A System-on-a-chip for Multimedia Stream Processing and Communication

E. Juárez, M. Mattavelli, D. Mlynek

Integrated Systems Laboratory (LSI), Swiss Federal Institute of Technology
CH-1015, Switzerland
Phone: +41 21 6936973; Fax: +41 21 6934663
E-mail: Eduardo.Juarez@epfl.ch

ABSTRACT

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A VLSI architecture for multimedia stream processing and communication is presented. This system-on-a-chip is able to communicate multimedia applications -like interactive multimedia or mobile multimedia- over generic networks. Main features of the architecture are scalability in the number of multimedia streams managed, bandwidth sharing, capacity to control the offered service quality and possibility to implement mobile applications. MPEG4 multimedia stream requirements are included in the architecture. Four main units are distinguished in the design: cell communication, QoS control, protocol processing and DMA (Direct Memory Access). Preliminary results of an implementation of the cell communication unit are presented.

1. PROBLEM STATEMENT

Available high-speed network throughputs, in the order of Gb/s, allow multimedia applications to interconnect using their infrastructures. In order to give service to these applications a system offering multimedia stream processing and transport capabilities is needed. Interactive multimedia and mobile multimedia applications (either computer supported cooperative work, CSCW, or emergency-response) are examples that will use such a system.

A potential problem in multimedia stream communication over high-speed networks is information loss [1]. When several sources transmit at their peak rates simultaneously, some buffers available in network switches may overflow and the subsequent drop of information, e.g. cells, packets, leads to severe degradation in service quality due to synchronization loss in channel coding mechanisms.

2. PROBLEM REQUIREMENTS

2.1 General requirements

A system offering this service of multimedia stream processing and communication over a generic network should meet the following requirements if it wants to cover applications such as those mentioned above:

- The system should easily scale the number of streams it manages and the bandwidth associated to each of them to accommodate future service demand increases. Scalability of multimedia content and management is critical for associating new information products with various services and applications.

- The system should fairly share the available bandwidth between all different users. This feature will enable, for instance, either to increase the number of streams to be multiplexed when the available bandwidth is fixed or to reduce the necessary bandwidth to multiplex a fixed number of them. If users with heterogeneous traffic patterns want to be simultaneously served different guarantee bandwidths should be reserved for different streams.

- The system should be able to give service to mobile/portable users connected by either wireless or infrared links.

- The system should be able to control the quality of service (QoS) offered. If no control is applied in order to keep it constant, quality degradation will depend sharply on network congestion conditions [2]. Hence, to prevent this degradation some kind of multimedia stream processing will be needed.

QoS control, fair bandwidth sharing and mobility/portability are system requirements not included in other works [3].

2.2 MPEG4 requirements

We have considered MPEG4 multimedia streams as inputs to the system. Figure 1 below positions the system functionality with respect to DMIF (Delivery Multimedia Integration Framework) [4] and MPEG4-Systems [5] standards. The requirements that should be met are the following:

- At the TransMux Interface (TMI), the system should generate a FlexMux (FM) Stream, i.e. any arbitrary mixture of Simple mode FlexMux_PDUs and MuxCode mode FlexMux-PDUs. At the DMIF Application Interface (DAI), an SL_PDU (Synchronization Layer Protocol Data Unit) packetized stream should be generated. (see numbers 1 and 2 in figure 1).

- As an implementation of an MPEG4 application does not have to include the Elementary Stream Interface (ESI), the system should be able to receive/send a sequence of packets through the DAI (DMIF Application Interface) - number 3 in figure 1.

- The system should generate SL variable syntax packets and hence, it should need to have access to the SLConfigDescriptor for each ES that determines the syntax elements. SLConfigDescriptors are part of Object Descriptors (ODs) - see number 4 in figure 1.

- The system should encapsulate Elementary Streams carrying control data: Object descriptors (ODs) and BIFS (BInary Format for Scene). ODs dynamically describe hierarchical relations, location and properties of Elementary Streams (see number 5 in figure 1).
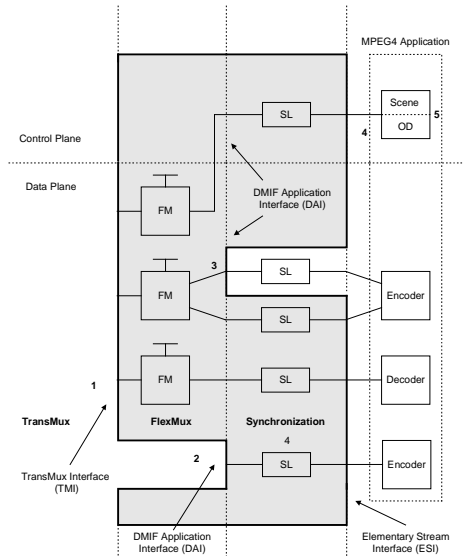

