Script generated by TTT

Title: Seidl: Virtual Machines (20.05.2014)

Date: Tue May 20 10:15:10 CEST 2014

Duration: 91:29 min

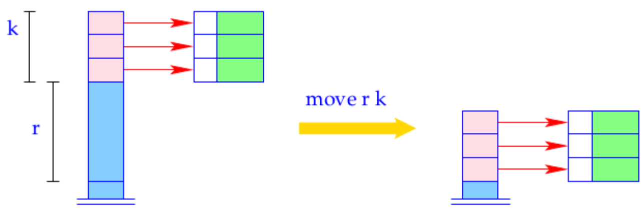
Pages: 32

The code for a last call $l \equiv (e' \, e_0 \ldots e_{m-1})$ inside a function f with k arguments must

1. allocate the arguments e_i and evaluate e' to a function (note: all this inside f's frame!);
2. deallocate the local variables and the k consumed arguments of f;
3. execute an apply.

$$
\begin{array}{lll}
\text{code}_V \, l \, \rho \, \text{sd} & = & \text{code}_C \, e_{m-1} \, \rho \, \text{sd} \\
& & \text{code}_C \, e_{m-2} \, \rho \, (\text{sd}+1) \\
& & \ldots \\
& & \text{code}_C \, e_0 \, \rho \, (\text{sd}+m-1) \\
& & \text{code}_V \, e' \, \rho \, (\text{sd}+m) \qquad \text{// Evaluation of the function} \\
& & \text{move } r \, (m+1) \qquad \text{// Deallocation of } r \text{ cells} \\
& & \text{apply}
\end{array}
$$

where $r = sd + k$ is the number of stack cells to deallocate.



SP = SP – k – r;
for (i=1; i≤k; i++)
  S[SP+i] = S[SP+i+r];
SP = SP + k;

Example

$\rho = \{ r \mapsto (G, 0), \; x \mapsto (L, 0), \; y \mapsto (L, -1) \}$

V-code for the body of the function

$$r = \textbf{fun} \; x \; y \; \rightarrow \; \textbf{match} \; x \; \textbf{with} \; [\,] \; \rightarrow y \mid h :: t \; \rightarrow r \; t \; (h :: y)$$

with CBN semantics:

0	targ 2	1		jump B	4		pushglob 0
0	pushloc 0				5		eval
1	eval	2	A:	pushloc 1	5		move 4 3
1	tlist A	3		pushloc 4			apply
0	pushloc 1	4		cons			~~slide 2~~
1	eval	3		pushloc 1	1	B:	return 2

Since the old stack frame is kept, return 2 will only be reached by the direct jump at the end of the [ ]-alternative.

$h \mapsto (L, 1)$
$t \mapsto (L, 2)$

Example

V-code for the body of the function

$$r = \textbf{fun}\ x\ y\ \rightarrow\ \textbf{match}\ x\ \textbf{with}\ []\ \rightarrow y \mid h :: t\ \rightarrow r\ t\ (h :: y)$$

with CBN semantics:

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Since the old stack frame is kept, return 2 will only be reached by the direct jump at the end of the []-alternative.

26 Exceptions

Example

$$
\begin{array}{l}
\textbf{let rec}\ gcd = \textbf{fun}\ x\ y \rightarrow \\
\qquad \textbf{if}\ x \leq 0 \mid\mid y \leq 0\ \textbf{then raise}\ 0 \\
\qquad \textbf{else if}\ x = y\ \textbf{then}\ x \\
\qquad \textbf{else if}\ y < x\ \textbf{then}\ gcd\ (x - y)\ y \\
\qquad \textbf{else}\ gcd\ x\ (y - x) \\
\textbf{in try}\ gcd\ 0\ 5 \\
\textbf{with}\ z\ \rightarrow z
\end{array}
$$

For simplicity, we assume that all raised exception values are of any type.

For every try expression, we maintain:

- An exception frame on the stack, which contains all relevant information to handle the exception;
- The exception pointer XP, which points the the current exception frame.

Each exception frame must record

- the negative continuation address, i.e., the address of the code for e_2;
- the global pointer and
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- the old exception pointer.

