INVENTION DISCLOSURE

1. **Invention Title.**

Out-of-Band Forward Data Channel Implementation Methods for Expanded Upstream Networks

2. **Invention Summary.**
Methods to carry Out-of-Band Forward Data Channel (OOB FDC) transmission to Set-Top Boxes in CATV networks where the upstream spectrum has been extended covering the frequency range used by standard OOB FDC.

3. **Invention Description**.

a. **Describe the invention in detail and/or attach a description, drawing(s) and/or diagram(s), if available.**
Methods to carry Out-of-Band Forward Data Channel (OOB FDC) transmission to Set-Top Boxes in CATV networks where the upstream spectrum has been extended covering the frequency range used by standard OOB FDC devices. Embodiments of this invention include a method using an up and down frequency conversion of the OOB FDC, a DOCSIS encapsulation method and a carrier digitization method. The details of this invention are described in the attached file "OOB FDC Disclosure.doc"

b. **Why was the invention developed? What problem(s) does the invention solve? How is it better?**
This invention was developed to continue to provide services to legacy Set Top Boxes even after an upstream split that uses the OOB FDC spectrum has been conducted. This allows operators to extend the life of their legacy system and provides a smother migration to extended upstream architectures.

c. **Briefly outline the potential commercial value and customers of the invention.**
This invention enables the migration to higher upstream capacity services with all its associated revenue. It also increases the lifespan of deployed Set Top Boxes so that they can continue to be useful in spite of a significant plant upgrade. The fact that this invention leads to a less disruptive migration towards a higher capacity services, leads to lower churn.

4. HOW is your invention different from existing products, processes, systems?
Not aware of existing products, processes or systems.

OOB FDC Implementation Methods for Expanded Upstream Networks

Invention Disclosure

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The need for upstream resources has been prompting cable TV operators to explore different mechanisms to increase the amount of capacity in the upstream direction. So far the most popular strategy has been that of node splitting. This strategy is practical when the nodes are large > 250 homes passed. Nevertheless these strategies does not increase the peak rate that customer can achieve and it also is less cost effective as the nodes decrease further in size. An upstream spectrum enhancement option is that of moving the split to higher frequencies. This result in more upstream capacity but leaves the question about what to do with the legacy Out-of-band Forward Data Channel (OOB FDC) traffic unanswered if operators want to maintain legacy OOB FDC support when migrating to an expanded upstream network architecture. This invention disclosure describes different methods supporting OOB FDC in upstream configurations that are not compatible with its typical spectrum usage.

The OOB FDC implementations have used a spectrum that ranges from 70 MHz to 130 MHz. This would not be compatible for a move of upstream spectrum split above 130 MHz. A move in the upstream spectrum split by definition comes with the elimination of downstream analog channels. Operators that remove a significant portion of analog channels have explored the option of re-generation of the analog spectrum from digital channels. This would require a digital terminal adapter (DTA) which takes a stream from a digitally modulated channel and regenerates an analog NTSC channel in its original portion of the spectrum (Figure 1).

Figure 1 DTA Functionality

Figure 1 shows how the DTA regenerates the analog spectrum within the home. The analog spectrum outside the home has been vacated and could be used for other purposes such as digital video content that is distributed within the home through an IP transport network such as MoCA, Ethernet or WiFi. This vacated spectrum can also be used to move the upstream split to a higher frequency and allow for more upstream capacity. As mentioned before, such an implementation could be in conflict with OOB FDC transmissions which occupy the 70 MHz to 130 MHz range (Figure 2)

Figure 2 OOB FDC Frequency Range

Figure 2 shows how a change in upstream split could be in conflict with the use of OOB FDC. In cases where the move of an upstream split is desirable, mechanisms to work around this spectrum incompatibility would be needed to support legacy OOB FDC along with an expanded US. This invention disclosure details several mechanisms to implement such systems.

In conventional systems, analog video, digital video, downstream DOCSIS and the OOB FDC are combined through an RF combining/distribution network before being delivered to the fiber nodes through laser transmitters. A basic representation of such a distribution network is shown in Figure 3.

