Towards Programming in a Certified Grid Computing Framework

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The ConCert project seeks to develop programming language and type theoretic technology for Grid Computing in a trustless setting.
Vision: Distributed-application developer utilization of donated resources is completely transparent to the donator, but the donator is confident the specified safety, security, and privacy policies will not be violated.
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ConCert Framework

With Tom Murphy, Margaret DeLap, and Jason Liszka, we seek to develop a real framework to:

- Motivate theoretical work
- Provide a source of technical ideas and problems to solve
- Provide a testbed for implementation

Margaret and Jason: Low-level to discover implementation issues.

- Conductor
- Raytracer

Evan and Tom: High-level to discover programming issues.

- ML Interface, New Programming Language?
- Parallel Theorem Prover
My Contribution

Idea: The process of developing a substantial application using the ConCert framework will help us better understand the requirements on the framework and how to program in such an environment.

Goals

- drive the framework to a more robust and stable state
- better understand the requirements from a programmer’s perspective

Last Semester: Develop a parallel theorem prover for linear logic.

This Semester: Bridge the gap between the implementation in CML and the low-level interface provided by Conductor.
ConCert Programming: Jobs and Tasks

**Job**: A whole-program that is injected into the network from the command-line.

**Task**: The unit of computation from the programmer’s point of view. Consists of a piece of closed code along with its arguments. The code should restartable.
Injecting a Task into the Network

**type** 'a task

**val injectTask :** bool -> ('b -> 'a) * 'b -> 'a task
**val enableTask :** 'a task -> unit

- A task can optionally be injected into the network in a suspended state (i.e. *disabled*).
- If disabled, the task will not run until an explicit *enable* instruction is issued.
Retrieving Results

val sync : 'a task -> 'a

- Returning a result and asking for results from other tasks are the only form of communication between tasks.
- Blocks the calling task until the result can be obtained.
- Let $t$ be the task that we seek the result from. Task $t$ could be in four possible states:
  1. $t$ has already completed execution successfully.
  2. $t$ is currently executing.
  3. $t$ has failed (or appears to have failed).
  4. $t$ is currently disabled.
Results from Multiple Tasks

val syncall : 'a task list -> 'a list
val relax : 'a task list -> 'a * 'a task list

- syncall blocks until results are obtained from all the given tasks.
- relax continues as soon as one result is available.
Example: Merge Sort

1 (* mergesort : int list * int -> int list *)
2 fun mergesort (nil, _) = nil
3  | mergesort ([x], _) = [x]
4  | mergesort (l, cutoff) =
5     let
6     (* partition : int * int list -> int list * int list * int list *)
7       ...
8     (* merge : int list * int list -> int list *)
9       ...
10    val len = List.length l
11    val (lt,md,rt) = partition (len div 3, l)
12    in
13       if (len <= cutoff) then
14          merge (mergesort (lt,cutoff), merge (mergesort (md,cutoff), mergesort (rt,cutoff)))
15       else
16          ...
17       end
Example: Merge Sort (cont’d)

```haskell
36  if (len <= cutoff) then
37    merge (mergesort (lt,cutoff), merge (mergesort (md,cutoff), mergesort (rt,cutoff)))
38  else
39    let
40      open CCTasks
4142      (* Start sorting each partition *)
43      val t1 = injectTask true (mergesort, (lt, cutoff))
44      val t2 = injectTask true (mergesort, (md, cutoff))
45      val t3 = injectTask true (mergesort, (rt, cutoff))
4647      (* Get the results of the three child tasks. Start merging
48        when receive 2 sorted lists. *)
49      val (sort1, sort2) = let
50        val (a, rest) = relax [ t1, t2, t3 ]
51        val (b, [last]) = relax rest
52          in
53            (merge (a,b), sync last)
54        end
55      in
56      merge (sort1, sort2)
57      end
```
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Jobs, Tasks, and Cords

*Cord*: The unit of computation scheduled by the ConCert framework (Conductor).
Invariants

To simplify implementation and allow for failure recovery and program mobility, we impose strong invariants on cords:

1. A cord is deterministic, or any possible result is “as good as” any other.

2. Cords do not communicate except through explicit dependencies.

3. Once its dependencies are filled, a cord is able to run to completion.

Are these invariants really necessary, and what sorts of applications do they preclude?
Next Steps

1. Make the theorem prover run on a simulator of the given interface.

2. Flush out as many issues as possible with regards to compiling the proposed interface.

3. Implement the interface (if possible).

4. Write everything up!