FUN — Untyped — Substitution

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Abstract

This is the substitution-based definition of FUN. For additional explanations regarding the semantics of the various FUN constructs, the reader should consult the environment-based definition of FUN.

Syntax

MODULE FUN-UNTYPED-SYNTAX

The Syntactic Constructs

SYNTAX *Name* ::= $Token\{[a-z][\_a-zA-Z0-9]*\}$ [notInRules]

SYNTAX *Names* ::= $List\{Name, ","\}$

SYNTAX *Exp* ::= *Int*
| *Bool*
| *String*
| *Name*
| *Exp* [bracket]

SYNTAX *Exps* ::= $List\{Exp, ","\}$ [strict]

SYNTAX *Exp* ::= *Exp* `*` *Exp* [strict, arith]
| *Exp* `/` *Exp* [strict, arith]
| *Exp* `%` *Exp* [strict, arith]
| *Exp* `+` *Exp* [strict, arith]
| *Exp* `-` *Exp* [strict, arith]
| *Exp* `-` *Exp* [strict, prefer, arith]
| *Exp* `<` *Exp* [strict, arith]
| *Exp* `<=` *Exp* [strict, arith]
| *Exp* `>` *Exp* [strict, arith]
| *Exp* `>=` *Exp* [strict, arith]
| *Exp* `==` *Exp* [strict, arith]
| *Exp* `!=` *Exp* [strict, arith]
| `!` *Exp* [strict, arith]
| *Exp* `&&` *Exp* [strict(1), arith]
| *Exp* `||` *Exp* [strict(1), arith]

SYNTAX *Exp* ::= `if` *Exp* `then` *Exp* `else` *Exp* [strict(1)]

SYNTAX *Exp* ::= $List\{Exp\}$ [strict]
| `cons`
| `head`
| `tail`
| `null?`
| $List\{Exp\}$ *Exp*

SYNTAX *ConstructorName* ::= $Token\{[A-Z][a-zA-Z0-9]*\}$ [notInRules]

SYNTAX *Exp* ::= *ConstructorName*
| *ConstructorName*$\{Exps\}$ [prefer, strict(2)]

SYNTAX *Exp* ::= `fun` *Cases*
| *Exp* [strict]

SYNTAX *Case* ::= *Exp* `->` *Exp* [binder]

SYNTAX *Cases* ::= $List\{Case, "|"\}$

SYNTAX *Exp* ::= `let` *Bindings* `in` *Exp*
| `letrec` *Bindings* `in` *Exp* [prefer]

SYNTAX *Binding* ::= *Exp* `=` *Exp*

SYNTAX *Bindings* ::= $List\{Binding, "and"\}$

SYNTAX *Exp* ::= `ref`
| *Name*
| `@` *Exp* [strict]
| *Exp* `:=` *Exp* [strict]
| *Exp* `;` *Exp* [strict(1)]

SYNTAX *Exp* ::= `callcc`
| `try` *Exp* `catch` $(Name)Exp$

SYNTAX *Name* ::= `throw`

SYNTAX *Exp* ::= `datatype` *Type* `=` *TypeCases* *Exp*

SYNTAX *TypeVar* ::= $Token\{"'"[a-z][\_a-zA-Z0-9]*\}$ [notInRules]

SYNTAX *TypeVars* ::= $List\{TypeVar, ","\}$

SYNTAX *TypeName* ::= $Token\{[a-z][\_a-zA-Z0-9]*\}$ [notInRules]

SYNTAX *Type* ::= `int`
| `bool`
| `string`
| *Type* `->` *Type*
| $(Type)$ [bracket]
| *TypeVar*
| *TypeName* [klabel("TypeName), onlyLabel]
| *Type* *TypeName* [klabel(Type-TypeName), onlyLabel]
| $(Types)TypeName$ [prefer]

SYNTAX *Types* ::= $List\{Type, ","\}$

SYNTAX *TypeCase* ::= *ConstructorName*
| *ConstructorName*$(Types)$

SYNTAX *TypeCases* ::= $List\{TypeCase, "|"\}$

Additional Priorities

Desugaring macros

RULE $\dfrac{P1 \;\; P2 \;\texttt{->}\; E}{P1 \;\texttt{->}\; \texttt{fun}\; P2 \;\texttt{->}\; E}$ [macro]

