# Foundations Software Technology ($F_aST$)

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**LIACS**

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…

# FaST

- Formal semantic foundations of software composition and coordination

- Software Engineering

- Theoretical Computer Science

# FaST

- Focus on the formal semantic foundations of software composition and coordination:

- Large *software systems* are difficult to construct and maintain due to their inherent complexity.
- *Compositional* techniques hold the key to breaking this complexity down to manageable levels.
- Composing systems out of *independent components* or services requires *coordination* of their interactions.
- Considerations for *concurrency, distribution, mobility, and dynamic reconfiguration* of systems, e.g., to upgrade or adapt to their changing environment, add to the complexity of a system and its interaction protocols.
- Coordination in Software Systems studies how complex systems can be constructed from independent components or services using a clear distinction between individual components or services, and the protocols for their coordinated interaction.

# Mission

- Development of formalisms, methods, techniques, and tools to design, analyze, and construct software systems out of components and services.

- Ingredients
  - Classes/Objects
  - Components
  - Services
- Construction
  - Composition
  - Correctness
- Issues
  - Concurrency
  - Coordination
  - Model
- Approach
  - Formal methods
  - Experimental systems
  - Empirical studies

# Areas

- Formal models of concurrent, distributed, object oriented, and component-based systems
- Formal semantics, process algebras and logics for reasoning about such systems
- Dynamically reconfigurable adaptable systems
- Concurrency on multi- and many-core platforms
- Testing, deductive verification, and model checking
- Software services and cloud computing
- Quality of service
- Empirical studies of the effects of methods and techniques on productivity and quality of industrial software development projects.

# Major challenge

Development of techniques for effectively establishing behavioral properties of dynamical systems

# Activities – F. Arbab

- Coordination models and languages
  - Coordinated composition of software intensive systems
  - Concurrency and interaction
  - Coordination language Reo
  - Constraint automata

- Use of coordination
  - Compositional QoS
  - Code generation for multi-core systems
  - Service oriented computing
  - Testing

# Activities – F.S. de Boer

- Software correctness

Programming logics
- Deductive proof methods for the verification of programs

Object Orientation
- Verification and Testing

Concurrency
- Semantics

Integrated Formal Methods
- Testing
- Model Checking
- Deductive Verification
- Abstraction

# Activities – M. Bonsangue

- Formal Methods

  Mathematically-based techniques for the specification, development and verification of software and hardware systems

  - Testing object-oriented languages
  - Semantics and model checking of software connectors
  - Semantics and verification of dynamical evolving systems

- Algebra, Coalgebra and Logic

  Mathematical frameworks for the specification of the reactive behaviour of systems

  - Process algebra, regular expressions
  - (Probabilistic, non-deterministic, …) automata
  - Modal logics

# Activities – J. Kleijn

- Formal Methods

Mathematical specification (of distributed behaviour)

- Automata and languages
- Concurrency Monoids (generalised traces)
- Extended partial orders

- Modeling Concurrency

Petri Nets

- Theory
- Biologically motivated models
  - membrane systems, reaction systems: analysis and synthesis
- Biomodeling

Team Automata

- cooperating components

Application:

- Financial/business processes

# Current projects:

- 25 different projects

# Parallelism toolkit on Kalray processor

- Problem: Modify the proto-runtime toolkit so that it operates efficiently on the Kalray ultra low power, high performance embedded processor.
- Required: Programming experience in C and assembly.
- Supervisors: Sean Halle and F. Arbab

# Proto-runtime + V8 Javascript interpreter

- Problem: Connect the proto-runtime toolkit to the high performance V8 javascript interpreter.
- Required: Programming experience in C and Javascript.
- Supervisors: Sean Halle and F. Arbab

# Proto-runtime on Dutch National Supercomputer

- Problem: Measure the performance of proto-runtime on the Netherland's national supercomputer, and experiment with ways to improve its performance.
- Required: Programming experience in C and assembly.
- Supervisors: Sean Halle and F. Arbab

# Implement your own parallel language

- Problem: Use the Rascal meta environment to write a simple source-to-source translator that translates your custom parallel syntax into calls to a parallel runtime system.
- Required: C programming on Linux
- Supervisors: Sean Halle and F. Arbab