Figure 1: MPEG4-related functionality considered in our system

3. ARCHITECTURE DESCRIPTION

Distributing the multimedia stream processing and communication functions between different sources allows meeting efficiently the requirements of mobility and streaming scalability. As can be seen in figure 2, this goal can be achieved using a basic unit (BU) with a communication processor (CP) and an stream processor (SP). The BU locally applies a communication function to each stream group that has been processed or not by the SP.
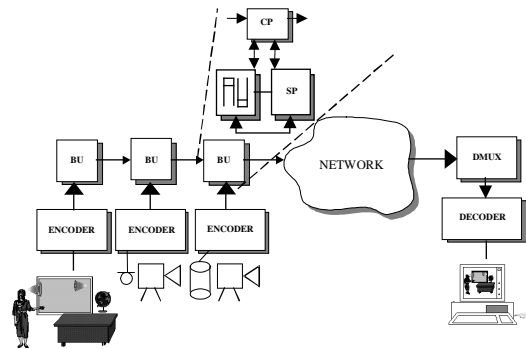

Figure 2: Decomposition of the system in an array of independent basic units and possible working scenario.

Inside the BU a mapping from network PDUs and multimedia stream data units (DUs) to generic, programmable-syntax cells is done (figure 3). A cell network, whose extension is the whole chip, interconnects different processing elements (PEs) of the BU: the communication processor, the stream processor and the storage. This concept of ChIp Area Network (CIAN) is an extension to a smaller scale of that of Desk-Area Network (DAN)[6].
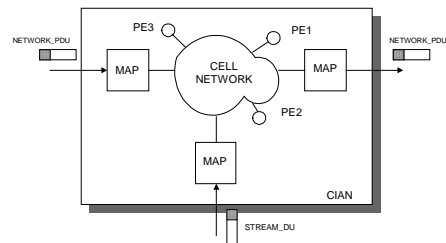

Figure 3: Mapping functionality and Chip Area Network (CIAN) inside the BU.

Figure 4 shows how the communication processor works when it is programmed as a multiplexer: cells carrying information from the multimedia

source are stored in a queue until the MAC (Medium Access Control) distributed algorithm gives permission to insert cells. When an empty cell is found at the communication processor input and the MAC algorithm allows insertion, this cell disappears from the flow and a new one is inserted.
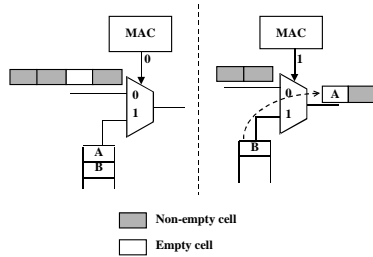

Figure 4: Communication processor working as multiplexer.

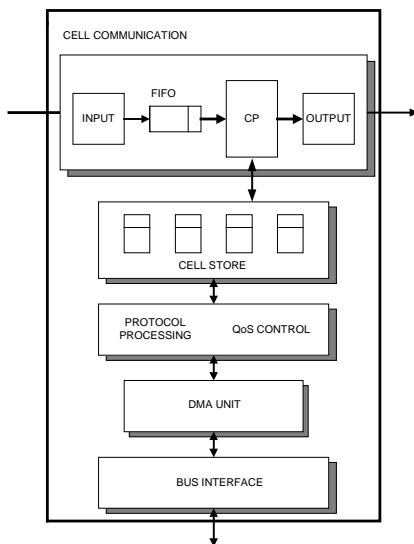Figure 5 shows the details of the basic unit. There are four main blocks:

Figure 5: Basic Unit Architecture

- Cell communication unit, with the input, output, input FIFO module and the communication processor.
- QoS control unit. It manages multimedia information in order to produce a smooth quality of service degradation when network suffers from congestion.
- Protocol processing unit. It adapts information either coming from the multimedia stream source for network transmission or coming from the network to the multimedia stream receiver
- DMA (Direct Memory Access) unit. It communicates with the application running on a host processor.

4. PRELIMINARY RESULTS

The cell communication unit has been initially implemented as a multiplexing unit for ATM networks. The main functionality of this unit consists on adding an ATM-cell stream to the ATM-cell input stream. Internally, the information unit used is an ATM cell and hence, no protocol mapping is necessary.

There are four modules in this unit: input, input FIFO, multiplexing and output. Interconnection between them is done through a simple linear network.

Table 1 summarizes area results for the Cell Multiplexing Unit (DLM CMOS 0.7 μm ATMEL-ES2 technology):

Area (mm^2)	Inp	FIFO	Mux	Output	TOTAL
Combinatorial	.13	.11	.11	.14	**.49**
Sequential	.14	.19	.19	.13	**.65**
Estimated interconnect.	.61	.63	.63	.55	**2.42**
Memory	.00	2.38	.00	.00	**2.38**
TOTAL	**.88**	**3.31**	**.93**	**.82**	**5.94**

Table 1: Area results for the different modules of the cell communication unit (ATM case)

The full version of the paper would include details of the functionality and implementation of each module and a more extensive reference section.

5. REFERENCES

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