Title: Provisioning of Cable Modems with Transmission Frequency Information

Abstract: A system for provisioning cable modems (205) with frequency information for communication with a Cable Modem Termination System (CMTS) (120) in a cable television plant. In a first embodiment, a virtual channel map of programming services (e.g., television program) is examined (150, 160) to determine which carrier frequencies are unused. These unused frequencies are used to form a table of available CMTS frequencies that is transmitted to the cable modems (205). The modems then have to only search a subset of all frequencies to locate one having a CMTS identifying signal. Alternatively, the modem (205) can be directly informed of the CMTS frequency, so no searching is required. In a further embodiment, multiple CMTSs are used at the headend (300), and a traffic monitoring function (310) dynamically adjusts the frequency used by the modems for upstream transmissions to balance the load on the CMTSs.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
PROVISIONING OF CABLE MODEMS WITH TRANSMISSION FREQUENCY INFORMATION

BACKGROUND OF THE INVENTION

The present invention relates to cable modems, such as those used in cable television plants to allow users to access computer networks such as the Internet, and to a Cable Modem Termination System (CMTS), such as used at a headend of a cable television plant.

A cable modem is a device that enables a personal computer (PC) to send and receive data via a cable television network at a data rate that typically far exceeds that of a telephone modem. In addition to the faster data rate, cable modems provide a continuous connection and avoid the need for a dial-up connection.

Moreover, the cable modem can be external to, or integrated with, a set-top box (e.g., terminal or integrated receiver-decoder) or the PC. Cable modems have become increasingly popular since they allow users to access the Internet at relatively high speeds. An Internet browser implemented in a standalone PC or a TV-based device may be used.

Typically, the cable modem attaches to a standard 10Base-T Ethernet card in the computer.

Moreover, the various cable modems at users' homes or businesses are connected to a cable TV company coaxial cable or hybrid fiber coax (HFC), and communicate with a CMTS at the local cable TV company office (headend). The cable modems can receive data from, and send data to, the CMTS. Moreover, larger cable systems may employ multiple CMTSs for handling large amounts of cable modem traffic.

The CMTSs are connected to the Internet, typically using a T1 line (1.544 Mbps) or faster.

The Data Over Cable Service Interface Specification (DOCSIS) (and the related EuroDOCSIS) has become a primary standard for cable modems. With this standard,
data is transmitted downstream, from the CMTS to the cable modem, using time
division multiplexing (TDM) and a video data standard such as MPEG. A spectrum of
42-850 MHz is used, with 64 or 256 Quadrature Amplitude Modulation (QAM)
signaling. For upstream transmissions, from the cable modem to the CMTS, time
division multiple access is used at a spectrum of 5-42 MHz, and Quadrature Phase-Shift
Keying (QPSK) or 16-QAM signaling.

Accordingly, the cable modem must determine the carrier frequency or
frequencies that one or more CMTSSs at the headend are using to transmit the
downstream data. This process must occur when the cable modem is installed, e.g., at a
user's home. Conventionally, the cable modem searches through a frequency range of
80-860 MHz in a trial and error process for an identifying signal from the CMTS that
the modem will receive data from. However, this hunting procedure is rather time
consuming and can take tens of minutes, during which the cable modem is not available
for use.

Accordingly, it would be desirable to provide a system for rapidly provisioning a
cable modem with the carrier frequency information that a CMTS is using for
transmitting data to the cable modem.

The system should provide a reduced set of frequencies for the cable modem to
search to find the CMTS identifying signal.

Alternatively, the system should directly inform the cable modem of the carrier
frequency being used by the CMTS, e.g., using an out-of-band message.

It would further be desirable to provide a system that dynamically changes
CMTS assignments (in a multi-CMTS headend) to route upstream cable modem traffic
to lightly-loaded CMTSs to improve system response.

The system should be compatible with DOCSIS and other cable modem
standards.

