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Study paper on

Interoperable Content Delivery Network –

A Win –Win situation for all!

Background :

Internet has carved out the cyber roads connecting each home and office across the world. The roads were primarily meant for text and low resolution multimedia object to travel. Today videos requiring higher bandwidths, are threatening to block the roads altogether, disrupting even the existing traffic. Incremental changes in terms of widening the road will not help as the web-servers themselves become the choking points. There is today a critical need for augmenting the internet with a purpose built "Content Delivery Network" - one which will not get suffocated even with users accessing services simultaneously and down loading video content in different formats and resolutions.

A new layer will emerge over the existing internet: that of "HDTV Internet". It will bring about best of both worlds: the clarity of HDTV with the universal accessibility of contents over Internet. The HDTV Internet will become ubiquitous – connecting finally each home in the world. The Age of "Universal Contents" would have arrived. The new era users will be able to select Any Program on Any Time and Any Where basis.

Vision of an interoperable CDN (iCDN) :

The Content Delivery Network (CDN) has to have the basic qualities of internet itself but has to go much beyond it. It has to be decentralized, like the internet and indefinitely scalable. However, unlike the Internet, it has to provide a limitless capacity for delivering HDTV quality contents in the last-mile. Unlike the internet, it has to also provide an uncompromising security for the contents. It has to have a built-in accounting mechanism for usage of each content by users, permitting billing and revenue distribution to the content providers. It should facilitate videos to be sent to the end devices (Set Top Boxes), using mobile like IDs which don't change even after the change of Content Service Provider (iCSP).

Internet came about using individual web-servers with interconnecting networks. Web contents are localized and accessed through a URL (Universal Resource Locator). In contrast, the CDN contents will be cached in Head-End servers connecting users through their last-mile networks. Each "Universal Content" will be a distributed content, allowing immediate access through a last-mile, high bandwidth network. A "Universal Content Locator" (UCL), will be used to refer to each of these Universal Contents.

Internet allows interoperability, despite diversity of the underlying networks which are used for connecting the web-servers and end-users. Diversity will be even more evident in CDNs with different last-mile networks being used, based on geographical and economical considerations. The interactive CDNs can be over networks such as Ethernet, ADSL, PON, Cable Modem, WiFi or WiMax. The Broadcast CDNs can be over mediums such as Cable, Satellite or Terrestrial with a weak return path including the one over the global internet.

Interoperable CDN (iCDN), will be the key towards allowing interoperable STBs (iSTBs) to access Universal contents through any Head-end or multiple head-ends simultaneously. The interoperability will ensure that the Servers in an iCDN can fetch the contents from each other in a Peer-to-Peer (P2P) basis. Many last-mile networks such as Ethernet, WiFi, and the like can allow iSTBs to fetch Universal contents from each other on a P2P basis. P2P networks have the remarkable scalability which enables better content delivery with increasing number of iSTBs.

The iCDN is possible due to secure Universal Contents which can float world-wide between Head-end servers and iSTBs in their encrypted state (AES 128 bits). The encrypted contents can only be viewed by the certified iSTBs when they are provided by the iCDN with a Content key for decrypting the content. The Content key, however, will itself be sent in a secure way encrypted by the public-key (RSA 2048 bits) belonging to the iSTB. This ensures that only the specific iSTB will be able to decode and display the contents. The certified iSTBs will ensure that neither the encrypted contents nor their keys can ever be compromised.

Each iSTB will also maintain an encrypted usage log, which records each usage of the Universal contents. This then will be made use of by the iCDN to generate the billing information. The iCDN will guarantee accounting of each universal content such that the content owner and other ecology partners can earn their share of money through each usage of the content.

Unlike the internet, the iCDN, right from the beginning, will be a thriving regulated market place with users being able to access the best of the Universal Contents and paying for it on a Library or Rental basis .This will obviate the need for buying. The Universal Contents will spread everywhere not only through the iCDN, but also through the manual distribution using USB Memory sticks, CDs, DVDs etc.

iCDN Ecology players

Like the Internet, the iCDN ecology has to be self-sustaining and positively scalable. Exponential growth would come with joining of each new ecology partner. This is possible with each ecology partner playing a dedicated role and complementing each other to cater to the needs of the iSTB users world-wide.

As in the case of the global Internet, there would be a need for a national level control too. This would be of even more importance for the iCDN since the Regulator of each country would like the Universal content to be subject to their censorship and copyright policies and their charging norms.

Content and Channel Aggregators play a key global role in the ecology. They are responsible for providing encrypted contents/channels to the interoperable Head-end Servers (iHES). An iSTB will be generally connected to one or more iHead-end Servers with high bandwidth connection to it.

Each iSTB will be registered with a Content Service Provider (iCSP) which will be responsible for giving it a unique iSTB-ID (much like the mobile ID) and billing it on a prepaid basis. The iSTB would send an encrypted Log of usage to its iCSP a number of times a day. The iCSP would use “Fees” file (as defined by the ecology players in that country) for generating the bill for each individual iSTB.