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217

For an expression of the following form:

$$e \equiv \textbf{try } e_1 \textbf{ with } x \rightarrow e_2$$

we generate:

$$
\begin{array}{rcl}
\text{code}_V\ e\ \rho\ \text{sd} & = & \text{try A} \\
& & \text{code}_V\ e_1\ \rho\ (\text{sd} + 4) \\
& & \text{restore B} \\
& A: & \text{code}_V\ e_2\ \rho'\ (\text{sd} + 1) \\
& & \text{slide } 1 \\
& B: & \dots
\end{array}
$$

where $\quad \rho' = \rho \oplus \{x \mapsto (L, \text{sd} + 1)\}$.

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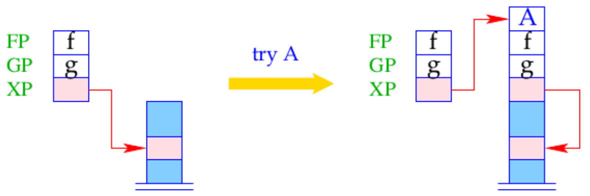
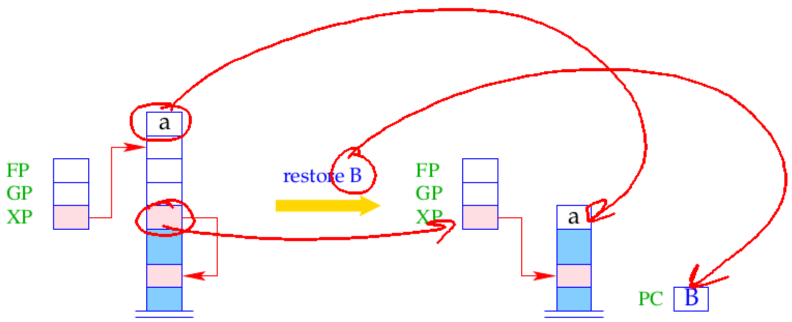
where $\rho' = \rho \oplus \{x \mapsto (L, \mathrm{sd}+1)\}$.



S[SP+1]=XP;
S[SP+2] = GP;
S[SP+3]=FP;
S[SP+4] = A;
SP =SP+4;



PC = B;
XP = S[SP-4];
S[SP-4] = S[SP];
SP = SP-4;

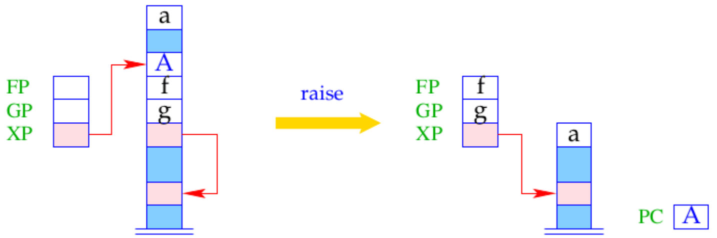
Now we have all provisions to raise exceptions.

For these, we do:

- We give up the current comutational context;
- We restore the context of the closest surrounding try expression;
- We hand over the exception value to the exception handler.

Thus, we translate:

$$\begin{array}{rcl} \mathrm{code}_V\ (\textbf{raise}\ e)\ \rho\ \mathrm{sd} & = & \mathrm{code}_V\ e\ \rho\ \mathrm{sd} \\ & & \mathtt{raise} \end{array}$$

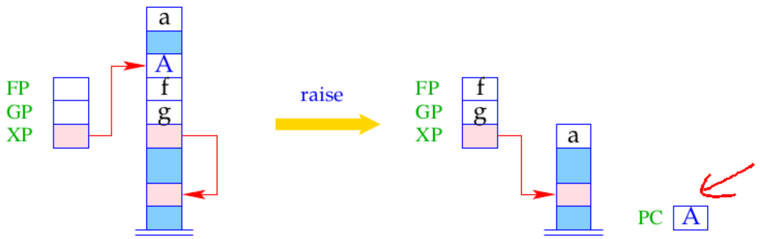


a = S[SP];
SP = XP-3;
PC = S[XP];
FP = S[XP-1];
GP = S[XP-2];
XP = S[XP-3];
S[SP] = a;

