H# Official Documentation

The official specification for H#

Contents

Abstract

This document is the official document for the H-Sharp (H#) programming language. The H stands for hybrid - as this is a multi-paradigm programming language heavily inspired by C# and Scala. This document will only contain the grammar of the language, the operational semantics as well as the type semantics of the language. The operational semantics may be explained with code samples - but obvious uses will not be explained.

This document will also contain the byte-instruction semantics. The official compiler, is written in C# for productivity purposes while the Virtual Machine is implemented using C++. At no point will this document be documenting the internal processes of those applications.

Grammar

The offical H# grammar. Note: $Id \in$ VarEnv and $TypeId \in$ TypeEnv. Both refer to the same grammatical definition, defined by the regular expression:

$$(\_|[\texttt{a}-\texttt{Z}])^{+}(\_|[\texttt{0}-\texttt{9}]|[\texttt{a}-\texttt{Z}])^{*}$$

If multiple elements can occur - and it'd be convenient, the element be sufficed with 'n' to show it may be contain n of such elements. $n \in \{0, 1, 2, \dots\}$. The notation $e_0, \dots, e_n$ represents the 1 to nth element with a specific separator. The full grammar is defined as follows:

CompileUnit ::= *CompileUnitElement*

CompileUnitElement ::= *CompileUnitElement CompileUnitElement*
| *Directive* | *Scope* | *ScopeElement* | *Declaration*

Scope ::= { *ScopeElement* }

ScopeElement ::= *ScopeElement ScopeElement*
| *Expr*; | *Statement* | *VarDeclaration*;

Expr ::= *Expr* | (*Expr*) | *Scope* | *LambdaExpr*
| *Expr BinaryOp Expr* | *UnaryOp Expr* | *Id UnaryOp*
| *Expr* ? *Expr* : *Expr*
| *Id* | *Name* | `this` | `base`
| *Expr*(*Argument*)
| `new` *TypeId*(*Argument*) | `new` *TypeId*[*Argument*]
| *Expr*.*Id* | *Expr*?.*Id*
| *Expr*.*Id*(*Argument*) | *Expr*?.*Id*(*Argument*)
| *Expr* `is` *TypeID* | *Expr* `is null` *Expr* `is` *TypeID Id*
| *Expr* `is` *TypeID Id* `where` *Expr*
| *Expr* `is not` *TypeID* | *Expr* `is not null`
| *Expr* `is not` *TypeID Id* `where` *Expr*
| *Expr* `as` *TypeId*
| (*TypeID*) *Expr*
| `sizeof`(*TypeId*) | `addressof`(*Id*) | `typeof`(*Expr*)
| *Assignment*
| *Literal*

LambdaExpr ::= (*Param*) `=>` *Expr*

Directive ::= `type` *Id* `=` *TypeId*;
| `using` *Id*; | `using` *TypeId* `from` *Id*;

Statement ::= *Assignment*; | *ControlStatement* | *MatchStatement*;
| *TryCatchStatement*

ControlStatement ::= `if` *Expr Scope*
| `if` *Expr Scope* `else` *Scope*
| `if` *Expr Scope* `else if` *Expr Scope*
| `if` *Expr Scope* `else if` *Expr Scope* `else` *Scope*
| `while` *Expr Scope*
| `do` *Scope* `while` *Expr*;
| `for` (*Assignment*; *Expr*; *Expr*) *Scope*
| `for` (*VarDeclaration*; *Expr*; *Expr*) *Scope*
| `foreach` (*TypeId Id* in *Expr*) *Scope*
| `throw` *TypeID*(*Argument*)
| `return` *Expr*;
| `break`;

MatchStatement ::= *Expr* `match` { *MatchCase* }

MatchCase ::= *MatchCase*, *MatchCase*
| `case` *Literal* `=>` *Expr* | `case` *TypeId* `=>` *Expr*
| `case` *TypeId Id* `=>` *Expr* | `case` *TypeId Id* `when` *Expr* `=>` *Expr*
| `case (`*MatchCaseId*`)` `=>` *Expr*
| `case (`*MatchCaseId*`)` `when` *Expr* `=>` *Expr*
| `case` *TypeId* `(`*MatchCaseId*`)` `=>` *Expr*
| `case` *TypeId* `(`*MatchCaseId*`)` `when` *Expr* `=>` *Expr*
| `case _ =>` *Expr*