# Eclipse GUI to run Reo applications

- Problem: Develop an Eclipse GUI for the ECT to produce the executable files for a concurrent application. This tool links various components and/or threads with the Reo coordinator code, produces a main program, and supplies it with its command-line parameters.
- Required: Java programming and Eclipse
- Supervisors: S-S Jongmans and F. Arbab

# An editor for data constraints

- Problem: Develop a basic editor (syntax highlighting, useful error messages, basic refactoring, etc.) for a simple constraint language in Eclipse, by using---and if necessary extending---an existing parser.
- Required: Java programming; (willingness to learn) Eclipse and Antlr

Supervisors: S-S Jongmans and F. Arbab

# Web service deployment in the cloud

- Problem: Develop a Java library for deploying web services, as jar files, on Amazon EC2 virtual machines in the cloud, by using functionality from Amazon's AWS Toolkit for Eclipse.
- Required: Java programming; (willingness to learn) Eclipse, JAX-WS, AWS, AWS Toolkit for Eclipse
- Supervisors: S-S Jongmans and F. Arbab

# Test cases generation for Java classes

- Problem: Given a piece of Java code generate inputs so to test it “enough”.
- Required: Knowledge of Java + P&C.
- Supervisors: F. de Boer and M. Bonsangue.

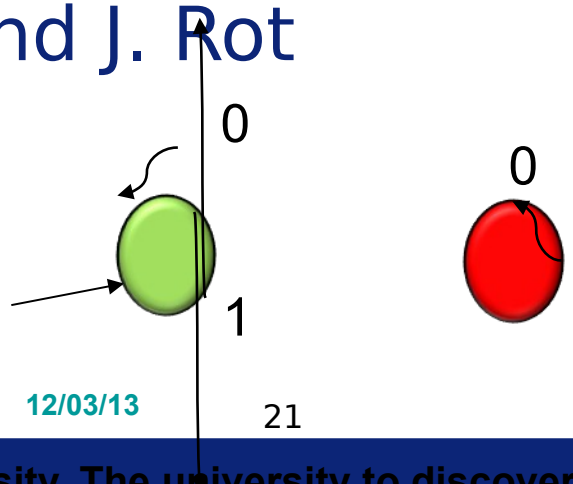
```
while ( low <= high ) {
    int mid = (low + high ) / 2
}
```

# Automata toolkit

- Problem: Implement novel techniques to
  Minimize automata
  Solve decision problems
  (language equivalence, minimality, inclusion)
  Go from regular expression to automaton and back

- Required: knowledge of automata theory (FI2),

- Supervisors: M. Bonsangue and J. Rot



# Model checking recursive programs

- Problem: Recursive programs over finite data structures may have infinite state. Implement a way to check all of them against a property.

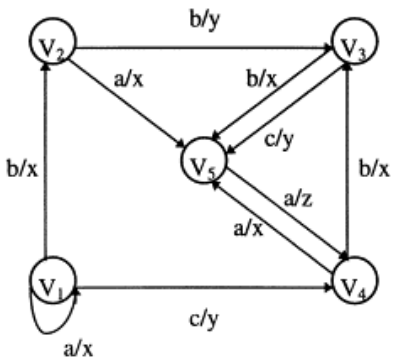
- Required: knowledge of automata theory (FI2), logic and P&C

- Supervisors: F. de Boer, M. Bonsangue and J. Rot

```
Proc P ==  .... call Q ...
Proc Q == ... call P ....
```

# Process equivalence checking

- Problem: Processes are abstract description of the behaviours of systems. They are subject to several equivalences: bisimulation, failure, ready, ... Implement recent techniques to check equivalent processes.
- Required: knowledge of automata theory (FI2).
- Supervisors: M. Bonsangue



# KAT partial derivatives

- Problem: Develop the theory to associate a non-dtereministic finite automaton to a KAT expressions using partial derivatives.
- Required: knowledge of formal languages and automata theory (FI2).
- Supervisors: M. Bonsangue and Jurriaan Rot

# Parsing Boolean grammars

- Problem: Develop parsing technique for the Boolean grammar, and syntactic formats so to characterize regular languages.
- Required: knowledge of formal languages and automata theory (FI2).
- Supervisors: M. Bonsangue and Jurriaan Rot