Example

The code for gcd is given by:

0		alloc 1	2	B:	rewrite 1	10		mkbasic
1		pushloc 0	1		try C	10		apply
2		mkvec 1	5		mark D	6	D:	restore E
2		mkfun A	8		loadc 5	2	C:	pushloc 0
2		jump B	9		mkbasic	3		slide 1
0	A:	targ 2	9		loadc 0	2	E:	slide 1
		...						
		return 2						



a = S[SP];
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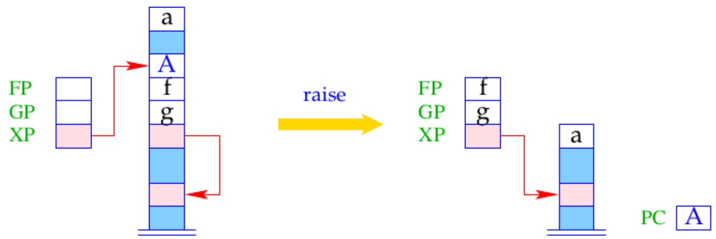
$2 \mapsto (L, 2)$
$\text{gcd} \mapsto (C, 1)$



a = S[SP];
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For every try expression, we maintain:

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Each exception frame must record

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Remarks

- In Ocaml, exceptions form a datatype on their own.
- The handler performs pattern matching on the exception value.
- If the given exception value is not matched, the exception value is raised again.

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Caveat

Exceptions only make sense in CBV languages !!

Why??

The Translation of Logic Languages

27 The Language Proll

Here, we just consider the core language Proll ("Prolog-light" :-). In particular, we omit:

- arithmetic;
- the cut operator;
- ~~self-modification of programs through assert and retract.~~

Example:

$$
\begin{array}{lll}
\text{bigger}(X, Y) & \leftarrow & X = \textit{elephant}, Y = \textit{horse} \\
\text{bigger}(X, Y) & \leftarrow & X = \textit{horse}, Y = \textit{donkey} \\
\text{bigger}(X, Y) & \leftarrow & X = \textit{donkey}, Y = \textit{dog} \\
\text{bigger}(X, Y) & \leftarrow & X = \textit{donkey}, Y = \textit{monkey} \\
\text{is\_bigger}(X, Y) & \leftarrow & \text{bigger}(X, Y) \\
\text{is\_bigger}(X, Y) & \leftarrow & \text{bigger}(X, Z), \text{is\_bigger}(Z, Y) \\
? \quad \text{is\_bigger}(\textit{elephant}, \textit{dog}) & &
\end{array}
$$

A More Realistic Example:

$$
\begin{array}{lll}
\text{app}(X, Y, Z) & \leftarrow & X = [\,],\; Y = Z \\
\text{app}(X, Y, Z) & \leftarrow & X = [H|X'],\; Z = [H|Z'],\; \text{app}(X', Y, Z') \\
? \quad \text{app}(X, [Y, c], [a, b, Z]) & &
\end{array}
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app([], Y, Y).

app([H|X], Y, [H|Z']) :-

app(X', Y, Z').

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Remark:

$[\,]$	$===$	the atom empty list
$[H|Z]$	$===$	binary constructor application
$[a, b, Z]$	$===$	shortcut for: $[a|[b|[Z|[\,]]]]$

A program p is constructed as follows:

$$
\begin{array}{lll}
t & ::= & a \mid X \mid \_ \mid f(t_1, \ldots, t_n) \\
g & ::= & p(t_1, \ldots, t_k) \mid X = t \\
c & ::= & p(X_1, \ldots, X_k) \leftarrow g_1, \ldots, g_r \\
p & ::= & c_1 \ldots . c_m ? g
\end{array}
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- A term t either is an atom, a variable, an anonymous variable or a constructor application.
- A goal g either is a literal, i.e., a predicate call, or a unification.
- A clause c consists of a head $p(X_1, \ldots, X_k)$ with predicate name and list of formal parameters together with a body, i.e., a sequence of goals.
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