INVENTION DISCLOSURE

1. **Invention Title.**

IP Transport Layer based Channel Bonding for High Speed Data Access Data Networks

2. **Invention Summary.**
A mechanism to provide channel bonding from different network access technology resources and potentially unrelated service providers using 2-way and 1-way data channels.

3. **Invention Description**.

a. Describe the invention in detail.
Dominant HSD technologies are HFC and fiber. Both provide large BW capabilities. In shared media access like HFC networks, high capacity links are constructed by linking different low capacity links like in DOCSIS3.0. In such models the access network MAC layer is in charge of aggregating and fragmenting data packets across the bonded links. Expansions and updates on capacity require both link ends to synchronize resources. This makes the systems closed and hard to extend beyond premises based services, for example, mobility of multiple technology access. Some use cases of those models are:

Redundant paths:
- DOCSIS + ATSC (bidirectional)
- DOCSIS + LTE
- DOCSIS + WiMax
- LET + WiMax

Mobility
- LTE, 3G + ATSC
- WiMax + ATSC
- LTE + Satellite DownLink
- 3G + ATSC down + Satellite UpLink

Capacity (asymmetric capacity)
- DOCSIS + DS QAMS
- DOCSIS + HFC 1G+ (above one Gighz band, upstream and or downstream).
- Unused channels in 2-way RANs (white spectrum) as DS (wireless QAM) + LTE, 3G

By providing a higher layer aggregation, access to physical media is kept on the domain of the access technology, separate to the application domain. The transport layer provides facilities to advertise applications about the connectivity capabilities.
Access shared channels such as DOCSIS, and wireless, have separate downlink and uplink physical channels, however, the MAC layer present to the IP layer bidirectional channels. This invention discusses the opportunity of linking 1-way channels to 2-way existing channels without interfacing the different MAC layers. From that perspective, the range of

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applications is less than the full spectrum of applications available in 2-way channels. However, for the most used applications this proposed approach could offer additional benefits over conventional models as discussed through the document.

Claims

1. A system that integrates unidirectional and bidirectional data channels into a single bandwidth resource available to applications. No data synchronization between network access is required at link layer, Control and admission is done end-to-end by the IP transport layer and the application

2. A Client connects to Access technologies directly (e.g., Wireless and wired). Wired Access network gateways may aggregate traffic from separate access networks
3. Network and IP connectivity is performed as conventionally for 2-way interfaces. Additional Helpers are deployed to allow clients to discover 1-way interfaces capabilities within the system by using Gateway aggregators and provide IP configuration (e.g., unidirectional channels, DS QAMs, HFC 1Ghz+ channels.
4. For 1-way channels use IPv6 as a mechanism for subnet partitioning channels (via helpers – see clause 3). 2-way channels can use IPv4, IPv6 or mixed
5. MTU (Maximum Transmit Unit) is calculated as normal per IP standards for 2-way channels, and allows MTU =0 for reverse path of 1-way channels (e.g., DS QAMS upstream)
6. Clients uses multi-home IP to send and receive traffic targeting the separate access technology.
7. SCTP is used as transport for applications (e.g., http-sctp:// HTTP over SCTP, video over SCTP).
8. Applications perform SCTP streams associations based on availability of 2-way or 1-way channels. For example, to allow datagrams ACKs from 1-way channels to go through primary
9. SCTP behavior in 2-way Channels is changed from primary/backup (based on hearbeats) transmission to simultaneous transmission on all streams. This is something TCP does well on web pages opening connections to separate pieces from different URLs) but all the session context is maintained separate. In this case data streams (e.g. video) is coming from same hosts using different strings. Additional host are not precluded and imply additional connections.
10. SCTP behavior for 1-way channels is changed to provide:
    a. A bulk stream path for one-way traffic flow.
    b. Primary stream uses two-way interfaces.
    c. Heartbeats being acknowledged using primary stream instead of the original steam.
    d. Data acknowledge (e.g., SACK) of data streams is sent using the primary stream
    e. Other control messages flow messages over. The primary stream.

