Revisions of Contract

- We propose to slightly adapt/broaden the research tasks 3.2, 3.3, and 3.5
- Industry Internships:  
selective and background knowledge
- Duration of Network:  
6 months extension?

Aspects to discuss?

- Eligibility Criteria
- Distribution of Money (from EU to Nodes, among Nodes)
- Recommendation: Central budget for central events



# What else to say . . . ?

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... the CALCULEMUS Family is not just

cooperating intensively

but also



socializing intensively

across national borders . . .



# Revisions of Contract

- 3.2 (Industrial-strength Applications) There are two main application areas for the systems and approaches developed in the Network: (i) Formal Methods and (ii) Mathematics Education. While the original work plan mainly focused on (i) the proposal is to additionally investigate (ii). At RISC the THEOREMA system is, for instance, already employed in practice to teach students in courses and similarly the  $\Omega$ MEGA system is used within the mathematical tutor system ACTIVEMATH.
- 3.3 (Exams in Calculus and Economics – Harvard) We propose to allow more flexibility with respect to the concrete mathematical domain to be chosen for the comparative analysis of the experimental results on using the prototype systems. Related work has already been completed on comparing solutions of different systems for the problem of proving the irrationality of  $\sqrt{2}$ .
- 3.5 (Challenge Mathematical Problems) The formalisation and (semi-)automation of some challenging mathematical problems with our approaches and systems is possible but typically requires special techniques and very experienced users. Therefore, we propose to additionally investigate to what extent our systems also support non-expert and novice users in doing normal and every day mathematics with a computer.