Bigraphical Programming Languages

A LaCoMoCo research project, January 2004 - 2008

2nd UK-UbiNet Workshop, May 2004

Thomas Hildebrandt
ITU University of Copenhagen
• Context-dependent Mobile Communication is a strategic research theme at ITU, ranging from social and cultural implications, over applications to technological infrastructure
• WLAN positioning system at ITU used by >100 students in projects
• Courses in Mobile Business, Location-Based Applications and CSCW, peer-to-peer systems and Model-based design of distributed and mobile systems (calculi)
• 8 research projects* initiated January 2004, ranging from Context-aware Computing, HCI and Location Based Gaming to Bigraphical Programming Languages

* 5 with funding from the Danish Research Council, CIT, Danish Broadcasting Corporation, and Nokia
Bigraphical Programming Languages
(January 2004 – 2008)

- **Goal:**
  Design Programming Language(s) for context-dependent mobile services and distributed mobile applications, based on the theory of bigraphs [Milner, H. Jensen]

- **Who:**
  - Logic and Semantics
    - Lars Birkedal (principal investigator)
    - Troels C. Damgaard (research assistant)
    - Mikkel Bundgaard (PhD-student)
    - Thomas Hildebrandt
  - Programming Language Implementation
    - Martin Elsman
  - Concurrency/Mobility theory
  - Web Programming
    - Henning Niss
  - Distributed and Mobile applications
    - Arne J. Glenstrup
  + two PhD students starting August 2004 (4 year scholarships)
Bigraphical context-dependent mobile services
A Core Syntax for Bigraphical Reactive Systems

/* Example Bigraph for context-dependent mobile butler service */
using sig Room:active (1); Butler:passive (2); Person:passive (1); Door:atomic (3);
    Visit:atomic(1); Path:atomic (3) end

local
  val butler = Butler<lars,e1> (Path<e1,d1,e2>|Path<e2,d2,e3>){/e1/,/e2/,/e3/} in
local
  val reception = Room <rec> (butler| Person <thomas>(Visit <lars>))
val corridor = Room <cor> ()
val office = Room <off> (Person<lars>())
val door1 = Door <rec,d1,cor>
val door2 = Door <cor,d2,off>
val redex = Room<a>(Person<x>(Visit<y>)|Butler<y,e>(Path<e,d,e’>|[0]) |[1]) |Door<a,d,b> |Room<b>][2])
val reactum = Room<a>][1])|Door<a,d,b> |
  Room<b>(Person<x>(Visit<y>)|Butler<y,e’>][0]) |[2])
rule redex=>reactum
in
  val itu = (reception | corridor | office | door1 | door2)
end
Why Bigraphs?

• The theory of Bigraphs focuses *simultaneously* on two of the most important aspects of mobile distributed systems: *connectivity* and *locality*.

• A *meta-language* which (analogously to XML) allows definition of domain specific languages, while benefiting from a general theory (e.g. for contextual equivalences).

• A *graphical* model: Eases communication and avoids introduction of syntactical distinctions.
Research Goals and Questions

- How to combine signatures, rules and state?
  - Block structure?
  - Normal forms?
  - Data types and constructors?
  - I/O?

- Domain specific Language(s) for context-dependent mobile services
  (Bindings to Java, ML, …)

- (Sugared) Bigraph Language

- Tools for Verification, Specification, Simulation and Test

- Bigraphical datatypes, e.g. context descriptions?
  - Security?
  - Types?
  - Views/Abstractions?

- Context-awareness?
  - Soundness & Security?
  - Efficiency?

- Compilation & Deployment
  - Run-time environment(s)

- XML

- Develop Theory

- (spatial) logics?, calculi?, bigraph model extensions (time, probability, …)?
Activities so far…

• Weekly BPL seminars (where theory meets practice)
• Implemented parsers and compilers in ML and Java (runs as an applet) for prototype BPL language
  – compiles to XML or internal data structure
  – so far no runtime environment
  – indeed only prototypes!
• Related masters thesis projects:
  – XML rewriting ("XML reactive systems")
  – Context-dependent/Location-based Systems
• Plenty of student project proposals (XML helps here!)
Links

- IT University of Copenhagen: www.itu.dk
- LaCoMoCO: lacomoco.itu.dk
- BPL Project: www.itu.dk/research/theory/bpl/
- Bigraph applet: www.itu.dk/research/theory/bpl/software/bip/
- Bigraphs and mobile processes (revised) [Milner, Høgh Jensen]:
- Axioms for bigraphical structure [Milner]: