

IFJ – protokol k projektu Tým xjarol06, varianta TRP

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06) - 25 bodů

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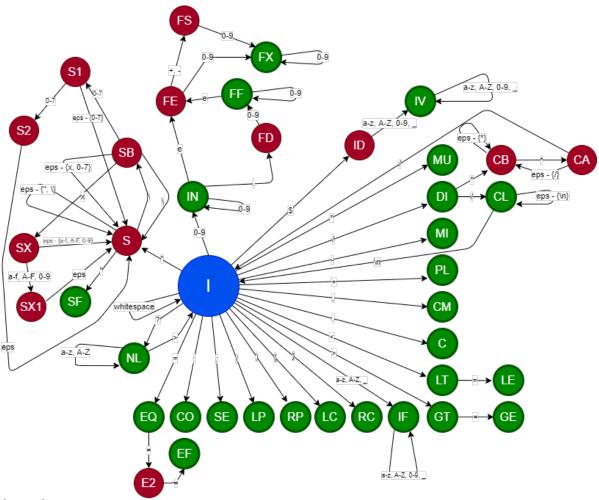
Rozdělení práce mezi členy týmu

Antonín Jarolím - syntaktický analyzátor top-down, generace kódu, LL-tabulka, gramatika **Jakub Vlk** - syntaktický analyzátor bottom-up, generace kódu, precedenční tabulka, gramatika

Jan Brudný - tabulka symbolů, generace kódu Jindřich Vodák - lexikální analyzátor, psaní testů, dokumentace

Body byly v týmu rozděleny s přihlédnutím k množství odvedené práce, aktivnímu zapojování se do práce na projektu v průběhu semestru a vyvinuté snaze. Rozdělování probíhalo postupně v průběhu semestru - v případě, že tři členové týmu shledali, že čtvrtý odvádí velmi dobrou práci, body byly přerozděleny tak, aby čtvrtý člen získal bod navíc. V opačném případě byl jeden bod čtvrtému členovi týmu odebrán.

Diagram konečného automatu



Legenda

```
I = init_s
S = string_lit_s
                                E2 = eq_2s
SF = string_lit_f_s
                                N1 = not_eq_1_s
IN = integer_lit_f_s
                                N2 = not_eq_2_s
FD = float_lit_dot_s
                                NF = not_eq_f_s
SB = string_lit_backslash_s
FE = float_lit_e_s
FS = float_lit_sign_s
                                SX = string_lit_backslash_x_s
FX = float_lit_exp_f_s
                                SX1 = string_lit_backslash_x_1_s
FF = float_lit_f_s
                                S1 = string_lit_backslash_1_s
IF = identifier_func_f_s
                                S2 = string_lit_backslash_2_s
ID = identifier_var_dollar_s
                                LP = left_par_f_s
IV = identifier_var_f_s
                                RP = right_par_f_s
MU = multiplication_f_s
                                CL = com_line_f_s
                                CB = com_block_s
DI = division_f_s
PL = plus f s
                                CA = com_block_ast_s
MI = minus f s
                                LC = left_curly_f_s
C = concatenation_f_s
                                RC = right_curly_f_s
LT = lesser_than_f_s
                                EQ = equals_f_s
LE = lesser_eq_f_s
                                CO = colon_f_s
GT = greater_than_f_s
                                SE = semicolon f s
GE = greater_eq_f_s
                                CM = comma f s
EF = eq_f_s
                                NL = null f s
```

LL-gramatika

ProgramBody ::= FceDefine ProgramBody ProgramBody ::= Command ProgramBody ProgramBody ::=" Command ::= DeclareVariable Command ::= Condition Command ::= While Command ::= Return Command ::= Exp semicolon Command ::= semicolon Command ::= FceCallFceDefine ::= functionKey FceHeader curlyBraceLeft FunctionBody curlyBraceRight FceHeader ::= identifierFunc leftPar FunctionDeclareParams rightPar colon FuncReturnColonType FunctionDeclareParams ::=" FunctionDeclareParams ::= DataType DeclareParam CommaOrEpsParams CommaOrEpsParams ::=" CommaOrEpsParams ::= comma DataType DeclareParam CommaOrEpsParams DeclareParam ::= identifierVar FuncReturnColonType ::= DataType FuncReturnColonType ::= voidKey FceCall ::= identifierFunc leftPar FirstFceParam rightPar FirstFceParam ::=" FirstFceParam ::= Statement CommaOrEpsParam CommaOrEpsParam ::=" CommaOrEpsParam ::= comma Statement CommaOrEpsParam Statement ::= identifierVar Statement ::= floatLiteral Statement ::= stringLiteral Statement ::= integerLiteral Statement ::= nullKey Exp ::= Statement Exp ::= Exp minusOp Exp Exp ::= Exp plusOp Exp Exp ::= Exp divisionOp Exp Exp ::= Exp multiplicationOp Exp Exp ::= Exp concatenationOp Exp Exp ::= Exp lesserThanOp Exp Exp ::= Exp lesserEqOp Exp