# Music from streams

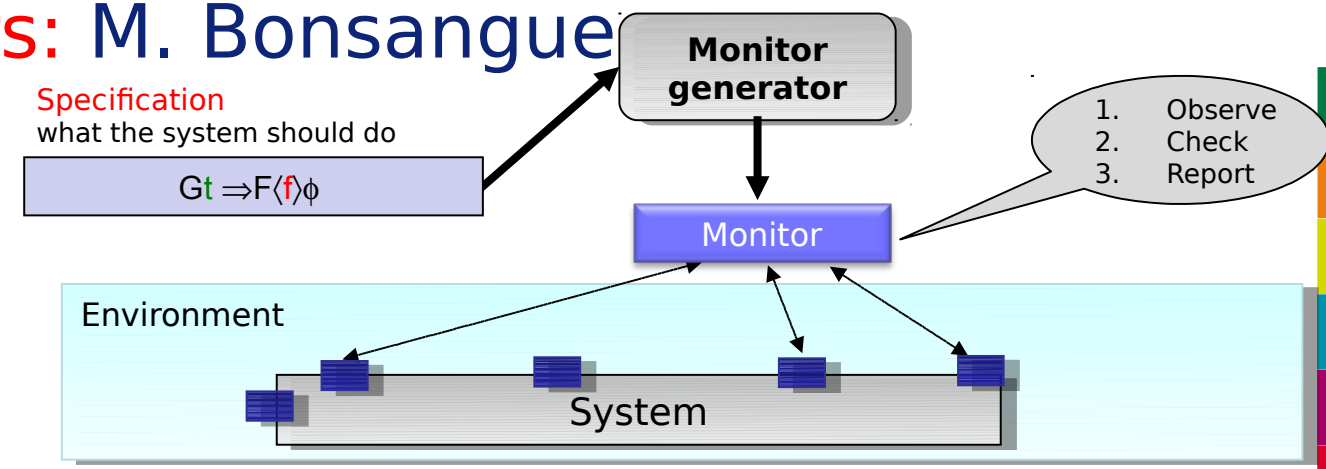
- Problem: Build a system to transform stream definitions into musical note. The idea is to generate interactively a midi file from the number of the stream defined by an user.
- Required: Programming in other languages than C++
- Supervisors: M. Bonsangue and Jurriaan Rot

# Bisimulation-up-to for formal languages

- Problem: Implement several bisimualtion-up-to techniques for language inclusion and equivalence.
- Required: Programming in other languages than C++; Running experiments
- Supervisors: M. Bonsangue and Jurriaan Rot

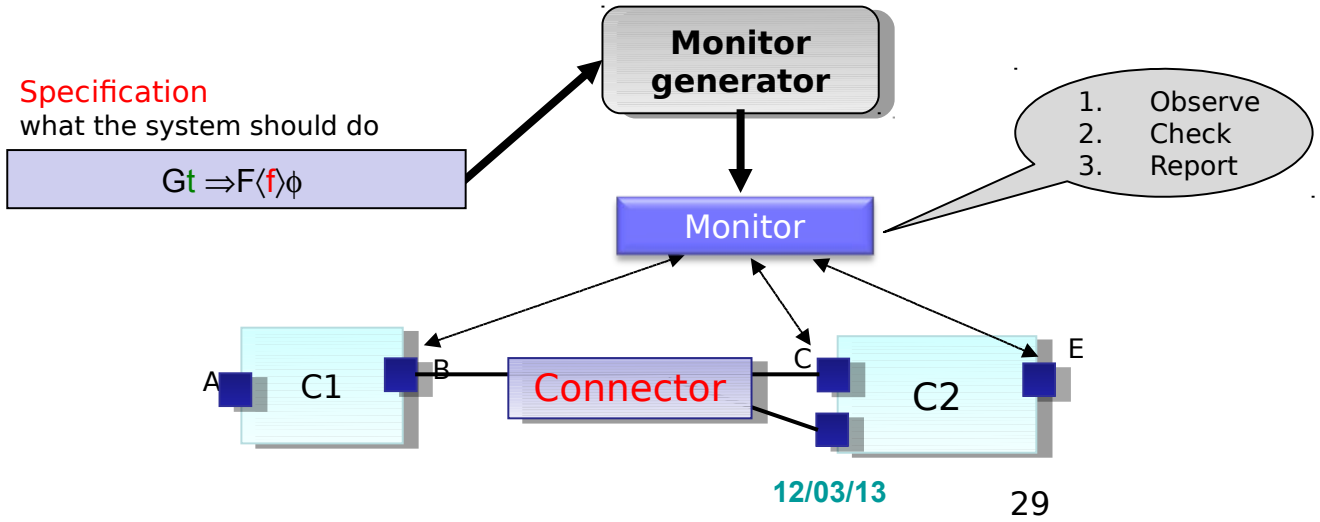
# Monitoring circuits

- Problem: Automatic generation of monitors for simple hardware circuits to check their behaviors at run time.
- Required: Knowledge of Logic and automata theory
- Supervisors: M. Bonsangue