Exhibits and Additional details

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Claim 1
SCTP main goals are support of load balancing and fault tolerance.

Figure 1 shows the comparison of TCP/IP with SCTP. SCTP provides multiple streams build based on source/destination address. In this multi-home environment, separate IPs maybe associated to separate network interfaces (access networks for our case), the application can do load balancing or switch over seamless without user or application intervention. In figure 1 this translate on transmitting simultaneous over coax, Ethernet and LTE. In the TCP/IP model while the client can have more than one IP, typically the application normally uses one IP stack at the time and might switch to the other in circumstances like loss of link.

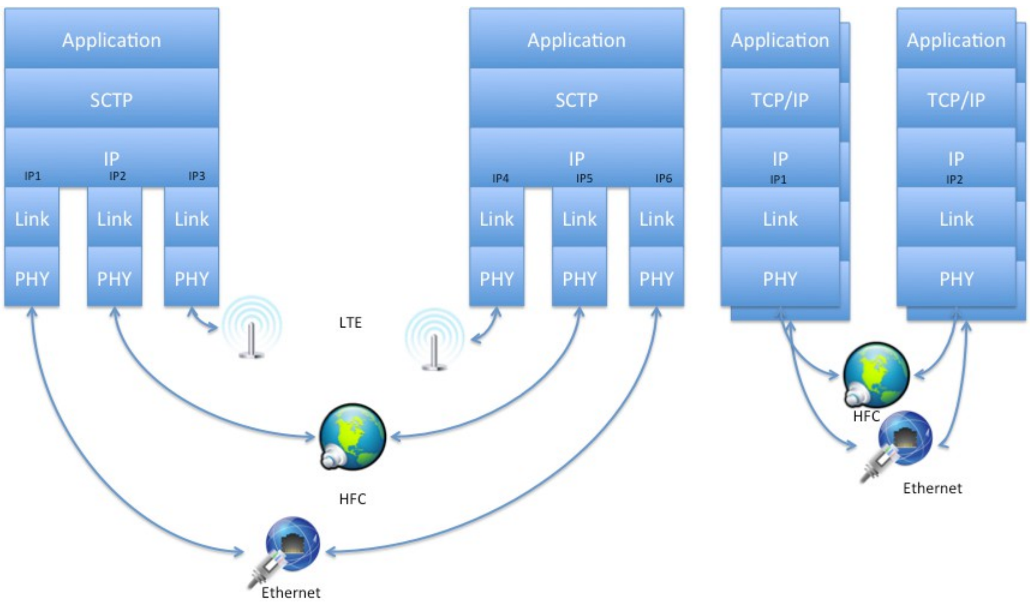

Figure 1

What SCTP does not support today is to seamless integrate unidirectional channels. An unidirectional channel is a physical and MAC media interface that has no coordination of the return path at the link layer. For example a NTSC broadcast channel is a one way channel. QAM Channels used for linear TV distribution are one-eay channel. Applications like VoD have performed some application centric bonding models but those are platform specific.

One example (expanded later) is enhancing DOCSIS with independent additional downstream capacity with EQAMs running a rudimentary DOCSIS downstream encapsulation (e.g., non-primary channel). Upstream BW is provided by 1+ Ghz channels Ethernet emulation connected to a separate fabric. Figure 2 shows the High level IP model and SCTP considerations. (QoS admission or BW reservation, priority is out of scope of this invention)

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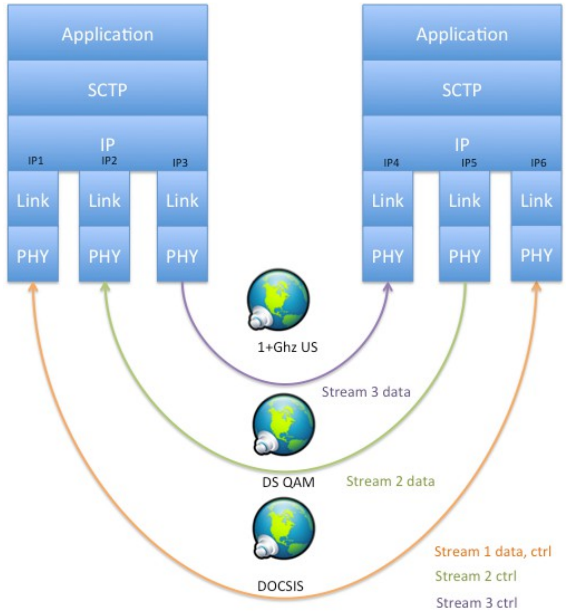

