

Logic, Computation, Communication

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Outline

History at a glance

- Logic and Computation

- λ -calculus

- Our contributions

A glance at present-day research of the NS π group

- Computation and Communication

- π -calculus

- Our contributions

Future

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Computable functions

1930s Computability models

- ▶ A. Church : method for defining functions **λ -calculus**
- ▶ A. Turing : theoretical model of a **machine** for calculation from inputs
- ▶ Church, S. Kleene, J.B. Rosser: class of functions calculated by **recursion**

In λ -calculus:

- ▶ Arithmetic: natural numbers (Church numerals), `SUCC`, `PLUS`, `MULT`, `POW`, `PRED`, `SUB`
- ▶ Logic and predicates: `true`, `false`, `and`, `or`, `not`, `ifthenelse`, `iszero`
- ▶ Recursions, fixed points (self-application)

λ -calculus

- ▶ Typed λ -calculi: Barendregt's cube, intersection types, recursive
- ▶ computational interpretations of logic

$$\vdash A \Leftrightarrow \vdash t:A$$

- ▶ intuitionistic logic: 1950-1970s Curry, Howard, Lambek (CCC), de Bruijn (Automath)
 - ▶ classical logic
- ▶ Scott models models, continuous functions $D \cong D \rightarrow D$ - denotational semantics
- ▶ proof assistance: COQ (INRIA), Isabelle (Cambridge, TU Munchen)
- ▶ functional programming languages: LISP, Miranda, ML, Haskell,

- ▶ Kosta Došen (proof theory, Curry-Howard, CCC)
- ▶ Žarko Mijajlović (denotational semantics)
- ▶ Zoran Marković (intuitionism)

- ▶ Aleksandar Kron
- ▶ Dean Rosenzweig
- ▶ Andreja Prijatelj

- ▶ H.P Barendregt, M. Dezani-Ciancaglini, J. Lambek, P. Lescanne, D. Dougherty, H. Herbelin, J. Espirito Santo

- ▶ D. Tomović, M. Grulović, S. Crvenković, S. Milić

- ▶ Z. Petrić, M. Borisavljević

- ▶ S. Likavec (U. Torino), V. Kunčak (MIT), D. Žunić (ENS Lyon)

Our contributions

- ▶ Typed λ -calculi - S.G., S. Likavec
- ▶ computational interpretations of logic
 - ▶ intuitionistic logic: Curry, Howard, Lambek, de Bruijn
 - ▶ classical logic
- S.G., S. Likavec, J. Ivetić, D. Žunić
- ▶ Scott models models - S.G., S. Likavec
- ▶ proof assistance: COQ (INRIA), ISABELLE (Cambridge, TU Munchen) P. Maksimović, S. Jakšić, J. Ivetić
- ▶ functional programming languages: LISP, Miranda, ML, Haskell
S.G., V. Kunčak

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Sequentiality vs concurrency - λ vs π

COMPUTATION

determinism

function

sequential composition

computational behaviour

λ calculus

COMMUNICATION

non-determinism

process

parallel composition

interactional behaviour

π calculus

1991. R. Milner - Turing laureat

(CCS - a theory of concurrency)

Process calculi

- ▶ π -calculus: Milner, Parrow, Walker
 - ▶ description and analysis of concurrent computation
 - ▶ **Processes**:
 - ▶ concurrency $P|Q$
 - ▶ communication:
 - ▶ replication $!P$
 - ▶ Turing completeness: encodings of λ -calculus
- ▶ Distributed π -calculus - Hennessy
 - ▶ **Locations**
 - ▶ processes: **movement**
- ▶ Calculus of mobile processes with data - Gardner, Mefeis
 - ▶ **Data**
 - ▶ processes: **run**, **update**

Types for Dynamic Web Data

Security properties - S.G. J.Pantović, S. Jakšić

- ▶ to control communication of values
- ▶ to control migration of processes
- ▶ to control access to data

Application:

- ▶ e-library
- ▶ remote voting system
- ▶ e-classroom



Mariangiola Dezani-Ciancaglini, Silvia Ghilezan, and Jovanka Pantovic

Security types for dynamic web data.

Trustworthy Global Computing 2006, LNCS 4661: 263-280, 2007.



Mariangiola Dezani-Ciancaglini, Silvia Ghilezan, Jovanka Pantovic, and Daniele Varacca.

Security types for dynamic web data.

Theoretical Computer Science, 402(2-3):156–171, 2008.



Mariangiola Dezani-Ciancaglini, Silvia Ghilezan, Svetlana Jaksic and Jovanka Pantovic

Types for Role-based Access Control of Dynamic Web Data.

19th Workshop on Functional and (Constraint) Logic Programming (PORL2010), 2010. (invited lecture)

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- ▶ Doctoral school FTN and MISANU
- ▶ doctoral students: J. Ivetić, S. Jakšić, B. Marinković, P. Maksimović (co-tutelle INRIA)
- ▶ doctoral students engineers LiCS: 10 each year
- ▶ projects: COST, Tempus, FP, bilateral, national
- ▶ Summer school: FIT 2009 -Foundation of Information Technologies (50 doctoral students)
- ▶ Conference: RDP 2011 - Conference on Rewriting, Deduction and Programming (TLCA + RTA + wokrshops) June 2011