MatchCaseId ::= *MatchCaseId*, *MatchCaseId*
| *Id* | _

TryCatchStatement ::= `try` *Scope* `catch (`*TypeId Id*`)` *Scope*
| `try` *Scope* `catch (`*TypeId Id*`)` `when` *Expr Scope*
| `try` *Scope* `catch (`*TypeId Id*`)` *Scope* `finally` *Scope*
| `try` *Scope* `catch (`*TypeId Id*`)` `when` *Expr Scope* `finally` *Scope*

Assignment ::= *Id* `=` *Expr*
| *Id* `+=` *Expr* | *Id* `-=` *Expr*
| *Id* `*=` *Expr* | *Id* `/=` *Expr*
| *Id* `&=` *Expr* | *Id* `|=` *Expr*
| *Id* `%=` *Expr*

Declaration ::= *NamespaceDecl*
| *VarDecl* | *FuncDecl*
| *ClassDecl* | *StaticClassDecl* | *InterfaceDecl*
| *UnionDecl* | *EnumDecl* | *StructDecl*

NamespaceDecl ::= `namespace` *Name Scope*

ClassDecl ::= `class` *Id* { *ClassMember* }
| *AccessMod* `class` *Id* { *ClassMember* }
| *StorageMod* `class` *Id* { *ClassMember* }
| *AccessMod StorageMod* `class` *Id* { *ClassMember* }
| `class` *Id*`(`*Param*`)` { *ClassMember* }
| *AccessMod* `class` *Id*`(`*Param*`)` { *ClassMember* }
| *StorageMod* `class` *Id*`(`*Param*`)` { *ClassMember* }
| *AccessMod StorageMod* `class` *Id*`(`*Param*`)` { *ClassMember* }

StructDecl ::= `struct` *Id* { *ClassMember* }
| *AccessMod* `struct` *Id* { *ClassMember* }
| *StorageMod* `struct` *Id* { *ClassMember* }
| *AccessMod StorageMod* `struct` *Id* { *ClassMember* }
| `struct` *Id*`(`*Param*`)` { *ClassMember* }
| *AccessMod* `struct` *Id*`(`*Param*`)` { *ClassMember* }
| *StorageMod* `struct` *Id*`(`*Param*`)` { *ClassMember* }
| *AccessMod StorageMod* `struct` *Id*`(`*Param*`)` { *ClassMember* }

StaticClassDecl ::= `object` *Id* { *ClassMember* }
| *AccessMod* `object` *Id* { *ClassMember* }
| `object` *Id*`(`*Param*`)` { *ClassMember* }
| *AccessMod* `object` *Id*`(`*Param*`)` { *ClassMember* }

InterfaceDecl ::= `interface` *Id* { *ClassMember* }
| *AccessMod* `interface` *Id* { *ClassMember* }

ClassMember ::= *ClassMember ClassMember*
| *Id*`(`*Param*`)` *FuncBody* | *AcessMod Id*`(`*Param*`)` *FuncBody*
| *VarDecl*; | *AcessMod VarDecl*;
| *FuncDecl* | *ClassDecl* | *UnionDecl* | *EnumDecl*
| `event` *TypeId id*; | *AccessMod* `event` *TypeId id*;

VarDecl ::= *TypeId Id* = *Expr* | *StorageMod TypeId Id* = *Expr*
| `var` *Id* = *Expr* | *StorageMod* `var` *Id* = *Expr*
| *TypeId Id* | *StorageMod TypeId Id*
| *LambdaType Id* = *LambdaExpr*
| *TupleDecl*

TupleDecl ::= `(`*ParamType*`)` *Id* = `(`*Argument*`)`
| `(`*Param*`)` = `(`*Argument*`)`

FuncDecl ::= *Id*`(`*Param*`):` *TypeId FuncBody*
| *AccessMod Id*`(`*Param*`):` *TypeId FuncBody*
| *Id* = `(`*Param*`):` *TypeId FuncBody*
| *AccessMod Id* = `(`*Param*`):` *TypeId FuncBody*
| *AccessMod* `const` *Id* = `(`*Param*`):` *TypeId FuncBody*

FuncBody ::= *Scope* | `=>` *Expr*

UnionDecl ::= `union` *Id* { *UnionMember* }
| *AccessMod* `union` *Id* { *UnionMember* }
| *AccessMod* `static union` *Id* { *UnionMember* }

