Data Structure Exploration of Dynamic Applications*

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The modern applications to be implemented in portable devices usually contain complex dynamic data structures. The selection of the dynamic data type (DDT) combination of the application affects the performance and the energy consumption of the memory subsystem. Thus, DDT exploration is used to perform trade-offs between design factors, such as performance and energy consumption. The above trade-offs should be taken into account, when designing the application. Choosing an improper DDT, may have negative impact at the total amount of memory needed to execute the program. Also, it affects the number of total memory accesses, thus taking up valuable resources from the embedded device that can cause performance issues and high energy consumption. Therefore, a systematic exploration that assists the designer to select the optimal data structure implementation for each application given the design constraints is needed. This optimization process is called DDT exploration and is an important part of the tools used to perform efficient Dynamic Memory Management [1] and optimal memory assignment and memory access scheduling. The size of the DDT affects the amount of data transferred, using DMA/DNA, through the interconnect resources and in between the memory hierarchy [4].

The work presented here is related to [2], where a DDT exploration methodology, named Matisse profiling tool, was presented. This methodology and the corresponding tool have several limitations, such as low flexibility and limited DDT support that do not allow the implementation of the methodology to applications with complicated dynamic behavior. In this paper, we introduce a DDT exploration methodology based on a new DDT Library tool. Using the new DDT Library, the exploration methodology is enhanced and can be applied in a wide range of application domains.

The new Library is designed following a completely different approach compared with the Matisse. It introduces the concept of Abstract Data Types (ADTs), which is an abstraction layer between the application and its data. The ADT layer enables the modular and hierarchical design of the new DDT Library. Additionally, the fact that the Library is designed in a modular way enables its extensibility and supports much more complex DDTs. It also provides a GUI environment for performing the DDT exploration. A qualitative comparison between Matisse profiling tool and the new Library is presented in Table I.

The methodology we introduce is supported by the new Library and consists of two steps. The first one is the DDT exploration, where all the selected DDT combinations are evaluated. The second step is the Pareto optimal exploration, where the optimal DDT implementations are selected, according to the design constraints. The new methodology not only extends the range of applications in which DDT exploration can be performed, but can also lead to more efficient solutions. This is because Pareto optimal DDT combinations that could not be obtained using Matisse can be reached using the new DDT exploration methodology.

Employing the new hierarchical and modular library, we performed DDT exploration in a number of dynamic wireless applications. We applied the methodology in Weighted Fair Queuing (WFQ) application, from NetBench Suite [3], which is a scheduler used in wireless telecom networks. The optimal DDT implementation resulted in reduced energy consumption by 20% and memory footprint by 5%. We also optimized Dijkstra algorithm, which is used for pathfinding in intra-domain networks and achieved energy savings up to 6% and reduced memory footprint to 18% compared with the original DDT implementation.

REFERENCES

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**Table I. Matisse and New Library Qualitative Comparison**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Matisse profiling tool</th>
<th>New DDT Library</th>
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</thead>
<tbody>
<tr>
<td>DDT Implementations</td>
<td>Limited (Unsorted Lists only)</td>
<td>Extended (Lists, Trees and more)</td>
</tr>
<tr>
<td>Abstract Data Type (ADT)</td>
<td>Not supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Extensibility</td>
<td>Not easy</td>
<td>Easy (due to the object oriented design of the Library)</td>
</tr>
<tr>
<td>Interface</td>
<td>No STL compliant</td>
<td>STL compliant</td>
</tr>
<tr>
<td>Application domains</td>
<td>Focused on multimedia applications</td>
<td>Wireless network, multimedia applications</td>
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</tbody>
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**Table II. New DDT Library**