The present invention provides a system having the above and other advantages.
SUMMARY OF THE INVENTION

The present invention relates to cable modems, such as those used in cable television plants to allow users to access computer networks such as the Internet, and to a Cable Modem Termination System (CMTS).

The invention extends the virtual channel table/map (VCM/VCT) concept, which conventionally provides information about video and data channels that are configured on a cable plant (e.g., channel name, frequency, channel type, and modulation mode) to the cable modem space. A new virtual channel type is added that specifies the cable modem type.

The operator builds the virtual channel table by including a channel for the cable modem path that identifies the cable modem type, source name for the CMTS, and frequency. Upon initialization, the cable modem code interrogates the virtual channel table for the channel type of "cable modem," and possibly specified source name. The query returns the frequency which the cable modem then uses to communicate with the CMTS.

If the cable modem channel is changed, the existing virtual channel table update mechanism is employed whereby the cable modem software receives notification of the change, and can update itself as required.

By using the virtual channel table construct, the cable modem can react to asynchronous changes in CMTS frequency through a standard update mechanism.

In a first embodiment, cable modems are provided with a table of available CMTS frequencies to reduce the required number of carrier frequencies to search. This table is obtained by determining which frequencies in the virtual channel table for the programming services are not being used.

In a second embodiment, the cable modems are directly informed of a specific frequency or frequencies to use to receive data from a CMTS. This avoids the need for searching.

In a third embodiment, load balancing of multiple CMTSs at a headend is
achieved by monitoring the upstream traffic at each CMTS and dynamically changing the upstream frequency or frequencies monitored by each CMTS accordingly to shift traffic to lightly loaded CMTSs.

Corresponding methods and apparatuses are presented.
BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a headend for provisioning a cable modem using a map of available CMTC transmission frequencies or by directly specifying a frequency in accordance with the present invention.

FIG. 2 illustrates an apparatus for receiving CMTC transmission frequency information in accordance with the present invention.

FIG. 3 illustrates a headend for dynamically balancing the upstream cable modem traffic load among multiple CMTCs in accordance with the present invention.
DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to cable modems, such as those used in cable television plants to allow users to access computer networks such as the Internet, and to a Cable Modem Termination System (CMTS).

FIG. 1 illustrates a headend for provisioning a cable modem using a map of available CMTS transmission frequencies or by directly specifying a frequency in accordance with the present invention.

A headend 100 includes an interface 110 for sending data to, and receiving data from, a computer network such as the Internet 115. For example, the received data may include web pages, e-mail and so forth. The transmitted data may include a request for a web page, e.g., such as a Uniform Resource Locator.

An example CMTS 120 is shown, although one or more may be provided. A bank of modulators and demodulators 130 is provided for modulating data that is transmitted from the CMTS to a downstream cable modem at a carrier frequency \( f_{\text{downstream}} \), and for demodulating data that is received from the downstream cable modem, typically at a different carrier frequency \( f_{\text{upstream}} \).

The bank of modulators and demodulators 130 includes modulators for modulating programming service data at a number of different carrier frequencies. This data is shown being provided by a processing function 140. For example, the processing may include transcoding for a received compressed bitstream, or encoding for uncompressed source data.

A virtual channel map decode function 150 decodes virtual channel map data from the received programming services signal, which may be provided, e.g., according to the MPEG video standard. A virtual channel map or table is a data structure that provides information regarding the video and data services (channels) that are configured on a cable television plant.

