Script generated by TTT

Title: Seidl: Virtual_Machines (09.06.2015)

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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.

$r \mapsto (G,0)$ $x \mapsto (L,0)$ $h \mapsto (L,1)$

$y \mapsto (L,-1)$ $t \mapsto (L,2)$

Example

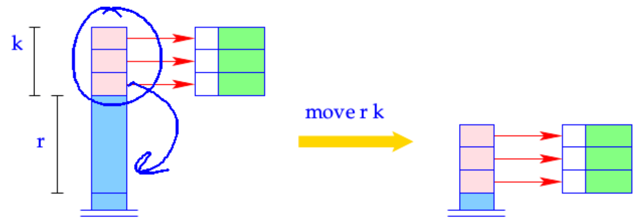
V-code for the body of the function

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

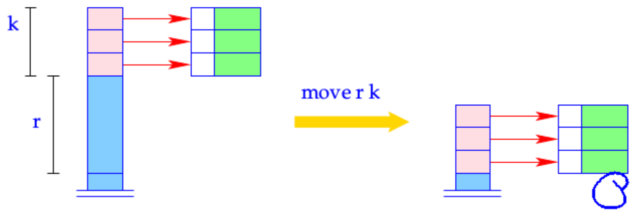
with CBN semantics:

0	targ 2	1		jump B	4		pushglob 0
0	pushloc 0				5		eval
1	eval	2	A:	$\boxed{\text{pushloc 1}}$	5		move 4 3
1	tlist A	3		$\boxed{\text{pushloc 4}}$			apply
0	pushloc 1	4		$\boxed{\text{cons}}$			~~slide 2~~
1	eval	3		$\boxed{\text{pushloc 1}}$	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.



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




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


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 the handler;
- the global pointer and
- the frame pointer; as well as
- the old exception pointer.

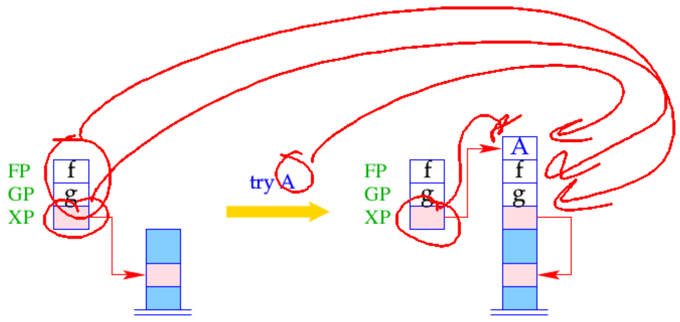
For an expression of the following form:

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

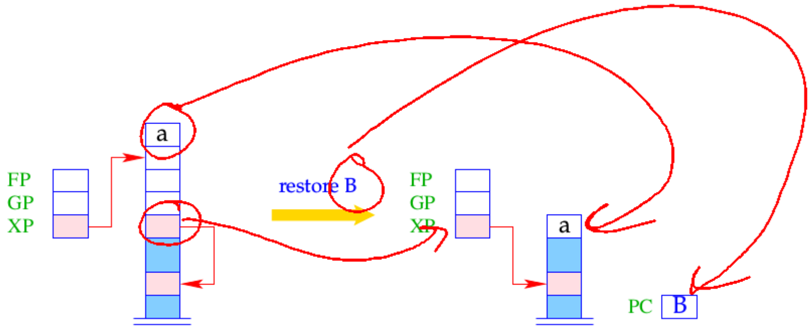
we generate:

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

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



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



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

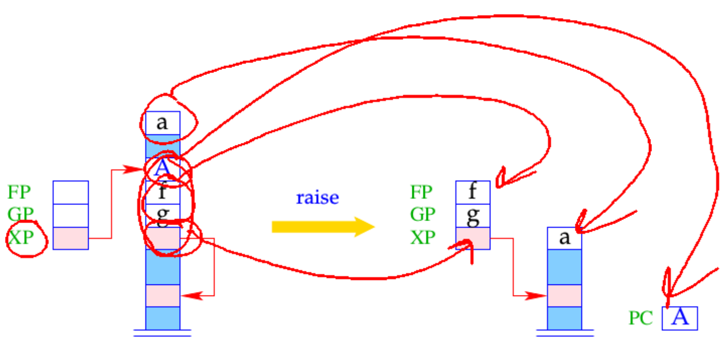
Now we have all provisions to raise exceptions.

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:

$$
\begin{array}{lll}
\text{code}_V\ (\textbf{raise}\ e)\ \rho\ \text{sd} & = & \text{code}_V\ e\ \rho\ \text{sd} \\
 & & \text{raise}
\end{array}
$$



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 V-code for *gcd* is given by:

0		alloc 1	2	B:	rewrite 1	10		mkbasic
1		pushloc 0	1		try C	10		pushloc 9
2		mkvec 1	5		mark D	11		apply
2		mkfun A	8		loadc 5	6	D:	restore E
2		jump B	9		mkbasic	2	C:	pushloc 0
0	A:	targ 2	9		loadc 0	3		slide 1
		...				2	E:	slide 1
		return 2						

Remarks

- In Ocaml, exceptions may also be raised by the runtime system.
- Therefore, exceptions form a datatype on their own, which can be extended with further constructors by the programmer.
- 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??

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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

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

... in Concrete Syntax:

$$
\begin{array}{lcl}
\text{bigger}\mathit{elephant}, \mathit{horse}). & & \\
\text{bigger}(\mathit{horse}, \mathit{donkey}). & & \\
\text{bigger}(\mathit{donkey}, \mathit{dog}). & & \\
\text{bigger}(\mathit{donkey}, \mathit{monkey}). & & \\
\text{is\_bigger}(X,Y) & :- & \text{bigger}(X,Y). \\
\text{is\_bigger}(X,Y) & :- & \text{bigger}(X,Z), \text{is\_bigger}(Z,Y). \\
?- \text{is\_bigger}(\mathit{elephant}, \mathit{dog}). & &
\end{array}
$$

Example

$$\begin{array}{lcl}
\boxed{\text{bigger}(X,Y)} & \leftarrow & \boxed{X = elephant, Y = horse} \\
\boxed{\text{bigger}(X,Y)} & \leftarrow & \boxed{X = horse, Y = donkey} \\
\boxed{\text{bigger}(X,Y)} & \leftarrow & \boxed{X = donkey, Y = dog} \\
\boxed{\text{bigger}(X,Y)} & \leftarrow & \boxed{X = donkey, Y = monkey} \\
\text{is_bigger}(X,Y) & \leftarrow & \text{bigger}(X,Y) \\
\text{is_bigger}(X,Y) & \leftarrow & \text{bigger}(X,Z), \text{is_bigger}(Z,Y) \\
? \;\; \text{is_bigger}(elephant, dog) & &
\end{array}$$

A More Realistic Example

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

A More Realistic Example

$\text{app}([\,], Z, Z).$

$\text{app}([H|X'], Y, [H|Z']) \;\; :- \;\; \text{app}(X', Y, Z').$

$?- \;\; \text{app}(X, [Y,c], [a,b,Z]).$

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$$?\;\; \mathsf{app}(X, [Y, c], [a, b, Z])$$

$[a \mid [b]]$

Remark

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

$\neq$

$[a|[b|Z]]$

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