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Just-In-Time Adaptive Decoder Engine: A Universal Video Decoder based on MPEG RVC

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ABSTRACT
In this paper, we introduce the Just-In-Time Adaptive Decoder Engine (Jade) project, which is shipped as part of the Open RVC-CAL Compiler (Orcc) project. Orcc provides a set of open-source software tools for managing decoders standardized within MPEG by the Reconfigurable Video Coding (RVC) experts. In this framework, Jade acts as a Virtual Machine for any decoder description that uses the MPEG RVC paradigm. Jade dynamically generates a native decoder representation suitable for X86, ARM and CELL platforms with a possibility of exploiting multi-core CPUs. Thus, according to the MPEG RVC decoder description coupled with a video coded stream, Jade can create, configure and re-configure video decompression algorithms adapting to the video content.

Categories and Subject Descriptors
4 [Multimedia systems and middleware]: Miscellaneous; 3 [Scalability in media processing, analysis, and applications]: Miscellaneous

General Terms: Algorithms, Languages, Performance, Standardization.

Keywords: Adaptive decoding, multimedia application, dataflow programs, decoder reconfiguration, scalable execution, MPEG Reconfigurable Video Coding (RVC).

1. INTRODUCTION
MPEG Reconfigurable Video Coding (RVC) has been chosen by MPEG to be an alternative paradigm for codec deployment. The goal of MPEG RVC is to provide dataflow representations of existing reference software decoders at component level. Thus MPEG RVC enables arbitrary decoder representations of any combination of fundamental algorithms, without additional standardization steps. By adding the side-information of the decoder description alongside the video coded bitstream, MPEG RVC defines the new concept of an RVC decoder. As shown on Fig. 1, an RVC decoder can create and handle several decoder descriptions on-the-fly, either by using coding tools standardized in MPEG, or proprietary implementations of coding tools, or other hybrid versions composed from proprietary and standardized implementations.

In this paper, we introduce the Just-In-Time Adaptive Decoder Engine (Jade) as the first portable decoder engine capable of managing on-the-fly MPEG RVC decoder descriptions. The goal of Jade is to exploit the generic properties of a dataflow representation to produce an efficient native decoder representation suited to the architecture of the underlying platform. Jade can create, configure and re-configure the video decompression algorithms adaptively to the coded video bitstream, avoiding incompatibility issues between decoders and coded bitstreams. This concept has significant advantages compared to a "statically" compiled decoder: a Just-In-Time decoding platform does not need decoder software updates. Moreover, RVC descriptions are generic and provide sufficient information to produce an efficient implementation suited for a wide range of platforms.

In the following, section 2 gives an overview of the MPEG
RVC standard and the property of its description. In section 3, we provide a presentation of the main concept of Jade and its implemented features. Finally, we give use procedure in section 4.

2. MPEG RVC OVERVIEW

The MPEG Reconfigurable Video Coding (RVC) [16] framework is a new, still evolving ISO standard from MPEG. It aims at providing video codec specifications based on a high-level library of components. The main goal of MPEG RVC is to produce new Abstract Decoder Model (ADM) of already existing MPEG standard which will be suitable for both hardware and software implementation [16]. An ADM is a generic representation of a decoder, built as a dataflow diagram of coding tools encapsulated into Functional Units (FUs). Dataflow representations are expressed with the XML Dataflow Format (XDF), an XML dialect standardized in MPEG-B part 4 [16] (Codec configuration representation) that describes the connections between FUs. Each FU is described in RVC-CAL Actor Language (RVC-CAL) and defines a processing entity of a decoder.

Figure 2 shows a typical use of a normative ADM description to produce a non-normative decoding solution that can target either software or hardware platform. MPEG RVC provides both a normative standard library of FUs standardized in MPEG-C part 4 [16], the Video Tools Library (VTL), and a set of decoder descriptions/configurations expressed as networks of FUs. Such a representation is modular and helps the reconfiguration of a decoder by modifying the topology of the network. Adding new coding technologies in an existing standard is a particularly sensitive part of any standardization process. As a consequence, MPEG RVC mainly focuses on the reusability of the standardized coding tools by allowing different decoder descriptions to instantiate common FUs across standards.

3. JUST-IN-TIME ADAPTIVE DECODER ENGINE FEATURES

Jade [13, 12], represented in Fig. 3, extends a Virtual Machine to handle a RVC decoder description. Its configuration engine (Fig. 4) has two inputs, a decoder configuration and a representation of the Video Tools Library (VTL) [11] standardized in MPEG-C. It outputs a complete dataflow representation of the decoder as a set of interconnected functional processing units in byte code format. This decoder representation can then be compiled or interpreted by a specific Virtual Machine (VM). We chose to base Jade on the open source LLVM infrastructure [15]. This VM provides efficient Just-In-Time compilation and multithread execution for a wide range of platforms (X86, X86-64, PPC, ARM, etc.).