An example simplified virtual channel map appears in Table 1.
Table 1 - Virtual Channel Map

<table>
<thead>
<tr>
<th>Channel Name</th>
<th>Carrier Frequency</th>
<th>Channel Type</th>
<th>Modulation Mode</th>
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</thead>
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<td>HBO</td>
<td>f1</td>
<td>satellite</td>
<td>QAM</td>
</tr>
<tr>
<td>available</td>
<td>f2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABC</td>
<td>f3</td>
<td>satellite</td>
<td>QAM</td>
</tr>
<tr>
<td>Showtime</td>
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<td>satellite</td>
<td>QAM</td>
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<tr>
<td>available</td>
<td>f5</td>
<td></td>
<td></td>
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<td>satellite</td>
<td>QAM</td>
</tr>
<tr>
<td>ESPN</td>
<td>f9</td>
<td>satellite</td>
<td>QAM</td>
</tr>
</tbody>
</table>

A CMTS frequency function 160 includes a table-forming function 162 for forming a table of available CMTS frequencies from the virtual channel map, or a frequency-specifying function 164 for directly specifying a CMTS frequency that is to be used. For example, the function 162 may form the available frequency table indicated in Table 2 from the example virtual channel map of Table 1.

Table 2 - Available Frequency Table

<table>
<thead>
<tr>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>f2</td>
</tr>
<tr>
<td>f5</td>
</tr>
<tr>
<td>f7</td>
</tr>
</tbody>
</table>

The available frequency table indicates the downstream carrier frequencies that
may possibly be used by one or more CMTSs at the headend. This information is provided to the modulation/demodulation bank 130 for modulation at any available modulation carrier frequency and communication across the cable plant 170 to one or more cable modems.

The available frequency information may also be provided from the function 162 to the CMTS 120 to enable the CMTS to select a frequency for sending its data, such as Internet data, to a cable modem.

The cable modem uses the received available frequency table to search the corresponding carrier frequencies to locate one used by a CMTS. The CMTS's frequency can typically be located by a pre-designated CMTS identifying signal, which can essentially be any agreed upon signaling sequence. Advantageously, since the number of available frequencies is typically a small subset of the total number of frequencies in the virtual channel map, the cable modem can locate the CMTS frequency much faster than if it had to search every frequency in the virtual channel map until the CMTS identifying signal was found.

Alternatively, the function 164 can be used to specify a CMTS frequency that is encoded and transmitted to the modulation/demodulation bank 130 for modulation at any available modulation carrier frequency (such as an out-of-band frequency) and communication across the cable plant 170 to one or more cable modems. In particular, this frequency data may be transmitted to all cable modems in a network when only one CMTS is used.

If multiple CMTSs are used, the frequency data can be targeted for transmission to specified cable modems or groups of modems using an identifier of the modems or of the set-tops. For example, known set-top addressing techniques may be used for this purpose. The function 164 may include a memory for storing the frequency assignments of the modems. The specified frequency information may be provided from the function 164 to the CMTS 120 to instruct the CMTS which frequency to use for sending its data to a cable modem.

With this embodiment, the cable modem uses the received frequency
information to immediately locate the carrier frequency used by a CMTS. Advantageously, this avoids the need for the modem to "hunt" by examining each frequency in a trial-and-error process until the CMTS identifying signal is found.

FIG. 2 illustrates an apparatus for receiving CMTS transmission frequency information in accordance with the present invention.

The apparatus 200 may be configured in a number of ways. For example, a single apparatus may include a cable modem portion 205, a video/audio receiver portion 260, and a personal computer (PC) portion 265. Or, these portions may be provided in separate apparatuses, or combined in other ways. For example, the cable modem portion 205 and video/audio receiver portion 260 may be combined, while the PC portion remains separate. An output device 280 may be combined with the other portions or may be separate.

The example cable modem 205 includes a modulation/demodulation function 210 for demodulating data received from a CMTS via the cable plant at a downstream carrier frequency, and for modulating data that is being transmitted upstream to a CMTS at an upstream carrier frequency.

For example, a browser 270 at the PC 265 may send a request via an interface 250 to the modulation/demodulation function 210, which modulates the request and transmits it to a CMTS. The CMTS, in turn, may transmit the request to the Internet.