Figure 2

Another example is an ATSC digital channel that is not currently used as it may interfere in an adjacent 2-way ATSC network. This channel used as a Downlink 6 Mhz data channel, and will not interfere with the current used channels Figure 3 represents this scenario

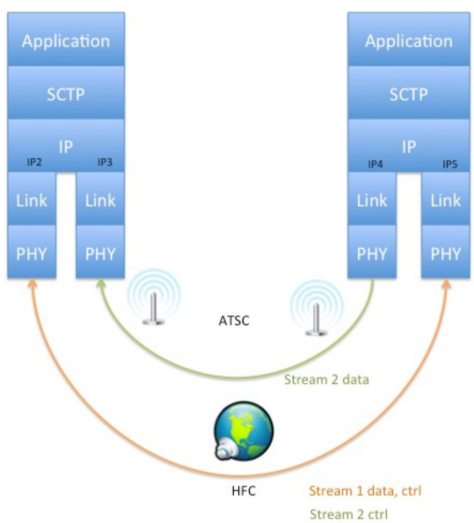

Figure 3

Claim 2
In figures 1,2,3 IP hosts are shown supporting separate interface media types (coax, wireless, Ethernet. There are cases where the end client does not support all those interfaces, but a gateway provides properly routing of client traffic to use those interfaces. Continuing with the case of Figure 2, the picture shown in Figure 4 explores this case. The

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PC host obtains separate addresses for each of the WAN interfaces where connectivity is provided. Note: While NAT translation is not discussed in this invention but could be possible. Therefore, it limits its interactions to IPv6 routable addresses as a practical implementation as NAT and local scoped address is not contemplated. Since this is a totally new approach that might take time and other political factors if considered, IPv4 will be of less interest on new developments.