RULE $\dfrac{F \;\; P \;\texttt{->}\; E}{F \;=\; \texttt{fun}\; P \;\texttt{->}\; E}$ [macro]

RULE $\dfrac{E{:}Exp_1 \;\; Es \;\; \mid \;\; T}{E \;\mid\; Es \;\mid\; T\,|}$ requires $Es \neq_K \bullet_{List}$ [macro]

RULE $\dfrac{T{:}TypeName\{Ts{:}TypeName\}}{(\bullet_{TypeName})\,Ts}$ [macro]

RULE $\dfrac{T{:}Type - Type{:}Name\{T{:}Type, Ts{:}TypeName\}}{(T)\,Ts}$ [macro]

SYNTAX *Name* ::= `$h`
| `$t`

RULE $\dfrac{}{\texttt{fun}\;[\texttt{\$h} \mid \texttt{\$t}]\;\texttt{->}\;\texttt{\$h}}$ [macro]

RULE $\dfrac{}{\texttt{fun}\;[\texttt{\$h} \mid \texttt{\$t}]\;\texttt{->}\;\texttt{\$t}}$ [macro]

RULE $\dfrac{}{\texttt{fun}\;[\bullet_{List}]\;\texttt{->}\;\texttt{true} \mid [\texttt{\$h} \mid \texttt{\$t}]\;\texttt{->}\;\texttt{false}}$ [macro]

SYNTAX *Name* ::= `$k`
| `$v`

RULE $\dfrac{}{\texttt{try}\;E\;\texttt{catch}\;(X)E'}$ [macro]

RULE $\dfrac{}{\texttt{callcc}\;(\;\texttt{fun}\;\texttt{\$k}\;\texttt{->}\;(\;\texttt{fun}\;\texttt{throw}\;\texttt{->}\;E)\;(\;\texttt{fun}\;X\;\texttt{->}\;\texttt{\$k}\;E'))}$ [macro]

RULE $\dfrac{}{\texttt{datatype}\;T\;\texttt{=}\;TCs\;\;E}$ [macro]

mu needed for letrec, but we put it here so we can also write programs with mu in them, which is particularly useful for testing.

SYNTAX *Exp* ::= `mu` *Case*

END MODULE

Semantics

MODULE FUN-UNTYPED

CONFIGURATION:

Both Name and functions are values now:

SYNTAX *Val* ::= *Int*
| *Bool*
| *String*
| *Name*

SYNTAX *Vals* ::= $List\{Val, ","\}$

SYNTAX *Exp* ::= *Val*

SYNTAX ***KResult*** ::= *Val*

RULE $\dfrac{I1{:}Int \;+\; I2{:}Int}{I1 +_{Int} I2}$

RULE $\dfrac{I1{:}Int \;/\; I2{:}Int}{I1 \div_{Int} I2}$ requires $I2 \neq_K \texttt{0}$

RULE $\dfrac{I1{:}Int \;\%\; I2{:}Int}{I1 \;\%_{Int}\; I2}$ requires $I2 \neq_K \texttt{0}$

