FUNAR
3 – Technologien

- statisches Typsystem, Typklassen
- effektvolle Berechnungen über explizite Monaden
- viele Erweiterungen
- nicht-strikte Auswertung
- viele Optionen für Parallelisierung und Nebenläufigkeit
- eigene Runtime
- hochoptimierender Compiler (Native Code)
- Entwicklung koordiniert bei Microsoft Research

- statisches Typsystem
- mächtiges Modulsystem
- imperative Features
- eigene Runtime
  (Bytecode, Native Code)
- optimierender Compiler
- Entwicklung koordiniert von
  INRIA, OCamlLabs

Beispiel

https://github.com/janestreet/async_smtp

```
module Spoolable = struct
  module type S = sig
    (** [Spoolable.Metadata.t] should be smallish since it is read and written more
        frequently than [Spoolable.Data.t]. *)
    module Metadata : sig
      type t

      (** [of_string] and [to_string] are used to persist and read [t] on disk. *)
      include
        Stringable.S with type t := t
    end

    (** [Spoolable.Data.t] is where the "real" data lives and it allows for data-specific
        [load] and [save] functionality. *)
    module Data : sig
      type t

      val load : string -> t Deferred.Or_error.t
      val save : ?temp_file:string -> t -> string -> unit Deferred.Or_error.t
    end

    (** [Queue.t] is an enumerable type that represents the available queues and the
        mapping to directory names on-disk. *)
    module Queue : sig
      type t [@@deriving sexp, enumerate, compare]

      val to_dirname : t -> string
    end

    module Name_generator : Name_generator.S

    (** All operations that touch disk are passed through [Throttle.enqueue] *)
    module Throttle : sig
      val enqueue : (unit -> 'a Deferred.t) -> 'a Deferred.t
    end
```

Beispiel

```
module Make_base (S : Multispool_intf.Spoolable.S) = struct
  include Shared

  type t = spool [@@deriving sexp]

  let dir t = t

  let load_metadata path =
    S.Throttle.enqueue (fun () ->
      Deferred.Or_error.try_with (fun () ->
        let%bind contents = Reader.file_contents path in
        return (S.Metadata.of_string contents)))

  let save_metadata ?temp_file ~contents path =
    S.Throttle.enqueue (fun () ->
      Deferred.Or_error.try_with (fun () ->
        Writer.save path ?temp_file ~contents ~fsync:true))

  module Data_file = struct
    type t =
      { spool : spool
      ; name : string
      }

    let create spool name = { spool; name }
    let path t = data_dir_of t.spool ^/ t.name
    let load t = S.Throttle.enqueue (fun () -> S.Data.load (path t))
    let save t ~contents = S.Throttle.enqueue (fun () -> S.Data.save contents (path t))

    let stat t =
      Deferred.Or_error.try_with (fun () ->
        S.Throttle.enqueue (fun () -> Unix.stat (data_dir_of t.spool ^/ t.name)))
end
```

- dynamisch getypt
- Actor-Modell
- inhärent verteilt
- spezialisiert auf fehlertolerante Systeme
- umfangreiches Ökosystem
  für Deployment und Betrieb
- eigene Runtime
  (Bytecode, auch Native Code)
- Entwicklung koordiniert von Ericsson

Beispiel

https://github.com/zotonic/zotonic

```
-module(mod_tkvstore).
-author("Marc Worrell <marc@worrell.nl>").
-behaviour(gen_server).

-include_lib("zotonic_core/include/zotonic.hrl").


%% @doc Fetch the persistent data of a type/key
pid_observe_tkvstore_get(Pid, #tkvstore_get{} = Message, _Context) ->
    gen_server:call(Pid, Message).

%% @doc Fetch persistent data, first check the data dict that is still being written

handle_call(#tkvstore_get{type=Type, key=Key}, _From, State) ->
    case dict:find({Type, Key}, State#state.data) of
        {ok, Data} ->
            % Data is being written, return the data that is not yet in the store
            {reply, Data, State};
        error ->
            {reply, m_tkvstore:get(Type, Key, State#state.context), State}
    end;
```

elixir

- alternative Sprache für die Erlang-Plattform
- inspiriert durch Ruby
- interoperabel mit Erlang
- eigenes Build-/Package-Tooling

