

WHAT IS CLAIMED IS:

1. A method of forming a virtual network, the method comprising:
passing frames of data at a frame rate across one or more fiber optic cables
5 that each has two or more physical fibers,
when the frame rate of the frames of data is greater than a maximum
frame rate of a first physical fiber in a fiber optic cable, the passing including:
passing a first number of the frames of data over the first
physical fiber at a first data rate that is equal to or less than a maximum data rate of
10 the first physical fiber; and
passing a second number of the frames of data over a second
physical fiber at a second data rate that is equal to or less than a maximum data rate
of the second physical fiber; and
when the frame rate of the frames of data is equal to or less than the
15 frame rate of the first physical fiber in the fiber optic cable, the passing including:
passing a pair of frames of data in sequence through the first
physical fiber such that the pair of frames include data from a plurality of sources.
2. The method of claim 1, further comprising generating the frames of
20 data to be passed across the fiber optic cable.
3. The method of claim 2, wherein generating the frames of data includes:
receiving frames of data from a source device at the frame rate greater than
the maximum frame rate to form received frames of data; and
25 splitting the received frames of data and the frame rate greater than the
maximum frame rate into a first number of received frames of data with a first data
rate that is equal to or less than the maximum data rate of a first physical fiber, and
a second number of received frames of data with a second data rate that is equal to
or less than the maximum data rate of a second physical fiber.

4. The method of claim 3, wherein generating the frames of data further includes:

determining a remote device from a received frame of data;
determining a virtual exit device from the remote device; and

5 first encapsulating the received frame of data to form a first encapsulated frame having a header that identifies the virtual exit device.

5. The method of claim 4, wherein generating the frames of data further includes:

10 determining the virtual exit device from the first encapsulated frame;
determining a first hop device from the virtual exit device; and
second encapsulating the first encapsulated frame to form a second encapsulated frame having a header that identifies the first hop device.

15 6. The method of claim 5, further comprising:
receiving the frames of data passed across the fiber optic cable;
unpacking the second encapsulated frame to extract the first encapsulated frame and the identity of the virtual exit device;
determining whether the first hop device is the virtual exit device;
20 when the first hop device is the virtual exit device, unpacking the first encapsulated frame to extract the received frame of data; and
when the first hop device is not the virtual exit device, determining a next hop device from the identity of the virtual exit device.

7. The method of claim 6, further comprising:

when the next hop device is a virtual forwarding device, encapsulating the first encapsulated frame to form a third encapsulated frame having a header that identifies the virtual forwarding hop device; and

5 when the next hop device is a network-to-network interface device, forwarding the first encapsulated frame to the network-to-network interface device.

8. The method of claim 2, wherein generating the frames of data includes:

receiving first frames of data from a first source at a first frame rate, and

10 second frames of data from a second source at a second frame rate; and

combining data from a first frame from the first source with data from a second frame from the second source to form a combined frame of data.

9. The method of claim 8, wherein generating the frames of data further

15 includes:

determining a remote device from the first frame from the first source;

determining a virtual exit device from the remote device; and

first encapsulating the combined frame of data to form a first encapsulated frame having a header that identifies the virtual exit device.

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10. The method of claim 9, wherein generating the frames of data further includes:

determining the virtual exit device from the first encapsulated frame;

determining a first hop device from the virtual exit device; and

25 second encapsulating the first encapsulated frame to form a second encapsulated frame having a header that identifies the first hop device.

11. The method of claim 10, further comprising:
receiving the frames of data passed across the fiber optic cable;
unpacking the second encapsulated frame to extract the first encapsulated
frame and the identity of the virtual exit device;
5 determining whether the first hop device is the virtual exit device;
when the first hop device is the virtual exit device, unpacking the first
encapsulated frame to extract the combined frame of data; and
when the first hop device is not the virtual exit device, determining a next hop
device from the identity of the virtual exit device.
- 10 12. The method of claim 11, further comprising:
when the next hop device is a virtual forwarding device, encapsulating the
first encapsulated frame to form a third encapsulated frame having a header that
identifies the virtual forwarding hop device; and
15 when the next hop device is a network-to-network interface device,
forwarding the first encapsulated frame to the network-to-network interface device.
13. The method of claim 2, wherein generating the frames of data includes:
receiving first frames of data from a first source at a first frame rate, and
20 second frames of data from a second source at a second frame rate;
determining a remote device from a first frame of data from the first source;
determining a virtual exit device from the remote device;
encapsulating a first frame of data from the first source to form a first
encapsulated frame having a header that identifies the virtual exit device; and
25 encapsulating a second frame of data from the second source to form a
second encapsulated frame having a header that identifies the virtual exit device.
14. The method of claim 13, wherein generating the frames of data further
includes:
30 determining the virtual exit device from the first encapsulated frame;

determining a first hop device from the virtual exit device;
encapsulating the first encapsulated frame to form a third encapsulated frame
having a header that identifies the first hop device; and
encapsulating the second encapsulated frame to form a fourth encapsulated
5 frame having a header that identifies the first hop device.