Exp ::= Exp greaterThanOp Exp Exp ::= Exp greaterEqOp Exp

```
Exp ::= Exp eqOp Exp
Exp ::= Exp notEqOp Exp
```

Exp ::= leftPar Exp rightPar

DataType ::= stringNullKey
DataType ::= floatNullKey
DataType ::= intNullKey
DataType ::= stringKey
DataType ::= floatKey
DataType ::= intKey

DeclareVariable ::= identifierVar equals DefVarAss

DefVarAss ::= Exp semicolon DefVarAss ::= FceCall semicolon

 $Condition ::= if Key \ left Par \ Exp \ right Par \ curly Brace Left \ Function Body \ curly Brace Right \ El-par \ Exp \ right Par \ Condition Par \ Condit$

seCond

ElseCond ::= elseKey curlyBraceLeft FunctionBody curlyBraceRight

ElseCond ::="

While ::= whileKey leftPar Exp rightPar curlyBraceLeft FunctionBody curlyBraceRight

Return ::= returnKey ReturnExp semicolon

ReturnExp ::= Exp ReturnExp ::="

FunctionBody ::= Command FunctionBody

FunctionBody ::="

LL-tabulka

1	S	semicolon	curlyB	raceLeft	curlyBraceRight			fu	nctionKe	ey	
	S ::= ProgramBody	\$ S ::= ProgramBody \$			S	::= ProgramBody					
ProgramBody	ProgramBody ::= ε	ProgramBody ::= Command Progr	ramBody		P	rogramBody ::= F	ceDefine Progra	mBody			
Command		Command ::= semicolon									
FceDefine						ceDefine ::= FceI					
ceHeader							tionKey identifie	rFunc leftPar Fu	nctionDec	lareParams rightPar colon FuncR	eturnColonTy
ElseCond	ElseCond ::= ε	ElseCond ::= ε		El	seCond ::= ε E	lseCond ::= ε					
ReturnExp FunctionBody		ReturnExp ::= ε FunctionBody ::= Command FunctionBody	tionBody	Fu	nctionBody ::= ε						
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·		ogramBody \$	n 1		S ::= ProgramI						
ProgramBody	Progran	nBody ::= Command Program	nBody		ProgramBody	::= Command	ProgramBo	dy			
Command	Comma	nd ::= FceCall			Command ::= I	Exp semicolor	1				
							_				
FunctionDeclarePar	rams							F	unctionl	DeclareParams ::= ε	
CommaOrEpsParar	ms							C	ommaC)rEpsParams ::= ε	
ceCall	FceCall	::= identifierFunc leftPar First	stFceParam ri	ghtPar							
irstFceParam								Fi	irstFceI	Param ::= ε	
CommaOrEpsParar	m							C	ommaC)rEpsParam ::= ε	
DefVarAss		Ass ::= FceCall semicolon			DefVarAss ::=	Exp semicol	on			-	
ElseCond	ElseCor				ElseCond ::= ε						
ReturnExp	Z.iScool	-			ReturnExp ::=	Exp					
FunctionBody	Function	nBody ::= Command Function	nBody		FunctionBody		FunctionBo	dv			
icuoiiDody	1 diledol	comma			identifierVar			voidKev		floatLiteral	
		- vmull	S	:= ProgramB				· Juney	S	::= ProgramBody \$	
ProgramBody			Pr	ogramBody ::	= Command ProgramB	ody				rogramBody ::= Command Progra	nBody
Command					eclareVariable				c	ommand ::= Exp semicolon	
CommaOrEpsParams	CommaOrEnsParan	ns ::= comma DeclareParam CommaC		ommand ::= E	xp semicoion				_		
uncReturnColonType	- Janua Si Lipsi di di		por mains				FuncReturnCo	lonType ::= voidI	Key		
irstFceParam				rstFceParam :	= Statement CommaO	rEpsParam			F	rstFceParam ::= Statement Comm	aOrEpsParar
CommaOrEpsParam Statement	CommaOrEpsParan	n ::= comma Statement CommaOrEps		atement ::= ide	entifierV2r		1		0.	tatement ::= floatLiteral	
DeclareVariable					e ::= identifierVar equal	s DefVarAss			3	iatement noathterai	
DefVarAss					Exp semicolon				D	efVarAss ::= Exp semicolon	
ElseCond				seCond ::= ε						lseCond ::= ε	
ReturnExp				eturnExp ::= E	xp = Command FunctionBo	. 4				eturnExp ::= Exp unctionBody ::= Command Functio	-D - d
