Is Functional Programming (FP) for me?

ACCU Conference 2008

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Overview of talk

- History of computing
- Types of problem, developers, solution, environments, managers
- Pros and cons of FP
- Comparison of FP to other choices
  - Success stories
  - Where traditional still wins
- FP language v. FP style

History

- Three strands in computing (1950s)
  - FORTRAN - numeric calculations
  - COBOL - state, process and I/O
  - LISP - symbolic calculations, AI
- These strands still exist
  - FORTRAN - still numerics, procedural
  - COBOL -> structured prog -> OO
  - LISP -> functional, higher-level langs
- These problem types still exist

Models of problem

Numeric	Mathematics
Symbolic/algorithmic	Functional
State	UML class
Process	UML statechart UML activity diagram
I/O	Pre/postconditions

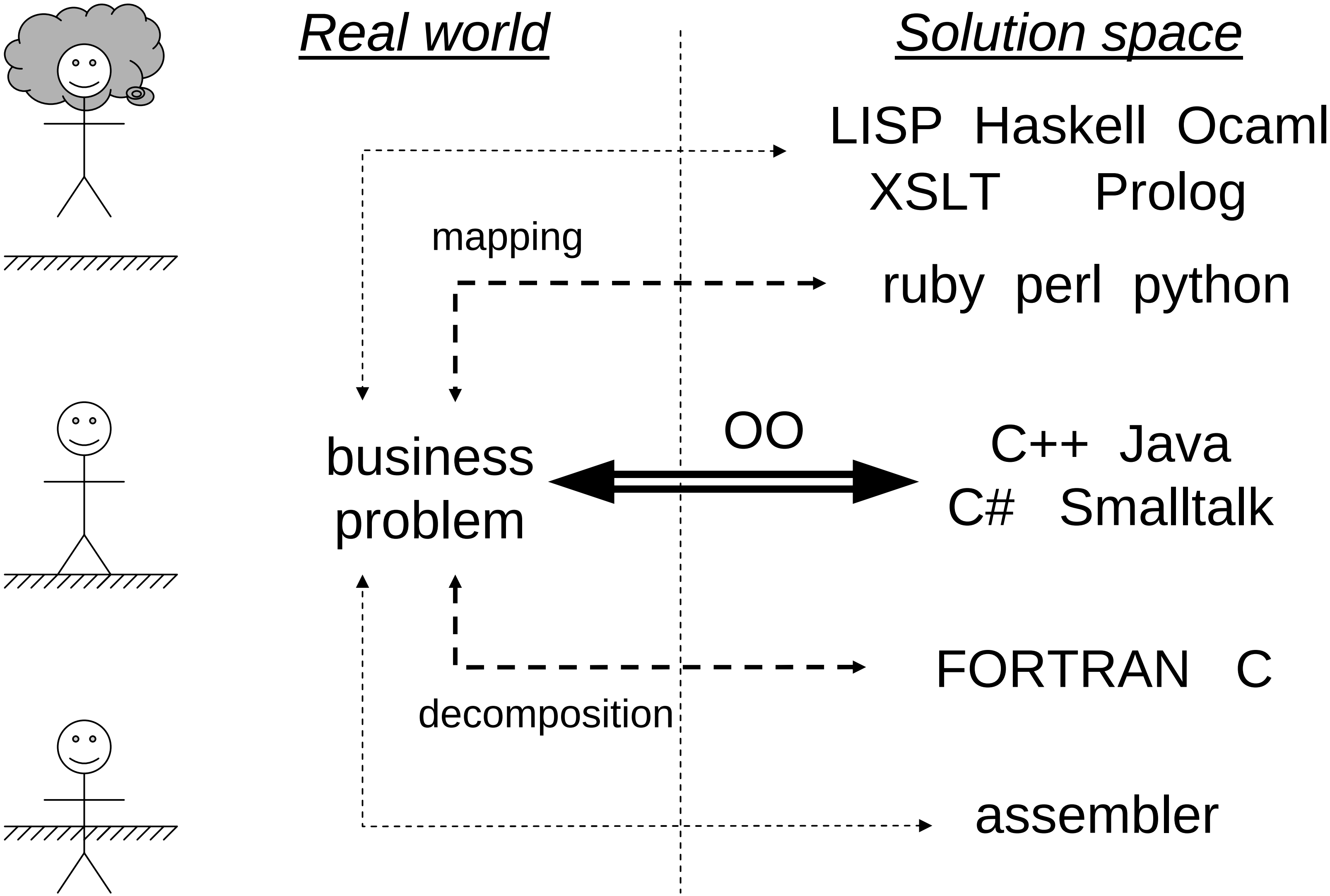
- Analysis models (not solution)
  - Describing the problem
- Some fit a functional description, some don't

Type of developers

- Scientist turned developer
- Mathematician turned developer
- Developer from OO world
- Novice

