Yet Another Parallel Hypothesis Search for Inverse Entailment

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Example of Distributed Computing Model: **MapReduce**

**Map Step**
Divide a Task (input data) into Subtasks

**Reduce Step**
- Gather the results
- Output the gathered result

*However...*
**MapReduce is effective when each subtask is full independent**

Not suitable for Inductive Logic Programming
Flow of ILP (Inductive Logic Programming)

ILP has 2 repetition processing loops in learning

① Choice a rule generation task and start learning
② Generate a rule by search process
③ Reduce rule generation tasks based on the rule (back to ①)

Many rule generation tasks → Executing a rule generation

There is much waste when divide loop ①
Our Purpose

Speed up ILP tool by parallel processing

We divide the search process for generate a rule

Design and Implement a Parallel Hypothesis Search System

- Divide the search area using Worker Nodes (CPUs)
- The Worker Node helps other Worker Nodes when finish own search task

Realize effective parallel processing
Our Approach

Usual method only assigns subtasks to workers

Our method

Each worker communicates with each other and requests (or accepts) a part of the subtask
System Configuration

[All modules were implemented by Java language]
Flow of Negotiation to Divide a Task

1. Learning worker requests a part of task to other all workers
2. Non-learning worker accepts the requested task
3. Requesting worker commits to an accepting worker
State that all Workers are Assigned (Saturation of the Task)

- All workers sent a request message to other all workers
- All workers received request messages from other all workers
State that all Workers are Assigned (Saturation of the Task)

*When one worker’s learning task is finished*

The worker accepts and is committed
Experiment

Environment
2 PC (total 12 CPUs)
   (Intel(R) Core(TM) i7-5820K CPU @ 3.30GHz 16.0GB 64bit)

Data
- Drug Design for Human (Sample Problem)
  From “In Silico Screening of Zinc (II) Enzyme Inhibitors Using ILP”
  [Ito, Ohwada et al., ILP2015] (Yesterday’s presentation)
  Using 1 CPU: 724 sec.

- Drug Design for Plant (Large Scale Problem)
  From “Extracting the Common Structure of Compounds to Induce Plant Immunity Activation using ILP”
  [Matsumoto, Ohwada et al., ILP2015] (Yesterday’s presentation)
  Using 1 CPU: 56,372 sec. (15.66hours)
Main Display of Parallel Execution (12 workers)
Operational status of each worker in the parallel-processing experiment using six workers (6CPUs) for the Sample Problem

<table>
<thead>
<tr>
<th>WorkerID</th>
<th>Task ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td></td>
</tr>
<tr>
<td>W2</td>
<td></td>
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<tr>
<td>W3</td>
<td></td>
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<tr>
<td>W4</td>
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<tr>
<td>W5</td>
<td></td>
</tr>
<tr>
<td>W6</td>
<td></td>
</tr>
</tbody>
</table>

**Time (Sec.)**

- Blue area: Learning
- White area: Communication or Waiting

**Average learning time:** 94.49 %

**Average communication time:** 3.07 %

*All workers work until the end (free time is very short)*
Experimental Results

Sample Problem (Drag Design for human) (12CPU: 6 CPU × 2 PC)

<table>
<thead>
<tr>
<th>Number of CPU</th>
<th>Execution time (sec.)</th>
<th>Speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56372</td>
<td>1.000</td>
</tr>
<tr>
<td>12</td>
<td>5723</td>
<td>9.850</td>
</tr>
<tr>
<td>20</td>
<td>3563</td>
<td>15.821</td>
</tr>
</tbody>
</table>

Large-scale problem (Drug Design for plant) (6CPU ×2 + 4CPU ×2)
Conclusion

Designed and Implemented a Parallel Hypothesis Search System

- Divide the search area using Worker Nodes (CPUs)
- The Worker Node helps other Worker Nodes when finish own search task

All workers work until the end (free time is very short)

Realize effective parallel processing