unctionBody		-toin -T it1	rt	ilicuolii30dy		r Literal					шопу
		stringLiteral							п	ullKey	ı
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5		ogramBody \$	n 1		ogramBody \$		N - 1 -	S ::= Progra	mBody		
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	Progran		nBody	Progran	ogramBody \$	and ProgramE	Body		mBody dy ::= C	ommand ProgramBody	
Command	Progran Comma	nBody ::= Command Program nd ::= Exp semicolon		Program Comma	ogramBody \$ nBody ::= Comma nd ::= Exp semico	and ProgramE blon	-	ProgramBo	mBody dy ::= C	ommand ProgramBody	
Command FirstFceParam	Program Comma FirstFce	nBody ::= Command Program nd ::= Exp semicolon Param ::= Statement Comm		Program Comma FirstFce	ogramBody \$ nBody ::= Comma nd ::= Exp semico :Param ::= Statem	and ProgramE olon nent CommaC	-	ProgramBo	mBody dy ::= C	ommand ProgramBody	
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Command FirstFceParam Statement DefVarAss	Program Comma FirstFce Stateme DefVar	nBody ::= Command Program nd ::= Exp semicolon Param ::= Statement Comme ent ::= stringLiteral Ass ::= Exp semicolon		Program Comma FirstFce Stateme DefVar	ogramBody \$ nBody ::= Comma nd ::= Exp semice eParam ::= Statem ent ::= integerLiter Ass ::= Exp semic	and ProgramE olon nent CommaC ral	-	ProgramBo Command :: DefVarAss	mBody dy ::= C := Exp s	ommand ProgramBody semicolon	
Command FirstFceParam Statement DefVarAss ElseCond	Program Comma FirstFce Stateme DefVar ElseCor	nBody ::= Command Program nd ::= Exp semicolon Param ::= Statement Comme ent ::= stringLiteral Ass ::= Exp semicolon nd ::= \(\varepsilon \)		Program Comma FirstFce Stateme DefVar ElseCom	ogramBody \$ nBody ::= Comma nd ::= Exp semico Param ::= Statem ent ::= integerLiter Ass ::= Exp semio d ::= ε	and ProgramE olon nent CommaC ral	-	ProgramBo Command :: DefVarAss ElseCond ::=	mBody dy ::= C := Exp s ::= Exp = ε	ommand ProgramBody semicolon	
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Command FirstFceParam Statement DefVarAss ElseCond ReturnExp FunctionBody mictionDeclareParams seclareParam micReturnColonType	Program Comma FirstFce Stateme DefVar ElseCor ReturnE Function FunctionDeclareParam DeclareParam := Data	nBody ::= Command Program nd ::= Exp semicolon Param ::= Statement Commit ent ::= stringLiteral Ass ::= Exp semicolon nd ::= 8 Exp ::= Exp Body ::= Command Function stringNollikey s := DeclareParam CommaOrEpsParam Type identifier Var := DataType Key	aOrEpsParam nBody	Program Comma FirstFce Stateme DefVar ElseCot ReturnF Function fontNu arms := Deck DataType iden ype := DataTy	ogramBody \$ nBody := Comma nd := Exp semico eParam := Statem ent := integerLiter Ass := Exp semi ed := 8 Exp := Exp mBody := Comma IKEY ureParam CommaOrEpsi tifierVar	and ProgramE olon nent CommaC ral colon and FunctionBe	ody intage Intage	ProgramBo Command :: DefVarAss ElseCond :: ReturnExp : FunctionBookullKey eclareParam ComdentifierVar	mBody dy ::= C := Exp s ::= Exp = ε ::= Exp dy ::= C	command ProgramBody semicolon ommand FunctionBody stri Params FunctionDeclareParams := D DeclareParam := DataType FunckerunColonType := Dat DataType := stringKey	eclareParam identifierVar
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Precedenční tabulka