- Keen to learn v. “old dog”
- Comfort level of change
- Human side of change
  - Change needs planning and selling

Mapping solution to problem



Levels of expressivity and power

- Paul Graham and BLUB programmers
  - Expressive “enough”
- Error rates and productivity per line
  - Denser code is better for both
- Mapping from problem to solution
  - Key strength of OO
  - Larger mapping gap leads to errors and reduced productivity

Glass's errors

- 30% missing reqts
  - No change for FP here
- 45% integration, complex state
  - Pure FP code gains, mixed code doesn't
- 25% could be caught by coverage

"Facts and Fallicies of Software Engineering", Robert Glass

Complexity

- Essential complexity
  - Inherent in the problem
- Accidental complexity
  - Part of the solution
  - Infrastructure (techies favourite!)
- Use power of higher-level languages to reduce mapping gap
  - Domain-specific languages
- Are you working on the real problem?

Type of environment

- Managers
  – Trust, recruitment, pay levels, blame
  – “Tell me again, why can’t we do this in Java?”
- Technical
  – Integration, existing libraries (FFI)
  – Native library support and tools (IDE, debugger)
- Commercial
  – Do your customers care?
- Cultural
  – Academic or not

Migrating and adopting FP

- Don’t underestimate the effort or time
- Standish failures
  - User rejection (here user == developer)
  - Lack of management support
- Manage expectations and risks
- Expect an initial reduction in productivity
  - New language, tools, data structures, etc

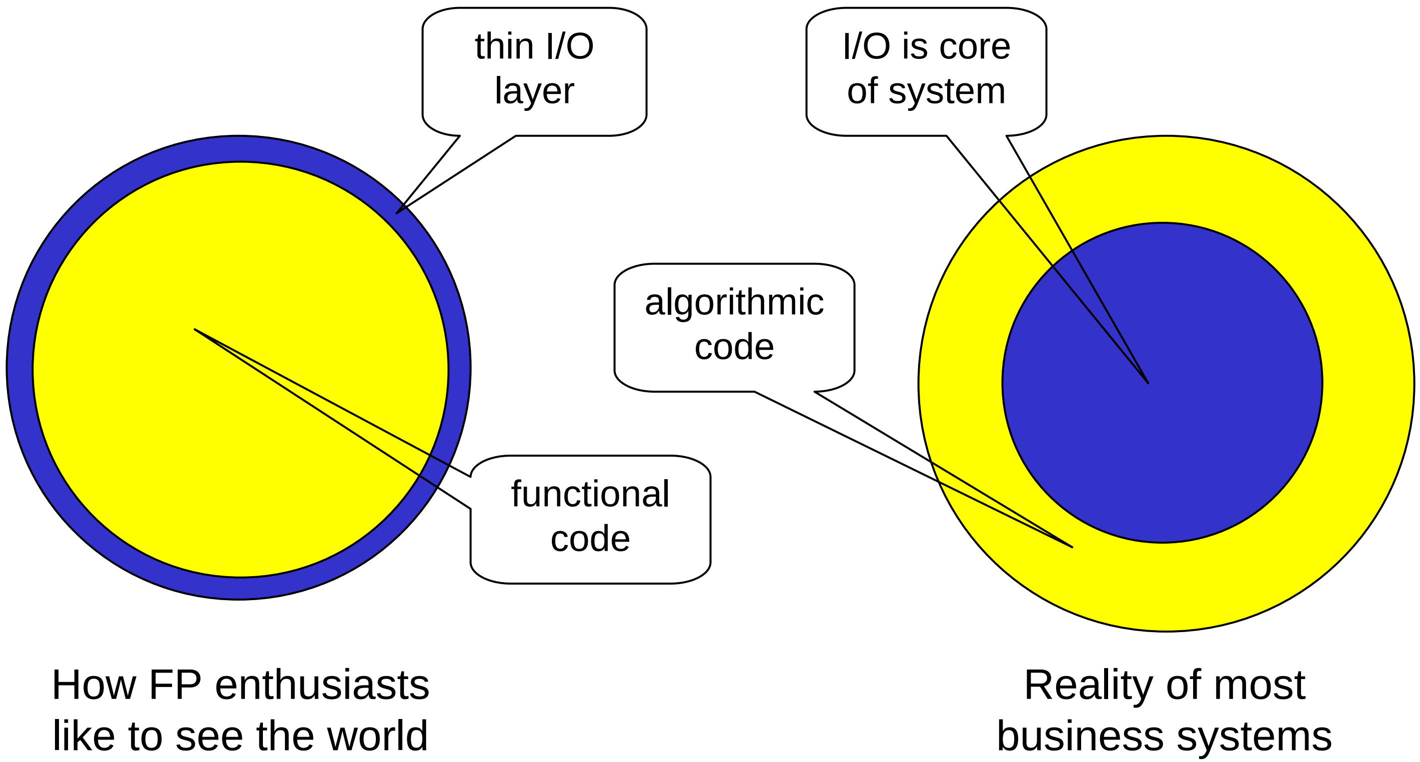
Cool stuff in FP

- Powerful type systems
- Higher-order functions
- Lazy and partial evaluation
- Continuations and tail recursion
- Referential transparency - no side effects
- List comprehensions
- Composability of modules
- Compiler does more work (optimisation)
- (C.f. the mapping problem)