Beispiel

https://github.com/elixir-ecto/ecto

```
defmodule Ecto.Repo.Registry do

  use GenServer

  def associate(pid, value) when is_pid(pid) do
    GenServer.call(__MODULE__, {:associate, pid, value})
  end

  @impl true
  def handle_call({:associate, pid, value}, _from, table) do
    ref = Process.monitor(pid)
    true = :ets.insert(table, {pid, ref, value})
    {:reply, :ok, table}
  end

  @impl true
  def handle_info({:DOWN, ref, _type, pid, _reason}, table) do
    [{^pid, ^ref, _}] = :ets.lookup(table, pid)
    :ets.delete(table, pid)
    {:noreply, table}
  end
end
```

- hybride OO-/FP-Sprache
- statisches Typsystem
- entwickelt von Apple
- eng mit Objective-C / Cocoa integriert
- eigene Runtime / Reference Counting
- Native Code

Beispiel

Eidhof, Kugler, Swierstra: Functional Swift

```
indirect enum Diagram {
  case primitive(CGSize, Primitive)
  case beside(Diagram, Diagram)
  case below(Diagram, Diagram)
  case attributed(Attribute, Diagram)
  case align(CGPoint, Diagram)
}
extension Diagram {
  var size: CGSize {
    switch self {
      case .primitive(let size, _): return size
      case .attributed(_, let x): return x.size
      case let .beside(l, r):
        let sizeL = l.size
        let sizeR = r.size
        return CGSize(width: sizeL.width + sizeR.width,
          height: max(sizeL.height, sizeR.height))
      case let .below(l, r):
        return CGSize(width: max(l.size.width, r.size.width),
          height: l.size.height + r.size.height)
      case .align(_, let r): return r.size
    }
  }
}
```

Racket

- Baukasten für Sprachen
- enthält mehrere spezielle Lehrsprachen
- Abkömmling von Scheme/Lisp
- untgetypte und getypte Varianten
- eigene Runtime
  (Byte-Code, Native Code, JIT)

Beispiel

https://racket-lang.org/

#lang racket

```
(require 2htdp/image) ; draw a picture
(let sierpinski ([n 8])
  (cond
    [(zero? n) (triangle 2 'solid 'red)]
    [else (define t (sierpinski (- n 1)))
```

#lang scribble/base

```
@; Generate a PDF or HTML document
@title{Bottles: @italic{Abridged}}
@(apply
  itemlist
  (for/list ([n (in-range 100 0 -1)])
```

#lang typed/racket

```
;; Using higher-order occurrence typing
(define-type SrN (U String Number))
(: tog ((Listof SrN) -> String))
(define (tog l)
  (apply string-append (filter string? l)))
```

#lang datalog

```
ancestor(A, B) :- parent(A, B).
ancestor(A, B) :-
  parent(A, C), ancestor(C, B).
parent(john, douglas).
parent(bob, john).
```

#lang racket/gui

```
(define f (new frame% [label "Guess"]))
(define n (random 5)) (send f show #t)
(define ((check i) btn evt)
  (message-box "." (if (= i n) "Yes" "No")))
(for ([i (in-range 5)])
```