Figure 3. Downstream Distribution Network at Headend or Hub

The OOB FDC component takes the OOB Data and generates the OOB Forward Data Channel within the 70 MHz to 130 MHz region. An example implementation of such a system is shown in Figure 4.

Figure 4 – Sample block diagram for OOB FDC generation

The proposed systems will require modifications of how the OOB FDC signals are generated at the Headend or hub in addition to changes needed at the home and/or at other locations in the network. The different embodiments of this disclosure are described next.

Frequency Up and Down Conversion of Out-of-band Forward Data Channel

In this embodiment the OOB FDC is upconverted at a higher frequency within the DS spectrum. This can be done in several ways one mechanism would be to take the RF OOB FDC data carrier between 70 -130 MHz and upconvert it at a higher frequency. This could be implemented externally to the OOB FDC generating device. Perhaps a more convenient approach would be to generate the OOB FDC at a higher frequency within the OOB FDC generating device. This would be done by upconverting the IF carrier of the OOB FDC. The downconversion to the conventional frequency range (70 MHz-134 MHz) can be done within the home. This functionality can be implemented in a stand alone device or could be embedded in a device like a digital terminal adapter (DTA). A DTA would be a logical place to implement this functionality since it is a device that reconstruct downstream analog spectrum. In general the down conversion would require a filter to select the OOB FDC and a mixer and a local oscillator with the delta frequency necessary to bring down the carrier within the OOB FDC conventional frequency range. A bandpass filter would follow the mixer to eliminate the image selecting only the OOB FDC carrier. The OOB FDC data is merged with the rest of the reconstructed spectrum and can be received by the legacy OOB FDC capable STBs. Figure 5 shows a general diagram of this implementation.

Figure 5 - Legacy OOB FDC support through up/down conversion

DOCSIS Encapsulated Out-of-band Forward Data Channel

A second method to carry OOB FDC information without using the 70 MHz-130 MHz spectrum would be by taking the OOB data prior to the encoding & symbol mapping shown in Figure 4 and encapsulating this data over DOCSIS which can be carried anywhere in the downstream spectrum. This encapsulated data would arrive to the home in a DOCSIS channel. In the home network, a cable modem would extract this data preferably through its serial/USB port so that it could be extracted and be used to drive the OOB FDC generator in the home (as in Figure 4) that reconstructs the OOB FDC carrier at the 70 MHz – 130 MHz conventional range so that it could be understood by legacy devices. Such a translation could take place in a stand alone device or it could be embedded in an MTA, home gateway or another device in the home network. Figure 6 show an implementation example of such a system.

Figure 6 – DOCSIS Encapsulated OOB Forward Data Channel

Digitized Out-of-band Forward Data Channel

A third method to carry OOB FDC information without using the 70 MHz-130 MHz spectrum would require the digitization of the OOB FDC carrier. This carrier occupies a bandwidth of 1.5 MHz. To fully capture the information within that channel following Nyquist sampling theorem we would need to sample the signal at least at 3 Msamples/second. Since the OOB FDC carrier has a modulation that is no more complex than a QPSK signal an 8 bit representation of each sample would be more than adequate. This results a digitization payload of 24 Mbps (3Msamples/sec * 8 bits/sample). This data stream can then be encapsulated over DOCSIS and carried to the homes over data channels running above 130 MHz. In the home, the data stream would be extracted from the USB or other data port of the CM and that would drive a DAC that generates the baseband OOB FDC carrier. This carrier is then upconverted to its typical 70 MHz to 130 MHz range.

Figure 7 – Digitized OOB Forward Data Channel

The second and third methods could also used encapsulation over digital video transport. This would be done in a similar fashion as video streams are encapsulated. At the home or CPE side instead of using a CM a STB would extract that “OOB FDC” stream in a similar fashion as a video stream and would output that through a serial port, thereby replacing the CM mentioned in the second and third methods.