In one embodiment, the modulation/demodulation function 210 demodulates the table of available frequencies that is provided as discussed in connection with the function 162 of FIG. 1. The table is recovered (e.g., decoded) and optionally stored at a function 220. Preferably, the function 220 uses a non-volatile memory so that the stored information can be recovered each time the apparatus 200 is powered on. Moreover, note that the table of available frequencies or the specified frequency may be provided to the apparatus 200 via the modulation/demodulation function 210, which is used for CMTS data, or via the demodulation function 262, which is used for programming services data.

When present, the table of available frequencies is used by a CMTS identifying
signal locating function 240 to locate a CMTS identifying signal by searching the carrier frequencies in the table. To achieve this, the function 240 causes the demodulator 210 to test each carrier frequency in the table. When a CMTS identifying signal is located, the function 240 notes the corresponding carrier frequency and stores it in the memory 220. Subsequently, the demodulator 210 remains tuned to the CMTS carrier frequency at which the identifying signal was detected to subsequently receive data from the CMTS, such as a requested web page from the Internet.

As noted, this embodiment allows the modem 205 to locate the CMTS carrier frequency relatively quickly, without having to test all possible frequencies.

In an optional embodiment, the function 210 demodulates the specified frequency information that is provided as discussed in connection with the function 164 of FIG. 1. The specified frequency information is recovered (e.g., decoded) and optionally stored at the function 220. The specified frequency information is used by the demodulator 210 to immediately tune to the designated CMTS carrier frequency to receive data from the CMTS.

As noted, this embodiment allows the modem 205 to locate the CMTS carrier frequency immediately. A trade-off with this embodiment is that, for headends that employ multiple CMTSs, it is necessary to account for which CMTS is transmitting to which cable modem or group of modems, possible changes in the frequency used by a given CMTS or the modems associated with the given CMTS, and the need to target the transmission of the specified frequency information to a specific modem or group of modems, e.g., based on some type of modem or group identifier.

The demodulator 210 may automatically retune to the identified CMTS carrier frequency each time it is powered up, assuming no new frequency tables or specified frequencies have been received from the headend. If a new CMTS carrier frequency table is received from the headend, the CMTS identifying signal is re-identified to see if the associated carrier frequency has changed. Or, the new specified frequency is tuned.

The video/audio receiver 260 is shown as being in use with the cable modem 205. However, this is not required. In some cases, data from the Internet or other
network may be accessed by the cable modem 205 and displayed on the output device 280 in conjunction with a programming service (e.g., television program). In other cases, the user may use the cable modem without accessing the programming services. The video/audio receiver 260 receives programming services from the headend and demodulates them at a demodulator 264. Subsequently, the data is decoded and other necessary processing is performed to provide a signal to the output device 280, such as a television.

Note that the browser 270 is shown providing a signal to the output device 280 as well. Optionally, or additionally, the browser 270 can have its own dedicated output, such as a PC monitor. However, the illustrated arrangement is expected to be more commonplace with the convergence of television and Internet systems.

FIG. 3 illustrates a headend for dynamically balancing the upstream cable modem traffic load among multiple CMTSs in accordance with the present invention. Like-numbered elements correspond to one another in the figures.

Larger cable television networks use multiple CMTSs, such as example CMTSs 120, ..., 122, with respective Internet interfaces 110, ..., 112, to handle larger volumes of cable modem and Internet traffic. For example, each CMTS may establish its own connection to the Internet, e.g., via a corresponding T1 line.

Here, a traffic monitor 310 monitors the amount of received upstream cable modem data at each CMTS 120, ..., 122. For example, the traffic monitor 310 may monitor the raw amount of data received, e.g., using a bit counter, or some other measure of traffic can be used, such as the number of messages received by a given CMTS, the amount or portion of time a given CMTS is busy receiving upstream messages, and so forth.