#lang web-server/insta

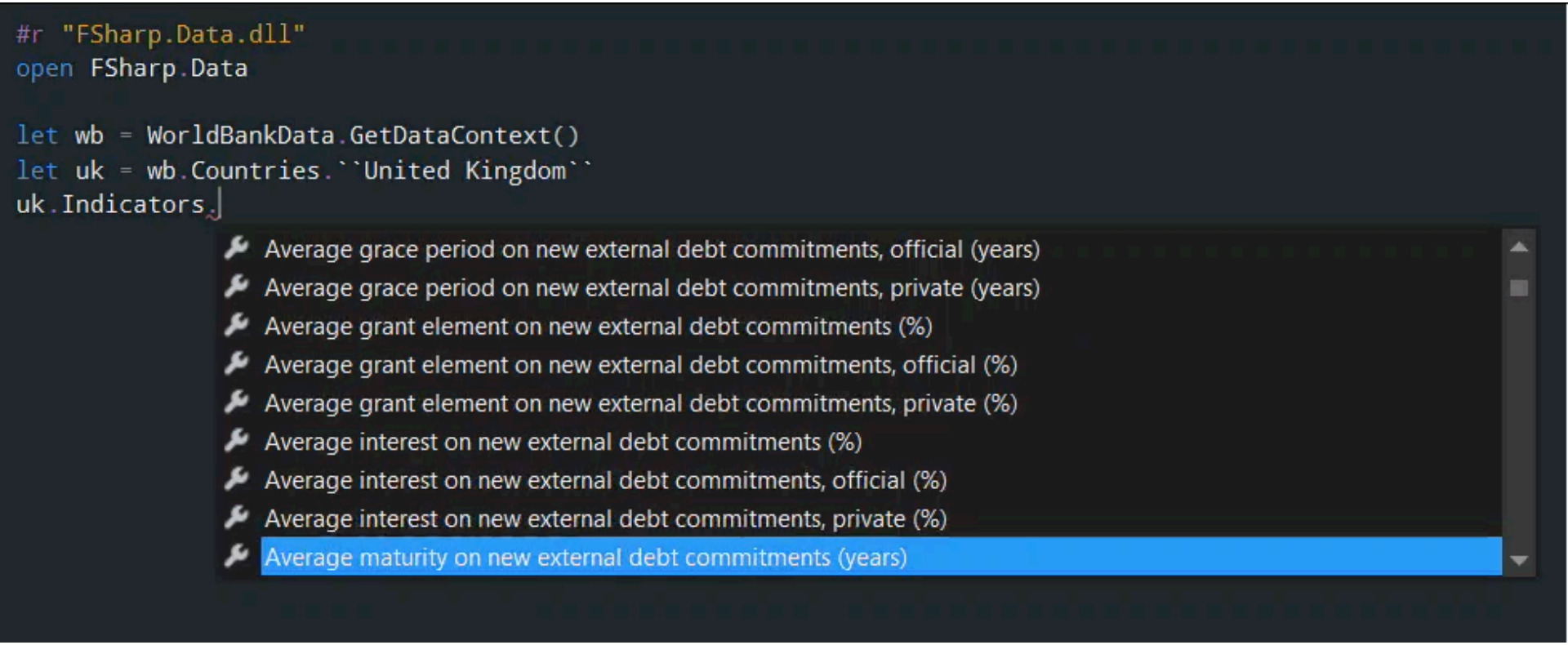
```
;; A "hello world" web server
(define (start request)
  (response/xexpr
   '(html
     (head (title "Racket"))
```

F#

- .NET-Abkömmling von OCaml
- allerdings ohne dessen Modulsystem
- statisches Typsystem
- … mit Maßeinheiten
- integriert in Visual Studio
- *type providers*
- Entwicklung bei Microsoft koordiniert

Beispiel

http://fsharp.github.io/FSharp.Data/



- hybride OO-/FP-Sprache
- statisches Typsystem
- Java-Plattform
- Entwicklung koordiniert bei Lightbend
- Fokus auf Weiterentwicklung

Clojure

- modernes Lisp
- dynamisch getypt
- Java-Plattform
- Entwicklung koordiniert bei Cognitect
- Fokus auf Stabilität

Beispiel

https://github.com/active-group/vfei

```
; value is a map
(define-record-type ListFormat
  (^{:doc "Make a list format for a VFEI data item."}
   make-list-format size)
  list-format?
  [size list-format-size])

(define-record-type ArrayFormat
  (^{:doc "Make an array format for a VFEI data item."}
   make-array-format element-format size)
  array-format?
  [element-format array-format-element-format
   size array-format-size])

(define-record-type DataItem
  (^{:doc "Make a VFEI data item."}
   really-make-data-item name format value)
  data-item?
  [name data-item-name
   format data-item-format
   value data-item-value])

(defn make-data-item
  "Assert that list length matches format."
  [name format value]
  (cond
    (list-format? format)
    (when (not= (list-format-size format) (count value))
      (c/error `make-data-item "list length does not match number of parsed values" name format (count value) value))

    (array-format? format)
    (when (not= (array-format-size format) (count value))
      (c/error `make-data-item "array size does not match number of parsed values" name format (count value) value)))

  (really-make-data-item name format value))
```