![Figure 3: Structure of the Just-in-time Adaptive Decoder Engine.](image)

3.1 On-the-fly reconfiguration of decoders

The configuration engine of Jade contains several mechanisms to switch between different decoder representations during the decoding process. The dataflow representation of the coding tools provided by MPEG RVC gives the ability to incrementally and partially re-program a decoder when receiving new configurations from a bitstream.

The configuration and the reconfiguration of decoder are illustrated in Table 1. Two representations of decoders are standardized by MPEG RVC, the Simple Profile (SP) [17, 14] from the MPEG-4 part 2 standards and the Constrained Baseline Profile (CBP) [10] of the Advanced Video Coding (AVC)/H.264 decoder from the MPEG-4 part 10. Reconfiguration is done by switching to a proprietary configuration of these decoders. The first configuration is an optimized configuration of the same decoder provided by Ericsson. The second reconfiguration is a configuration developed by the IETR laboratory which represents the Fidelity Range Extensions (FRExt) of MPEG-4 AVC. The benchmarks are real-
Table 1: Configuration and reconfiguration times between implementations of MPEG-4 part 2 Simple Profile (SP) and MPEG-4 part10 Advanced Video Coding.

<table>
<thead>
<tr>
<th>Std.</th>
<th>Configurations</th>
<th>conf.</th>
<th>reconf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>RVC -&gt; Ericsson</td>
<td>1141 ms</td>
<td>380 ms</td>
</tr>
<tr>
<td>AVC</td>
<td>CBP -&gt; FRext</td>
<td>3313 ms</td>
<td>1610 ms</td>
</tr>
</tbody>
</table>

3.2 Clustering and spreading execution on processing units

Jade maximizes the use of the computing resources of any target platform by taking advantage of the inherent parallelism present in an MPEG RVC decoder. The configuration of a decoder gives information about the interconnection between coding tools (algorithms) that compose a decoder without carrying any implementation details for a specific platform. Therefore, Jade can execute the adaptive decoder according to the features (e.g. multiple cores) of the underlying platform.

Two optimizations algorithms based on execution models were incorporated in Jade to utilize the concurrency of a decoder configuration, depending on the number of cores in the underlying platforms. The first optimization analyzes a configuration and removes concurrency between tools to find an efficient execution on a same core. The second optimization applies an efficient distribution of independent coding tools onto separate cores. Table 2 shows the ability of Jade for exploiting multi-core CPUs. Each decoder configuration is executed on both cores of an Intel E6600 Core2 Duo processor at 2.40 GHz.

3.3 Easy edition and creation of decoders

Jade provides a command line and a simulator interface to demonstrate its configurability. It also provides two other test interfaces: the scenario or console modes that provides dynamic interaction with the engine.

1. Command line: The simplest way to test Jade is to use the command line. The option –help gives a full list of all options available for tuning Jade performance depending on the underlying platform. The mandatory options to launch Jade are an XDF network (-xdf), an encoded video (-i), and the location of your Video Tool Library folder (-L).

2. Console or scenario mode: These interfaces enable testing the dynamic behavior of Jade. Series of commands can be applied to Jade manager for on-the-fly configuring and reconfiguring of multiple decoders.

Table 2: Decoding performance of the two RVC implementations of MPEG-4 part 2 (SP) and MPEG-4 part 10 (AVC) running on 1 and 2 cores.

<table>
<thead>
<tr>
<th>Decoder</th>
<th>One core</th>
<th>Two cores</th>
<th>Speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP (RVC)</td>
<td>33 fps</td>
<td>61 fps</td>
<td>1.86</td>
</tr>
<tr>
<td>AVC (RVC)</td>
<td>36 fps</td>
<td>79 fps</td>
<td>2.19</td>
</tr>
</tbody>
</table>

1Graphiti is available at: http://graphiti-editor.sf.net
5. CONCLUSIONS

Orcc is a two-year-old framework now used by industry and research laboratories worldwide. In only one year, Jade has evolved from its experimental origins to become a real proof of concept of the MPEG RVC paradigm. It provides the first Virtual Machine which is able to dynamically instantiate RVC decoder descriptions into/from mp4 video files. Jade is natively included in this project as a GPAC plug-in that allows the player to instantiate on-the-fly an RVC description from an mp4 file and to decode the associated embedded rawstream.

7. REFERENCES