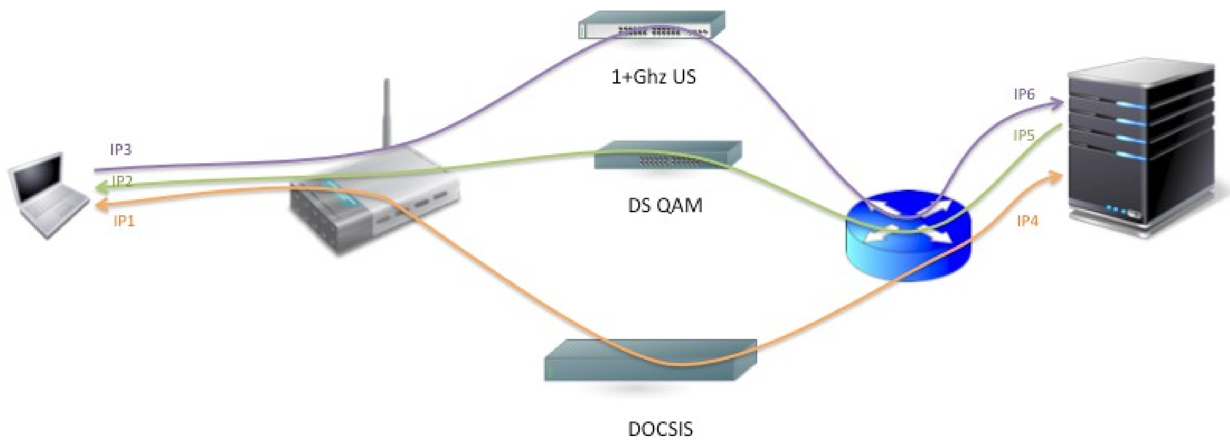

Figure 4

Claim 3
Network Topology discovery via helpers aids on the process configure each IP address in the host.
The configuration of clients WAN interfaces as shown in figures 1,2,3 is not discussed in this disclosure and though possible using existing protocols and technology. Configuration of clients IP addresses for WAN interfaces where the client is behind a gateway (as shown in figure 4) is in the scope of this disclosure
The gateway will expose 2-way interfaces to clients as per conventional standards (DHCP, SLAC). Gateways will properly enable and obtain IP Connectivity of WAN interfaces based on configuration parameters during the gateway bootstrap process.
The gateway exposes 1-way interfaces to clients by advertising information about those interfaces and extending traditional IP provisioning methods (e.g., DHCP options, RA extensions) to cover:

- Proper identification of one way channels for transport based bonding
- High level procedures to claim and maintain ownership of network numbers of interfaces, including variations to e.g., MTU and ping procedures interoperability.

The gateway itself obtain information of the 1-way interfaces and/or additional non-primary 2-way interface by direct configuration or by querying external systems that keep track of the WAN access network topology and configuration.

- Potential models include (but not limited to): DOCSIS/DSG MDD extensions, TLVs with URLs to service locators at provisioning or bootstrapping, DHCP options, embedded RA options. Rationale: 1-way interfaces can't perform neighbor and router solicitation (NS/RS), thus it won't receive RAs directly from the interfaces. As a matter

of fact this invention claim can be summarized as a high level neighbor discovery instead of in-channel neighbor discovery managed and controlled as a service in the network
- IP Address validation follows standard procedures for 2-way interfaces, and procedures of clause 4 in 1-way interfaces

Clause 4
IPv6 large space is used for one-way interface configuration. End clients behind the gateway learns using conventional neighbor discovery with extensions to indicate 1-way interfaces. This will indicate the client such interfaces are only usable by transport stack bonding such as the SCTP model proposed herein.
There is a high level Connectivity discovery (CD) process (analogous to router solicitation RS and router advertisement RA performed over links and covers neighbor discovery functions as well).
Connectivity Discovery is then a service that helps the gateway to identify valid and active interfaces, and register (e.g., prefix delegation) clients with those interfaces.
The Connectivity Discovery services is performed using 2-way interfaces with automatic registration and test of clients service to guarantee end-end connectivity and uniqueness.

Figure 5 shows the normal IPv6 Neighbor and Router Discovery protocols interactions. Those interactions occurs over the specific by-directional interface of interest.

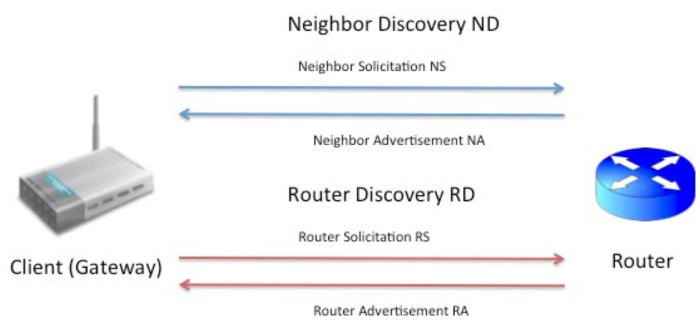

Figure 5

Figure 6 shows a high level the Connectivity Discovery protocol (CD). As shown in the figure, CD is performed over existing 2-way channels. 1-way channel hubs (e.g., DS QAMS, US 1+ GHz channels devices) exchange configuration and topology information with the DC Service (Analogous to Edge QAM Resource Managers ERMs) and perform CD testing of connectivity and address validations such as but not limited to:
- Authentication of clients requesting 1-way resources and proper registration of clients on hubs
- Gateway gets assigned link-local addresses and prefixes. Time expiring test messages are instructed to be send/received by the gateway and hubs and reported to the CD service for validation.

