Distributed Maple

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Maple is a general-purpose commercial computer algebra system. It is developed and sold by Maplesoft (Waterloo Maple Inc.) based in Ontario, Canada.

The current version is Maple 12, released in May 2008.
What is Maple?

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- The Heriot Watt Maths department has considerable expertise with Maple and is always interested in new problems!
What is Distributed Maple?

- Distributed Maple is a software package for running parallel programs in Maple on a group of Linux machines.
- It allows the user to create concurrent tasks, and have them executed by Maple kernels running on different machines in the network.
Distributed Maple is a software package for running parallel programs in Maple on a group of Linux machines. It allows the user to create concurrent tasks, and have them executed by Maple kernels running on different machines in the network. It was developed by Wolfgang Schreiner (RISC, Linz).

The software and manual can be downloaded for free at www.risc.uni-linz.ac.at/software/distmaple/
Setting Up Distributed Maple

> currentdir(getenv("HOME"));
> currentdir("DM-45");

> read("dist.maple");
Distributed Maple V1.1.16 (c) 1998-2004 Wolfgang Schreiner (RISC-Linz)
See http://www.risc.uni-linz.ac.at/software/distmaple
> maths:=[ [`distmaple11`, `maths-ssh`],
           [`distmaple12`, `maths-ssh`],
           [`distmaple18`, `maths-ssh`],
           [`distmaple19`, `maths-ssh`],
           [`distmaple20`, `maths-ssh`]];

> dist[initialize](maths);
  connecting distmaple11...
  connecting distmaple12...
  connecting distmaple18...
  connecting distmaple19...
  connecting distmaple20...
  okay

> dist[visualize](600,600,1,90);
  okay
Simple Example I

```
> for i from 1 to 5 do
t[i] := dist[start](expand, (a+b)^i);
od:
> [t[1], t[2], t[3], t[4], t[5]];
[0, 1, 2, 3, 4]
> for i from 1 to 5 do
  ans[i] := dist[wait](t[i]);
od;

  ans_1 := a + b
  ans_2 := a^2 + 2 a b + b^2
  ans_3 := a^3 + 3 a^2 b + 3 a b^2 + b^3
  ans_4 := a^4 + 4 a^3 b + 6 a^2 b^2 + 4 a b^3 + b^4
  ans_5 := a^5 + 5 a^4 b + 10 a^3 b^2 + 10 a^2 b^3 + 5 a b^4 + b^5
> dist[terminate]();
  okay
```
Simple Example I

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Distributed Maple
Simple Example II

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Distributed Maple

```maple
> sum_rand_int := proc(n)
    local j, ANS; ANS := 0;
    for j from 1 to n do
        ANS := ANS + RandomTools[Generate](integer(range=-100..100));
    od;
    RETURN(ANS);
end proc:

> StringTools[FormatTime]( "%H-%M-%S");
SUM1 := sum_rand_int(500000);
StringTools[FormatTime]( "%H-%M-%S");

"19-59-38"
"19-59-58"

> read("load.maple");
> `dist/load`(sum_rand_int);

okay

> StringTools[FormatTime]( "%H-%M-%S");
for i from 1 to 5 do t[i] := dist[start](sum_rand_int, 100000): od;
SUM2 := 0:
for i from 1 to 5 do SUM2 := SUM2 + dist[wait](t[i]): od;
StringTools[FormatTime]( "%H-%M-%S");

"20-00-12"
"20-00-17"

> SUM1; SUM2;

69512
53985
```

Our Research

- We research the properties of the Abelian functions associated to specific classes of algebraic curves.
- Formulated with algebraic geometry, applications in non-linear wave theory.
- Construct explicit formulae and derive the details for specific cases of interest.

During our research we have used Distributed Maple to increase the speed of our calculations and spread the memory requirements over several machines. The types of problem we need to tackle include:

- Expanding multiples of large polynomials.
- Solving large systems of linear equations.
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  - Expanding multiples of large polynomials.
  - Solving large systems of linear equations.
Distributed Maple in Action!

