THE SOFTWARE HEADEND ARCHITECTURE - A NEW APPROACH FOR MULTI-STANDARD CATV HEADENDS

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***Abstract* – Cable television (CATV) networks are in transition to digital two-way broadband networks. The industry has already developed devices according to the data-over-cable service interface specifications (DOCSIS) or digital video broadcasting (DVB) standards for cable. Both standards are incompatible.**
This digest introduces a new concept for headends in CATV networks. The goal of the Software Headend architecture is to handle multiple standards on the same hardware platform. Architectures with flexible signal processing elements are presented and classified.
Advantages of this new concept are an easy exchange of standards by setting the appropriate configuration without changing hardware and the possibility to install Software Headends and Software Terminals in any cable environment.

1 INTRODUCTION

Cable networks are currently being upgraded towards digital two-way broadband networks. DOCSIS and the DVB standards for cable (DVB-C) and return channel for cable (DVB-RCC) were developed for the delivery of high-speed interactive services across these cable networks. Devices for each standard are already available from industry.

In fact, there is great demand for new devices that can handle both incompatible standards. These devices should be very flexible and a solution similar to the Software Radio principle from mobile communications is applied in this digest. The new concept of Software Cable and Software Headend is introduced in section 3. In section 4, the architecture of a Software Headend with flexible digital signal processing is described. Three different classes of Software Headends are derived from this architecture in section 5.

2 FUNCTIONAL REQUIREMENTS

The following considerations refer to a CATV network environment as defined in the standards DVB-C, DVB-RCC, DOCSIS and Euro-DOCSIS [1-4].

3 NEW DEFINITIONS

The definitions "Software Cable," "Software Terminal" and "Software Headend" are derived from mobile communications ("Software Radio") [5,6], but Software Cable is related to bi-directional transmission in CATV networks. Software Cable consists of "Software Terminal," the software driven cable modem / set-top-box, and "Software Headend," the software driven headend.

Characteristics of Software Headend and Software Terminal devices are:

- Implementation of multiple standards on the same hardware platform.
- Analog to digital (A/D) and digital to analog (D/A) conversion as close to the cable outlet as possible.
- Application of programmable and flexible devices (DSPs, FPGAs) for digital signal processing.

4 SOFTWARE HEADEND ARCHITECTURE

Fig. 1 illustrates the connection of a Software Headend to the coax cable and the wide-area network. An important characteristic is the wideband analog-to-digital converter (ADC) that digitizes the complete upstream spectrum in the range of 5 to 65 MHz .

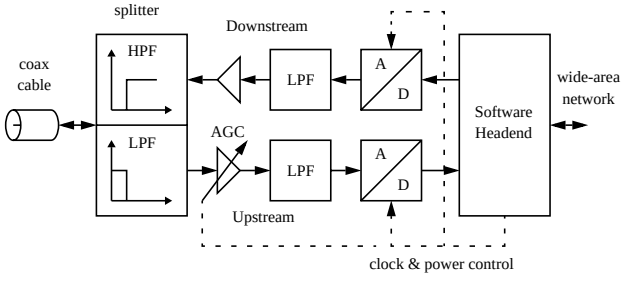

Fig. 1. Connecting the Software Headend to the cable outlet

Fig. 2 shows the digital signal processing elements required to demodulate and decode one specific channel out of the upstream spectrum. A functional unit (FU) in Fig. 2 is a multi-standard element which can be configured according

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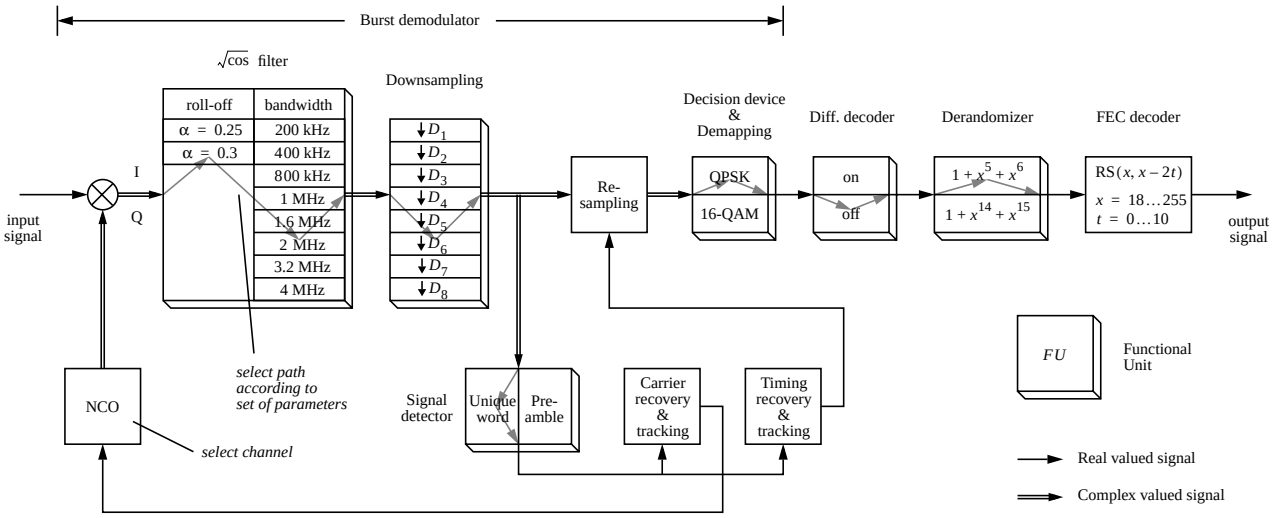

Fig. 2. Software Headend architecture

to the different standards.

Important signal processing elements in Fig. 2 are:

- Channel selection: downconversion of the radio frequency spectrum by means of a numerically controlled oscillator (NCO).
- Matched filter FU for all possible roll-off factors and bandwidths.
- Downsampling.
- Signal detector to detect the arrival of an upstream burst.
- Carrier and timing recovery plus tracking units.
- Resampling unit to select optimum sampling instant.
- FUs for symbol decision, demapping, differential decoding and derandomization.
- Forward error correction (FEC).

5 CLASSIFICATION OF SOFTWARE HEADENDS

To cover the complete frequency range in upstream direction, the Software Headends are classified into:

- The Modular Software Headend architecture that manifolds the single channel structure N times to support N upstream channels. All signal processing elements for one upstream channel are grouped into a module.
- The Parallel Software Headend architecture that associates a module with a FU. Only one implementation of each FU is required in this case, resulting in less hardware amount but significantly faster circuits.
- The FFT-based Software Headend that incorporates a fast Fourier transform (FFT) to separate the upstream channels. This conversion is possible with few restrictions concerning frequency allocation [7]. All restrictions are consistent with the standards. If this structure is used, the computational amount can be decreased.

6 CONCLUSIONS

We have investigated new architectures for headends in CATV networks with advanced digital signal processing. The flexible Software Headend was designed to handle multiple standards on a single hardware platform. The architecture of the Software Headend was presented and subdivided into modules and functional units. Starting from this architecture, the three different classes Modular Software Headend, Parallel Software Headend and FFT-based Software Headend were outlined.

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