Not so cool stuff in FP

- State, I/O, exceptions
  – "The Awkward Squad" (Simon P-J)
- I/O is not possible in "pure" FP
  – C++ templates are pure!
  – Haskell's monads keep pure and impure separate
- Variables/state also not possible
  – Type system maintains the separation
- Neither are natural idioms in FP

The problem of I/O



- I/O is central to most real applications
- Haskell's monads v. Erlang CSP-style I/O
- Input, process, output - algorithmic core

The problem of state

- State is ubiquitous in the real world
- Object-orientation models this very well
  - One of the reasons for its dominance
- Most real-world applications do not perform complex calculations
- Most FP languages can be impure

Concurrency and optimisation

- Implicit
  - FP compilers can optimise aggressively because of immutable state (no aliasing)
  - Graph reduction is inherently parallel
  - Finding data parallelism is still hard (DPH)
  - Still no silver bullet even with FP
- Explicit
  - Erlang's process-oriented programming
  - Haskell's SW transactional memory

Parallelising

- Parallel calculations relatively simple
  – Add more CPUs/cores
  – Erlang's SMP scales well (32 CPUs, 28x)
- Parallelising I/O is harder
  – Particularly when sharing mutable state
- Scalability of web apps limited primarily by I/O not CPU (database)
- OpenMP is primarily numeric, not FP
  – pmap - explicit
- MPI is message based (I/O)

Commercial uses of FP

- CUFP conference (2004 onwards)

What	Who	Language
Credit risk	ABN Amro	Haskell
Terrorism response	Dartmouth	Scheme
Driver verifier	Microsoft	Ocaml
DB migration tool	IBM	Ocaml
DSL for robots	Dassault	Ocaml
Pricing instruments	LexiFi	Ocaml
Quantitive research	Jane Street Capital	Ocaml
Machine learning	Microsoft	F#
Darcs	Open source	Haskell

- Algorithmic examples dominate
  - Verification, compilation, calculation, not parallel

Erlang

- More a concurrent language than a functional one
  - Functional aspects are there to make concurrency easier
  - Also for programmer productivity gains
- Most widely deployed FP
  - Telephone switches (large systems)
- Came from research on reliability
  - Distributed error handling, supervisors
- Has I/O at its core

FP efficiency

- Numeric efficiency
  - Usually optimised for integers
  - Floating point not as good (boxing/tagging)
- Alioth benchmarks (CPU usage)
  - Compared to C and C++ (1x)
  - LISP, Haskell, Ocaml, Clean, Java (2x-5x)
  - Perl, python slower (20x)
  - Ruby much slower (50x)
  - Prolog (70x)
- Edinburgh comparison of Erlang and C++

Functional style v. FP

- How can we gain some benefits of FP in imperative languages?
- Pure “const” functions
  - All context on call stack (debugging easy)
  - Makes unit testing easier
  - Tension with OO
  - More “leaves” in call tree, less coupling
- Ring-fence I/O and mutable state
  - Use *Parameterise from Above* for purity
- List comprehensions
  - C++ STL, map/reduce in other languages
- Immutable data types

Separation

- Easier to test functional code (non-modifying)
  - Even in an imperative language
- Command query separation
  - Doesn’t play nicely with concurrency or distribution however
- Puts testing burden on integration
  - Parameterise from above

Functional envy

- Imperative languages keep acquiring FP-like features
  - Garbage collection (LISP)
  - Closures and blocks (higher-order funcs)
  - List comprehensions
  - Type inference (C++ templates)
  - Continuations (Ruby’s call/cc)
- These may be enough to gain benefits of FP without losing benefits of host language

Composite systems

- Different layers or components can use different technologies
- Large-scale separation
- Games
  - Rendering - highly parallelisable, “FPable”
  - State layer - where stuff is, OO
  - Game play - what to do (AI), scripting
- Web site using FP
  - XSLT, StringTemplate, SQL

FP sweet spot

- Complex algorithms
- More academic cultures
- Simple integration and external library requirements

So why bother with FP?

- Very good on algorithmic code
  - Defined semantics, maths basis
- Very good on complex calculations
  - Optimisation possibilities
- Higher order thinking
- C.f. Raymond’s comment on Lisp
- Makes imperative programs cleaner

Summary

- FP fits certain problem types, people, environments well
  - …and some it doesn't fit at all…
  - Context is King (as ever)
- Do not underestimate the cost and difficulty of migrating
- You can use FP thinking in non-FP languages fruitfully
- You can write anything in anything!