15. The method of claim 14, wherein generating the frames of data further
includes outputting a number of third encapsulated frames and a number of fourth
encapsulated frames such that a combined frame rate of the third encapsulated
10 frames and the fourth encapsulated frames are equal to or less than the maximum
frame rate of the first fiber.

16. The method of claim 15, further comprising:
receiving the frames of data passed across the fiber optic cable;
15 unpacking the third encapsulated frame to extract the first encapsulated
frame and the identity of the virtual exit device;
determining whether the first hop device is the virtual exit device;
when the first hop device is the virtual exit device, unpacking the first
encapsulated frame to extract the first frame of data from the first source;
20 when the first hop device is not the virtual exit device, determining a next hop
device from the identity of the virtual exit device;
when the next hop device is a virtual forwarding device, encapsulating the
first encapsulated frame to form a fifth encapsulated frame having a header that
identifies the virtual forwarding hop device; and
25 when the next hop device is a network-to-network interface device,
forwarding the first encapsulated frame to the network-to-network interface device.

17. The method of claim 2, further comprising:
generating a test frame having a header that identifies a virtual exit device
30 under test, and transmitting the test frame to the virtual exit device under test; and

receiving the test frame, unpacking the test frame, and determining one or more measures of status from the unpacked test frame.

18. A virtual forwarding device, comprising:
- 5 a receive physical port that receives a second encapsulated frame;
a transmit physical port to be coupled to a next hop device;
an alternate physical port to be coupled to an alternate hop device; and
a virtual port coupled to the receive physical port, the transmit physical port,
and the alternate physical port, the virtual port to:
- 10 receive the second encapsulated frame from the receive physical port
determine whether a current device is a last hop device;
when the current device is not the last hop device, unpack the second
encapsulated frame to extract a first encapsulated frame;
extract an identifier of a virtual exit device from the first encapsulated
15 frame;
determine a next hop device and an alternate hop device from the
identifier;
determine whether the transmit physical port can accept frames for
forwarding;
20 when the transmit physical port can accept frames for forwarding,
encapsulate the first encapsulated frame to form a third
encapsulated frame, the third encapsulated frame having a header than identifies the
next hop device; and
forward the third encapsulated frame to the transmit physical
25 port; and
when the transmit physical port cannot accept frames for forwarding,
determine whether the alternate physical port can accept frames for forwarding.

19. A method of operating a virtual forwarding device, the method comprising:
- receiving a second encapsulated frame;
 - unpacking the second encapsulated frame to extract a first encapsulated
 - 5 frame;
 - extracting an identifier of a virtual exit device from the first encapsulated frame;
 - determining a next hop device and an alternate hop device from the identifier;
 - determining whether a transmit physical port coupled to the next hop device
 - 10 can accept frames for forwarding;
 - when the transmit physical port coupled to the next hop device can accept frames for forwarding,
 - encapsulating the first encapsulated frame to form a third encapsulated frame, the third encapsulated frame having a header that identifies the next hop
 - 15 device;
 - forwarding the third encapsulated frame to the transmit physical port coupled to the next hop device; and
 - when the transmit physical port coupled to the next hop device cannot accept frames for forwarding, determining whether a transmit physical port coupled to the
 - 20 alternate hop device can accept frames for forwarding.

20. A non-transitory computer-readable storage medium having embedded therein program instructions, which when executed by a processor causes the processor to execute a method of operating a virtual forwarding device, the method comprising:
- 5 receiving a second encapsulated frame;
unpacking the second encapsulated frame to extract a first encapsulated frame;
extracting an identifier of a virtual exit device from the first encapsulated frame;
- 10 determining a next hop device and an alternate hop device from the identifier;
determining whether a transmit physical port coupled to the next hop device can accept frames for forwarding;
when the transmit physical port coupled to the next hop device can accept frames for forwarding,
- 15 encapsulating the first encapsulated frame to form a third encapsulated frame, the third encapsulated frame having a header that identifies the next hop device;
forwarding the third encapsulated frame to the transmit physical port coupled to the next hop device; and
- 20 when the transmit physical port coupled to the next hop device cannot accept frames for forwarding, determining whether a transmit physical port coupled to the alternate hop device can accept frames for forwarding.