Členění implementačního řešení

Lexikální analyzátor sestává ze dvou souborů - hlavičkového souboru lex.h, ve kterém jsou definovány všechny důležité struktury a hlavičky funkcí používaných dále v programu, a zdrojového souboru lex.c, jehož kód vykonává samotnou lexikální analýzu. Lexikální analyzátor generuje tokeny ve formě struktury definované v hlavičkovém souboru, která obsahuje typ lexému (využit výčtový typ lexType definovaný rovněž v hlavičkovém souboru), informace o pozici v textu (pro ladění a chybové výpisy) a vnořenou datovou strukturu data_t. Tato vnořená struktura je typu union a jejím účelem je uchovávat datový obsah tokenu (pokud jej tedy token má) - například v případě celočíselného literálu je do proměnné valueInteger datového typu int uvnitř struktury uložena hodnota daného literálu. V případě řetězcového literálu využívá struktura data_t pomocné knihovny dynstring.c, která obsahuje speciální datový typ dynStr_t a funkce výrazně usnadňující práci s dynamickými řetězci. To s sebou přináší značné výhody nejen skrze jednodušší ladění, ale také například při práci s escape sekvencemi.

Pro vygenerování tokenu ze zdrojových dat je nutno zavolat hlavní a největší funkci celého lexikálního analyzátoru getToken(). Tato funkce načítá vstupní data znak po znaku pomocí jednoduché funkce getNextChar() a skrze vnitřní konečný automat nalezne pro lexém odpovídající stav. Pokud je detekován identifikátor či literál, je při čtení dat zároveň aktivován také buffer, který všechny přečtené znaky ukládá, a pokud jde o řetězcový literál obsahující jednu nebo více escape sekvencí, je zároveň aktivován druhý buffer uchovávající danou escape sekvenci. Tato escape sekvence je okamžitě zpracována dle svého typu, konvertovaný znak je uložen do datového bufferu a sekvenční buffer je vyčištěn. Při dosažení separátoru (dle lexému může jít o bílý znak, speciální znak či jen začátek dalšího lexému) je konečný stav a buffer předán druhé části analyzátoru, která na základě stavu rozhodne o typu tokenu a uloží do něj jeho data, a pokud je to nutné (v případě přerušení začátkem nového lexému), na začátek vstupního proudu je pomocí funkce ungetNextChar() vrácen poslední načtený znak.

Lexikální analyzátor podporuje několik zajímavých funkcí, které slouží buď ke zjednodušení procesu ladění nebo k usnadnění práce při dalších fázích překladu. Jako první příklad uveďme funkci printTokenData(), jejímž vstupem je token a výstupem informace o typu tokenu, jeho obsahu a jeho pozici ve zdrojovém textu. Jde o velmi jednoduchou funkci, která se ale ukázala jako zcela nepostradatelná i v posledních fázích práce na projektu. Pro účely testování vznikl jednoduchý program obsahující tuto funkci, který byl schopen načíst data ze zdrojového souboru a cyklicky vypsat informace o všech zpracovaných tokenech. Tento program sloužil jako důležitá pomoc při práci na lexikálním analyzátoru a pomohl vyřešit spoustu obtížně zachytitelných chyb.

Druhým příkladem je funkce ungetToken(), která funguje analogicky s ungetNextChar() - na výstup lexikálního analyzátoru vrátí poslední zpracovaný token. Samotný lexikální analyzátor obsahuje buffer, v němž je vždy uložen poslední zpracovaný token, a přepínač uchovávající informaci o tom, zda se má při volání funkce getToken() zpracovat nový lexém či právě vrátit tento poslední token. Jde o funkci důležitou pro syntaktický analyzátor, který se tak nemusí starat o uchovávání tokenů a stačí mu funkci jednoduše zavolat.

Závěr