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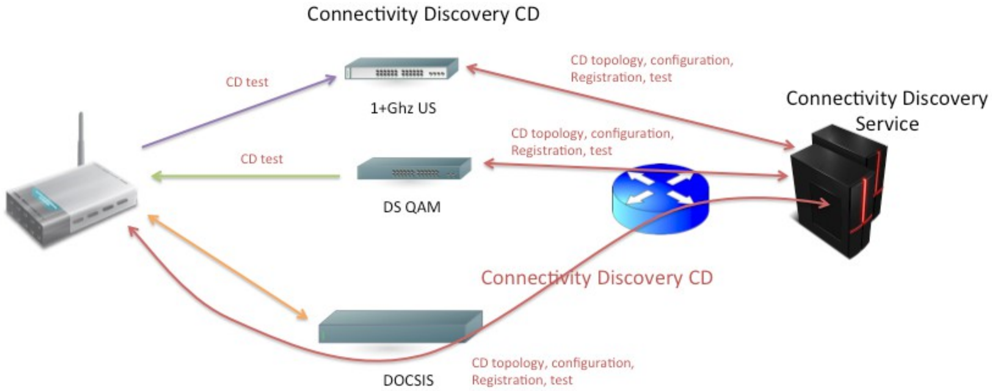

Figure 6

Claim 5
MTU discovery for 1-way channels is part of the CD protocol

Claim 6,7, 8,9,10

Figure 7 shows the main characteristics of the L4 bonding model. Multihomed devices send and receive data in using multiple IPs with the application far end (claims 6,7). The far end can be single IP or multihomed as well. Both ends support SCTP with the variations listed on claims. All available SCTP streams are active on both ends all the time, data flows between interfaces as needed in a application specific manner. SCTP 1-way channels reverse packets are multiplexed in 2 way channels. This is the major change in the protocol and the core of the bonding model (claims 8,9,10).

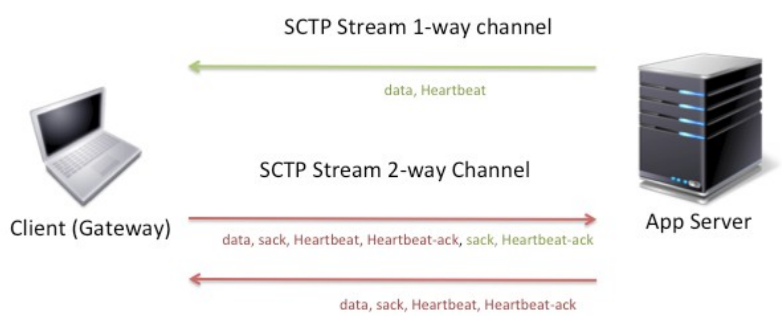

Figure 7

b. Why was the invention developed? What problem(s) does the invention solve? How is it better?

I think moving to a CDN (Content Delivery Network) makes relevant the use of high level control mechanisms plus network topology with network delivery aware of

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user/application behavior to harvest the bandwidth as needed and as available. Today IP connectivity and applications running are orthogonal, with very little awareness of each other. This invention provides one of the pieces to bring seamless bandwidth and applications to work collaboratively. In addition this invention simplifies MAC layer models for quick exploitation of different physical layer bandwidth availability by decoupling up and down links.

c. **Briefly outline the potential commercial value and customers of the invention.**
This is a model very close related to VoD model. However it brings the IP layer and higher layers interconnect that could bring bandwith harvesting to a different level before 2 way complex mac layers can be developed. It is presumed to work very well in high asymmetric services with bandwidth reservations and control. This model targets medium term solution to bandwidth needs over private HSD networks. This solution also compete and complement TCP/IP services and while maybe seen some drawbacks from the perspective of net-neutrality, it does not legally precluded as a viable solution to provide low cost for private content delivery. By providing high level control of the BW admission (another disclosure topic), it could also play well on managed bandwidth access via clearinghouse, wholesale and spot bandwidth consumption models right as extensions to the SCTP connection and streams setup. Highly profitable model can be develop at large scale deployments.

4. **HOW is this invention different from existing products, processes, systems?**
I am not aware of models for L4 bonding. Most bonding model stay at most at the IP layer and below (e.g., DOCSIS 3.0) as they are focused in TCP/IP support. This invention is related to using SCTP as a competitor and complimentary option to current TCP/IP based applications