To balance the load between CMTSs, the traffic monitor 310 instructs a CMTS to begin receiving upstream cable modem data at a different frequency (i.e., from a different demodulator in the bank 130). The traffic monitor may also communicate with the available/specified frequencies function 320 to cause the cable modems to use
different upstream frequencies. This can be achieved directly, e.g., by assigning the modems to the desired frequency.

Note that a cable modem can send its upstream data to a different CMTS than the CMTS from which the modem receives its downstream data.

The available/specified frequencies function 320 may incorporate the functions of the CMTS frequency function 160 of FIG. 1, for example, to inform the CMTSs 120, ..., 122 and the cable modems of the available or assigned downstream frequencies.

Thus, the headend 300 optionally informs the cable modems to change the carrier frequency for upstream communications, such as DOCSIS data, to enable the cable plant to dynamically route the upstream traffic to the CMTSs that are relatively lightly-loaded, thereby improving system response.

Accordingly, it can be seen that the present invention provides a system for enabling cable modems to efficiently locate a downstream frequency for recovering data from a CMTS. The cable modems can be provided with a table of available CMTS frequencies to reduce the required number of carrier frequencies to search to locate a CMTS identifying signal, or the modems can be directly informed of a specific frequency or frequencies to avoid the need for searching.

Additionally, load balancing of multiple CMTSs at a headend can be achieved by monitoring the upstream traffic at each CMTS and dynamically changing the upstream frequency monitored by each CMTS accordingly to shift traffic to lightly loaded CMTSs.

Although the invention has been described in connection with various preferred embodiments, it should be appreciated that various modifications and adaptations may be made thereto without departing from the scope of the invention as set forth in the claims.
What is claimed is:

1. A method for use at a headend of a cable television network for provisioning at least one cable modem in the network with frequency information to allow communication with the headend, comprising the steps of:

   receiving channel map information at the headend that indicates unavailable carrier frequencies that are being used for communicating programming services, and at least one available carrier frequency that is not being used for communicating programming services;

   providing a signal from the headend to the at least one cable modem to inform the cable modem of the at least one available carrier frequency; and

   configuring at least one cable modem termination system at the headend to use the at least one available carrier frequency for providing data to the at least one cable modem.

2. The method of claim 1, wherein:

   the at least one cable modem termination system is configured to send an identifying signal on the at least one available carrier frequency for detection by the at least one cable modem.

3. The method of claim 1, wherein:

   the signal specifies that the at least one cable modem is to use the at least one available carrier frequency for receiving data from the at least one cable modem termination system.

4. The method of claim 1, wherein:

   the signal specifies that the at least one cable modem is to use the at least one available carrier frequency for providing data to the at least one cable modem termination system.
5. The method of claim 1, wherein:
the channel map information received at the headend indicates a plurality of
available carrier frequencies that are not being used for communicating programming
services; and
the signal informs the at least one cable modem of the plurality of available
carrier frequencies.

6. The method of claim 5, wherein:
the at least one cable modem is adapted to search said plurality of available
carrier frequencies provided thereto to locate a particular frequency that is used by the at
least one cable modem termination system for providing data to the at least one cable
modem.

7. The method of claim 6, wherein:
the at least one cable modem locates said particular frequency by detecting a
cable modem termination system-identifying signal carrier thereat.

8. A headend apparatus of a cable television network for provisioning at
least one cable modem in the network with frequency information to allow
communication with the headend, comprising:
means for receiving channel map information at the headend that indicates
unavailable carrier frequencies that are being used for communicating programming
services, and at least one available carrier frequency that is not being used for
communicating programming services;
means for providing a signal from the headend to the at least one cable modem
to inform the cable modem of the at least one available carrier frequency; and
means for configuring at least one cable modem termination system at the headend to use the at least one available carrier frequency for providing data to the at least one cable modem.