RULE $\dfrac{I1{:}Int \;-\; I2{:}Int}{I1 -_{Int} I2}$

RULE $\dfrac{S1{:}String \;\hat{}\; S2{:}String}{S1 +_{String} S2}$

RULE $\dfrac{I1{:}Int \;-\; I2{:}Int}{I1 \;-_{Int}\; I2}$

RULE $\dfrac{I1{:}Int \;<\; I2{:}Int}{I1 <_{Int} I2}$

RULE $\dfrac{I1{:}Int \;<=\; I2{:}Int}{I1 \leq_{Int} I2}$

RULE $\dfrac{I1{:}Int \;>\; I2{:}Int}{I1 >_{Int} I2}$

RULE $\dfrac{I1{:}Int \;>=\; I2{:}Int}{I1 \geq_{Int} I2}$

RULE $\dfrac{V1{:}Val \;==\; V2{:}Val}{V1 =_K V2}$

RULE $\dfrac{V1{:}Val \;!=\; V2{:}Val}{V1 \neq_K V2}$

RULE $\dfrac{!\;T{:}Bool}{\neg_{Bool}\,T}$

RULE $\dfrac{\texttt{true}\;\&\&\;E}{E}$

RULE $\dfrac{\texttt{false}\;\&\&\;\_}{\texttt{false}}$

RULE $\dfrac{\texttt{true}\;||\;\_}{\texttt{true}}$

RULE $\dfrac{\texttt{false}\;||\;E}{E}$

RULE $\dfrac{\texttt{if true then}\;E\;\texttt{else}\;\_}{E}$

RULE $\dfrac{\texttt{if false then}\;\_\;\texttt{else}\;E}{E}$

SYNTAX *Val* ::= `cons`
| $\{Vals\}$

RULE $\dfrac{isVal(\texttt{cons}\;\;V{:}Val)}{\texttt{true}}$

RULE $\dfrac{\texttt{cons}\;\;V{:}Val\;\;\{Vs{:}Vals\}}{[\,V\,,\,Vs\,]}$

SYNTAX *Val* ::= *ConstructorName*
| *ConstructorName*$\{Vals\}$

SYNTAX *Val* ::= `fun` *Cases*

SYNTAX *Variable* ::= *Name*

RULE $\dfrac{(\;\texttt{fun}\;P\;\texttt{->}\;E)\,(\_) \;\;\; V{:}Val}{E[\,\texttt{getMatching}\;(P, V)\,]}$ requires $\texttt{isMatching}\;(P, V)$

RULE $\dfrac{\left(\begin{array}{l}\texttt{fun}\;P\;\texttt{->}\;\_\;|\;Cs{:}Cases\\ \hline Cs\end{array}\right) \;\; V{:}Val}{V{:}Val}$ requires $\neg_{Bool}\,\texttt{isMatching}\;(P, V)$

RULE $\dfrac{}{\texttt{decomposeMatching}\;(\{H{:}Exp\;\mid\;T{:}Exp\},\,\{V{:}Val,\,Vs{:}Vals\})}$
$H,\;T \qquad\qquad V\,,\,[\,Vs\,]$

We can reduce multiple bindings to one list binding, and then apply the usual desugaring of let into function application. It is important that the rule below is a macro, so let is eliminated immediately, otherwise it may interfer in ugly ways with substitution.

RULE $\dfrac{}{\texttt{let}\;Bs\;\texttt{in}\;E}$ [macro]
$(\{\;\texttt{fun}\;[\,\texttt{names}\;(Bs)]\;\texttt{->}\;E)\;\;[\,\texttt{exps}\;(Bs)]$

We only give the semantics of one-binding letrec. Multipe bindings are left as an exercise.

RULE $\dfrac{\texttt{mu}\;X{:}Name\;\texttt{->}\;E}{E[\texttt{mu}\;X\;\texttt{->}\;E)\,/\,X]}$

RULE $\dfrac{\texttt{letrec}\;F{:}Name = E\;\texttt{in}\;E'}{\texttt{let}\;F = (\texttt{mu}\;F\;\texttt{->}\;E)\;\texttt{in}\;E'}$ [macro]

We cannot have λ anymore, but we can give direct semantics to `ref`. We also have to declare `ref` to be a value, so that we will never heat on it.

SYNTAX *Val* ::= `ref`

RULE 

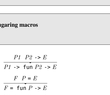
requires $\texttt{fresh}\;(L{:}Int)$

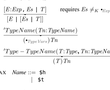
RULE 

RULE 

RULE $\dfrac{V{:}Val \;;\; E}{E}$

SYNTAX *Val* ::= `callcc`
| `cc` (K)

RULE 

RULE 

Auxiliary getters

SYNTAX *Names* ::= `names` $(Bindings)$ [function]

RULE $\dfrac{\texttt{names}\;(\bullet_{Bindings})}{\bullet_{Names}}$

RULE $\dfrac{\texttt{names}\;(X{:}Name = \_\texttt{and}\;Bs)}{X\,,\;\texttt{names}\;(Bs)}$

SYNTAX *Exps* ::= `exps` $(Bindings)$ [function]

RULE $\dfrac{\texttt{exps}\;(\bullet_{Bindings})}{\bullet_{Exps}}$

RULE $\dfrac{\texttt{exps}\;(\_ = E\texttt{and}\;Bs)}{E\,,\;\texttt{exps}\;(Bs)}$

END MODULE