Nach Plattform

Plattform	Sprache
Java	Clojure
Erlang (Unix, Windows)	Elixir
Erlang	Erlang
.NET	F#
Haskell (Unix, Windows)	Haskell
OCaml (Unix)	OCaml
Racket (Unix, Windows, Mac)	Racket
Java	Scala
Apple, Linux	Swift

Statisch/dynamisch getypt

Typsystem	Sprache
dynamisch	Clojure
dynamisch	Elixir
dynamisch	Erlang
dynamisch (auch statisch)	Racket
statisch	F#
statisch, Typklassen	Haskell
statisch, Module	OCaml
statisch, OO-Integration	Scala
statisch, OO-Integration	Swift

Merkmal pro Sprache

Typsystem	Sprache
Lisp	Clojure
Erlang, andere Syntax	Elixir
verteilte, fehlertolerante Systeme	Erlang
Sprache der Wahl auf .NET	F#
„fancy types“	Haskell
Modulsystem	OCaml
Sprach-Baukasten	Racket
hybrid OO/FP auf Java-Plattform	Scala
hybrid OO/FP auf Apple-Plattform	Swift

Grund pro Sprache

Grund	
Performance, große Projekte	OCaml
Performance, Parallelismus, fancy types	Haskell
Verteilung, Fehlertoleranz	Erlang, Elixir
.NET	F#
Java	Clojure, Scala
DSL	Racket
Apple	Swift

Hindley-Milner-Typsystem

```
let rec sum lis =
  match lis with
  | [] -> 0
  | x::xs -> x + sum xs
;;

let rec product lis =
  match lis with
  | [] -> 1
  | x::xs -> x * product xs
;;

let rec length lis =
  match lis with
  | [] -> 0
  | _::xs -> 1 + length xs
;;

let rec fold f z lis =
  match lis with
  | [] -> z
  | x::xs -> f x (fold f z xs)
;;

let sum' = fold (+) 0
let product' = fold ( * ) 1
let length' = fold (fun _ s -> 1 + s) 0
;;
```

Nicht-Strikte Auswertung

```
data Tree a = Node a [Tree a]

maptree f (Node a sub) =
  Node (f a) (map (maptree f) sub)

reptree :: (a -> [a]) -> a -> Tree a
reptree f a =
  Node a (map (reptree f) (f a))

gametree :: Board -> Tree Board
gametree p = reptree moves p
```

Endrekursion / Tail Calls

```
reverse l =  rev l []
  where
    rev []     a = a
    rev (x:xs) a = rev xs (x:a)
```

Tail Calls vs. Plattform

Plattform	“Proper Tail Calls“
JavaScript	Standard: , Implementierungen: 😢
Java (Scala, Clojure)	😢
.NET (F#)	
Racket, OCaml, Haskell, Erlang	

Lightweight Concurrency

```
do v1 <- new
   v2 <- new
   fork (put v1 (f x))
   fork (put v2 (g x))
   r1 <- get v1
   r2 <- get v2
   return (r1 + r2)
```

Lightweight Concurrency

```
new >>= \ v1 ->
new >>= \ v2 ->
fork (put v1 (f x)) \ () ->
fork (put v2 (g x)) \ () ->
get >>= \ r1 ->
get >>= \ r2 ->
return (r1 + r2)
```

Par-Monade

```
newtype Par a = Par {
  runCont :: (a -> Trace) -> Trace
}
```

Continuation!

```
instance Monad Par where
  return a = Par (\ c -> c a)
  m >>= k  =
    Par (\ c ->
          runCont m (\ a ->
            runCont (k a) c))
```

Eingebettete DSLs

Sprache	DSL-Mechanismus
Racket	Makros
Haskell	Monaden + Typklassen
Scala	Monaden+ Implicits

Exemplarisches Framework

- http4s, fs2, cats-effect
- siehe Code