9. A method for enabling at least one cable modem to provision itself with frequency information in a cable television network to allow communication with a headend of the network, comprising the steps of:
   receiving a signal from the headend that identifies a plurality of available carrier frequencies that are not being used for communicating programming services; and
   searching said plurality of available carrier frequencies provided thereto to locate a particular frequency that is used by at least one cable modem termination system at the headend for providing data to the cable modem.

10. The method of claim 9, wherein:
    said available carrier frequencies are derived from channel map information that is received at the headend, said channel map information including both unavailable carrier frequencies that are being used for communicating programming services, and said available carrier frequencies.

11. The method of claim 9, wherein:
    the cable modem is adapted to use the particular frequency for providing data to the cable modem termination system.

12. The method of claim 9, wherein:
    the cable modem locates said particular frequency by detecting an identifying signal of the cable modem termination system thereat.
13. An cable modem apparatus that provisions itself with frequency information in a cable television network to allow communication with a headend of the network, comprising:

means for receiving a signal from the headend that identifies a plurality of available carrier frequencies that are not being used for communicating programming services; and

means for searching said plurality of available carrier frequencies provided thereto to locate a particular frequency that is used by at least one cable modem termination system at the headend for providing data to the cable modem.

14. A method for enabling at least one cable modem to provision itself with frequency information in a cable television network to allow communication with a headend of the network, comprising the step of:

receiving a signal from the headend that specifies at least one available carrier frequency for receiving data from at least one cable modem termination system at the headend; wherein:

the at least one available carrier frequency is not being used for communicating programming services.

15. The method of claim 14, wherein:

said at least one available carrier frequency is derived from channel map information that is received at the headend, said channel map information including both unavailable carrier frequencies that are being used for communicating programming services, and said at least one available carrier frequency.

16. A cable modem apparatus that provisions itself with frequency information in a cable television network to allow communication with a headend of the network, comprising:
means for receiving a signal from the headend that specifies at least one available carrier frequency for receiving data from at least one cable modem termination system at the headend; wherein:

the at least one available carrier frequency is not being used for communicating programming services.

17. A method for use at a headend of a cable television network that receives upstream data from a plurality of a cable modems in the network, comprising the steps of:

providing a plurality of cable modem termination systems at the headend for receiving the upstream data, wherein each cable modem termination system is assigned to at least one associated upstream carrier frequency for receiving a portion of the upstream data;

monitoring the amount of upstream data received by each cable modem termination system; and

in response to said monitoring step, balancing a load of the upstream data among the cable modem termination systems.

18. The method of claim 17, wherein:

said balancing step comprises the step of dynamically changing the at least one upstream carrier frequency that at least one of the cable modem termination systems is assigned to.

19. The method of claim 17, wherein:

said balancing step comprises the step of communicating data to at least one of the cable modems to cause it to use a different upstream carrier frequency.

20. A headend apparatus of a cable television network that receives upstream data from a plurality of a cable modems in the network, comprising:
a plurality of cable modem termination systems for receiving the upstream data, wherein each cable modem termination system is assigned to at least one associated upstream carrier frequency for receiving a portion of the upstream data; means for monitoring the amount of upstream data received by each cable modem termination system; and means, responsive to said monitoring means, for balancing a load of the upstream data among the cable modem termination systems.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/173

According to international Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>-page 13, line 10 figures 7-10</td>
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<td>US 5 734 589 A (KOSTRESKI BRUCE ET AL) 31 March 1998 (1998-03-31) column 21,</td>
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<td>WO 91 15064 A (SCIENTIFIC ATLANTA) 3 October 1991 (1991-10-03) page 32, line 5</td>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

* Special categories of cited documents:

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*OP* document referring to an oral disclosure, use, exhibition or other means

*P* document published prior to the international filing date but later than the priority date claimed

*"* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

*"* document member of the same patent family

Date of the actual completion of the international search: 9 January 2002

Date of mailing of the international search report: 16/01/2002

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Authorized officer: Van der Zaal, R
# INTERNATIONAL SEARCH REPORT

<table>
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