We know that the following must equal zero for unknown constants h[i] and A,B,C,D

\[ pol:=Qfbasis(basis,\lambda daw,10) - A*Q(2,6,6,6) - B*Q(3,5,6,6) - C*Q(4,4,4,6); \]

\[ pol := h1 P_{2,4} + h2 P_{4,4} \lambda_4 + h3 (P_{5,5,6,6} - 2 P_{5,5,6,6} - 4 P_{5,6,6}) \lambda_4 + h4 P_{6,6} \lambda_4^2 + h5 P_{6,6} \lambda_3 \]

\[ - A (P_{2,6,6,6} - 6 P_{2,6,6,6}) - B (P_{3,3,6,6} - 2 P_{3,3,6,6} - 4 P_{3,6,6,6}) - C (P_{4,4,4,6} - 6 P_{4,4,4,6}) \]

The lambda[i] are fixed constants.
The P's are Abelian functions that can be defined as log derivatives of the Kleinian sigma function.

We substitute these definitions in and set the numerator to zero.

\[ polnum:=\text{numer(factor(subs(psibs, pol))}); \]

\[ \text{nops(polnum); op(1,polnum);} \]

\[ \text{27} \]

\[ -h3 \lambda_4 \left( \frac{\partial^4}{\partial u_0^2 \partial u_5^2} \text{si}(u_1, u_2, u_3, u_4, u_5, u_6) \right) \text{si}(u_1, u_2, u_3, u_4, u_5, u_6) \]

We have a series expansion for sigma in its variables u[i], we substitute it in:

\[ \text{li:=eval(subs(si=sigma,polnum));} \]

It is true for all u[i] so for simplicity we substitute in a specific case

\[ \text{lii:=subs(u3=1,u4=1,u5=1,u6=1, li);} \]

We now have a sum of pairs of long series expansions multiplied together.

We have designed a procedure that "essentially" multiplies these out, discarding the powers of high order.

It is called super_chop!
Distributed Maple in Action!

```
> read("super_chop.txt"): `dist/load`("super_chop");
> tasks:=[[];
  for i from 1 to nops(li) do
    t:=dist[start](super_chop, op(i,lii), 13): tasks:=[op(tasks),t];
   od: tasks;
[32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58]
>
> linn:=0:
  for i from 1 to nops(li) do
    linn:=linn + dist[wait](tasks[i]);
  od:

We now have a sum of monomials in lambda and u that must be zero. Therefore each coefficient of a lambda-u-monomial must be zero. We have designed a procedure to take the set of coefficients.

> Lm:=LM(linn):

We now use the Maple solve command to find the values of the unknown constants, neccessary for them all to be zero

> sol:=solve( Lm );

\[
\text{sol} := \{ h4 = -2 C, C = C, h1 = -2 C, h2 = 6 C, h5 = -4 C, A = -2 C, h3 = \frac{3 C}{2}, B = \frac{3 C}{2} \}
\]

> subs(sol,C=1,pol);

\[-2 P_{2,4} + 6 P_{4,4} \lambda_4 + \frac{3}{2} (P_{5,5,6,6} - 2 P_{5,5} P_{5,6} - 4 P_{5,6}^2) \lambda_4 - 2 P_{6,6} \lambda_4^2 - 4 P_{6,6} \lambda_3 + 2 P_{2,6,6,6} - 12 P_{2,6} P_{6,6}
\]

\[-\frac{3}{2} P_{3,5,6,6} + 3 P_{3,5} P_{6,6} + 6 P_{3,6} P_{5,6} - P_{4,4,4,6} + 6 P_{4,4} P_{4,6} \]
```

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Distributed Maple in Action!

The user can set many tasks at once. As nodes become available they are sent a new task.
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- If one node goes down the computation fails.
- You have to manually put restrictions on cpu time and memory usage.
- Only runs on Linux machines.
Other parallel computer algebra software.

- Distributed Mathematica:
  www.risc.uni-linz.ac.at/software/distmath/

- Developing software to run parallel computations.
- Part of a larger project to use procedures from various computer algebra systems together in one shell.
- Still in development.
- Others?

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