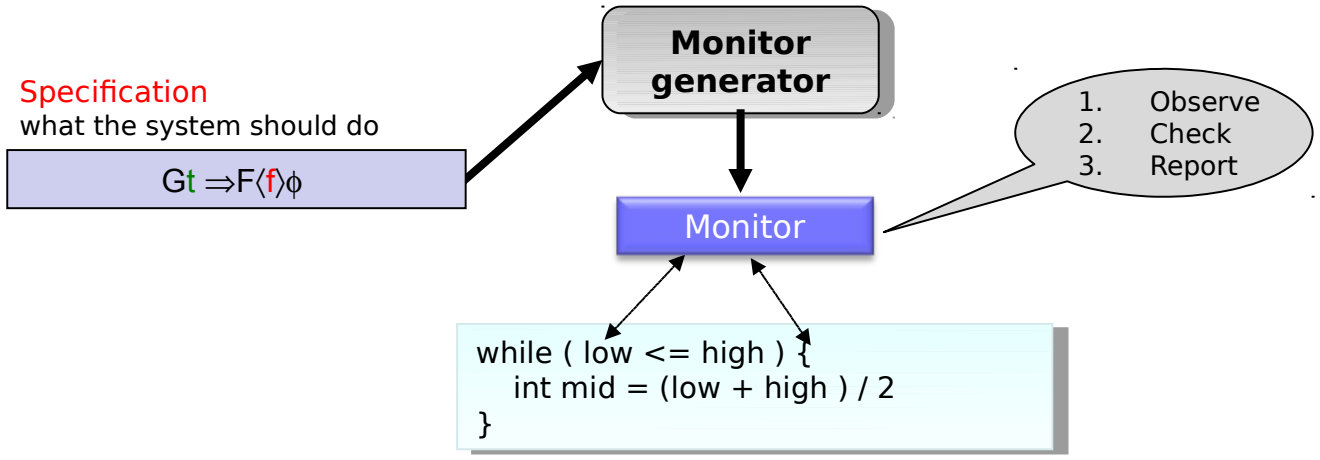
# Monitoring sofware circuits

- Problem: Same as previous one, but now with coordination software instead of circuits.
- Required: Knowledge of Java
- Supervisors: F. Arbab and M. Bonsangue



# Monitoring Java

- Problem: Same as previous one, but now with Java.
- Required: Knowledge of Java
- Supervisors: F. de Boer and M. Bonsangue



# Coverability

- Problem: Overview of algorithms and constructions for boundedness, finiteness and coverability properties for different classes of Petri Nets.

- Required: Theory of concurrency, algorithmic interest.

- Supervisors: J. Kleijn

# Compatibility of Teams

- Problem: Implement compatibility checks for team automata: can components collaborate successfully?

- Required: theory of concurrency, automata

- Supervisors: J. Kleijn

# Bio inspired Modeling

- Problem: Set Nets, a Petri net model for reaction systems. Relation to classical net models.
- Requirements: Theory of Concurrency.
- Supervisors: J. Kleijn

# Bio Modeling

- various issues:

- Petri nets as operational models for real-life phenomena
- Feature modeling

- Tools:

- -Requirements: Theory of Concurrency.

- Supervisors: J. Kleijn and F.Verbeek

# Financial product Markup Language

- Problem: The development of the domain specific language FpML: design and challenges
- Required: Informatica en Economie
- Supervisors: P. Kwantes and J. Kleijn

# Business Process Modeling Notation

- Problem: The ontological adequacy of BMPN
- Required: Informatica en Economie
- Supervisors: P.Kwantes, J.Kleijn/F.Verbeek

# Treemaps

- Problem: Multi-scale visualisation of maps
- Required: Datastructures, SE, Imaging (?)
- Supervisors: N. Kokash and J.Kok