UnionMember ::= *UnionMember UnionMember*
| *TypeId Id*;

EnumDecl ::= `enum` *Id* { *EnumBodyMember* }
| *AccessMod* `enum` *Id* { *EnumBodyMember* }
| `enum` *Id*`(`*EnumMember*`)`{ *EnumBodyMember* }
| *AccessMod* `enum` *Id* `(`*EnumMember*`)` { *EnumBodyMember* }

EnumBodyMember ::= *EnumMember* | *FuncDecl* | *FuncDecl EnumBodyMember*

EnumMember ::= *EnumMember*, *EnumMember*
| *Id* | *Id* = *LiteralNoNull*

StorageMod ::= `const` | `static` | `abstract` | `override` | `virtual` | `final` | `lazy`

AccessMod ::= `public` | `private` | `protected` | `internal` | `external`

Param ::= *Param*, *Param*
| *TypeId Id* | `const` *TypeId Id*
| *ParamType Id*

ParamType ::= *TypeId* | *TypeId*, *TypeId*

Argument ::= *Expr* | *Expr*, *Expr*

Name ::= *Id* | *Name*.*Name*

LambdaType	::=	`(`*ParamType*`):` *TypeId*
	|	*TypeId* `:` *TypeId*
BinaryOp	::=	`+` | `-` | `*` | `/` | `%` | < | > | <= | >= | `==` | `!=`
	|	|| | && | | | & | << | >> | `=>` | `::` | `??` | `..`
UnaryOp	::=	`-` | `!` | `#` | `++` | `--`
LiteralNoNull	::=	*IntLit* | *FloatLit* | *DoubleLit* | *BoolLit* | *CharLit* | *StringLit*
Literal	::=	*LiteralNoNull* | *NullLit*
Letter	::=	[`a-Z`]
Digit	::=	[`0-9`]
IntLit	::=	$Digit^+$
FloatLit	::=	$Digit^+$`.`$Digit^+$`f`
DoubleLit	::=	$Digit^+$`.`$Digit^+$
CharLit	::=	`'`*Letter*`'` | `'\`*Letter*`'`
StringLit	::=	¨$(Letter\|Digit)^*$¨
BoolLit	::=	`true` | `false`
NullLit	::=	`null`

Operational Semantics

VariableLookup
$$\frac{\rho, \mu, \phi, \kappa, \sigma \vdash \rho(x) = v \neq (\ell, \omega, \sigma)}{\rho, \mu, \phi, \kappa, \sigma \vdash x \Rightarrow v, \sigma}$$

HeapObjectLookup
$$\frac{\rho, \mu, \phi, \kappa, \sigma \vdash \rho(x) = (\ell, \omega, \sigma) \quad \sigma(\ell) = v \quad \omega = \texttt{O}}{\rho, \mu, \phi, \kappa, \sigma \vdash x \Rightarrow v, \sigma}$$

HeapStringLookup
$$\frac{\rho, \mu, \phi, \kappa, \sigma \vdash \rho(x) = (\ell, \omega, \sigma) \quad \sigma(\ell) = v \quad \omega = \texttt{S}}{\rho, \mu, \phi, \kappa, \sigma \vdash x \Rightarrow v, \sigma}$$

HeapArrayLookup
$$\frac{\rho, \mu, \phi, \kappa, \sigma \vdash \rho(x) = (\ell, \omega, \sigma) \quad \sigma(\ell) = v \quad \omega = \texttt{A}}{\rho, \mu, \phi, \kappa, \sigma \vdash x \Rightarrow v, \sigma}$$

Type Semantics

VariableLookup
$$\frac{\rho, \mu, \phi, \kappa, \sigma \vdash \rho(x) = v \neq (\ell, \omega, \sigma)}{\rho, \mu, \phi, \kappa, \sigma \vdash x \Rightarrow v, \sigma}$$

HeapObjectLookup
$$\frac{\rho, \mu, \phi, \kappa, \sigma \vdash \rho(x) = (\ell, \omega, \sigma) \quad \sigma(\ell) = v \quad \omega = \texttt{O}}{\rho, \mu, \phi, \kappa, \sigma \vdash x \Rightarrow v, \sigma}$$

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Compilation Semantics

Bytecode Semantics