Each iCSP shall also own the responsibility of passing the request for content keys from iSTBs to the concerned Content Aggregators (iCA) or Channel Aggregators (iCHA). The iCA or iCHA will encrypt a content key with the Public Key of the iSTB before passing it back through the iCSP. As the iCHA will be changing the keys associated with its channel as many times as required in a single day, each iSTB will have to fetch the same every time the key is changed. For additional security each Content/Channel Aggregator will fetch the public key of the iSTB directly from the Revenue Distributor who is the Certifying authority for the iSTB.

The prepaid nature of the billing ensures, that an iCSP would already have recovered the money for which an iSTB would be liable. If an iSTB registers with another iCSP , he will have to pay again the Library fees, a deterrent towards arbitrary switching.

The iCDN ecology is of self-stabilizing and self-scaling nature without requiring central planning. This is achieved in a natural manner through the earning motive of each eco-partner. iCDN ensures that each eco-partner can do better, if he takes care of the needs of the iSTBs in a better way. It is thus in the self-interest of each iHE Operator to ensure that it gives a good bandwidth, as the revenue returns from each iSTB will be proportionate to the bytes delivered by different iHE servers.

Revenue Distributor: Regulating the Ecology

Revenue Distributor (iRD) is the key ecology partner in a country for smooth functioning of the iCDN eco-system. An 'iRD' is primarily a bank, appointed by the Regulator of the country to ensure proper and timely sharing of revenues amongst the eco-partners. The Government of the country would also be an eco-partner for the purpose of getting the applicable taxes automatically transferred to its accounts.

Each iCSP is responsible for billing collection, but not its distribution with the ecology player; this responsibility is vested with the Revenue Distributor (iRD). Each iCSP in that country will have to open an Escrow account with the bank, whereby the amount collected through billing each month would be made available for distribution to other eco-partners.

The iRD maintains a "Share" file which indicates the sharing percentages for different services between the concerned eco-partners. This Share file is revised through consensus of eco-partners based on the advice of the Regulator in the country. Similarly, iRD is also responsible for maintaining a "Fees" file, which details out the applicable fees for Library Services, Pay Channels, Voting, Ad Rates, TRP Rates etc. The Fees file is used by the iCSPs in the country for generating the iSTB billings.

Like the iCSP, the Content Aggregators too open an Escrow account with the Revenue Distributor if they wish to release Pull Ads or Spot Ads in the iCDN. The bills for the Ad usage are generated by the iCSP for payment by the concerned CAs.

The iRD is also responsible for "Certifying" the iSTBs at the time of manufacture. It maintains a list of Certified iSTBs, with their MAC-ID and their Public Keys for use by the eco-partners.

The iRD can make available all the details of Revenue transfer on its portals for use by the eco-partners. Thus a complete transparency is maintained for a hassle free, automatic revenue sharing every month. This can give the peace-of-mind to each eco-partner to concentrate on his prime responsibility – benefiting the overall ecology.

Uncompromising Security for the iSTB

The security requirements of an iSTB are guaranteed not by the manufacturer or the middle-ware provider, but the "iSTB Chip Manufacturer". The iSTB Chip Manufacturer has to provide a "Content Protection Module" (iCPM) which will work along with the hardware to ensure that on-the-fly decryption of contents can happen with the content-keys. The content keys are decrypted using the internal private key of the iSTB. It is the responsibility of the iCPM never to let out the contents or the keys in any manner.

The iSTB security can thus be considered very significant as if it were a part of the basic hardware which cannot be compromised by any manufacturer, middle-ware provider or even a hacker. Indeed many of the new generation iSTB chips have a capability of providing all the iCPM functionality within the chip, using an embedded secure processor.

The iCPM also has the responsibility of encrypting a Log file containing the usage records and sending it with MAC to the iCSP twice a day. The encryption has to be done using the Public key of the iCSP so that the same can't be received through any other means. The iCSP will send an encrypted acknowledgement after receiving the Log, so that the iCPM can be sure that there has been no compromise due to any intervening party.

The iSTB Chip Manufacturer also has to open a Limited Liability Escrow account with an iRD which will take care of any eventuality occurring from any problem with its iCPM. The iRD in turn will give the iSTB chip manufacturer an iRD's Public key for embedding within the iCPM module

At the time of manufacturing, the iCPM module will generate a set of public/private keys for the iSTB. The iSTB's Public key along with the allotted MAC-ID will be transferred securely to the iRD by encrypting the same using the embedded Public Key of the iRD, and sending it to the web address of the iRD (also embedded in the iCPM). The iSTB Public key will not change afterwards, and will be used subsequently for sending encrypted keys etc. to the iSTB such that no other entity can decode it.

The entire iCDN ecology is based on the principle of each eco-partner playing its role, without having to trust the other party. As the iSTB security will be total, the only source of leakage of the content keys can presumably be attributed to the Content Aggregator who can take care of these issues. It is not possible for any iSTB to evade payments by not submitting usage logs to an iCSP through the internet. The iCPM will allow only 24 hours of playing of encrypted contents without uploading of the Log file.

It is possible for proprietary DRMs to co-exist along with the iCPM, so long as it doesn't lead to any compromise in security or billing aspects. The proprietary DRMs will be responsible for the security and accountability of content encrypted using their methodology. These aspects may be considered, for all practical purposes, as outside the iCDN eco-system.

Advantage to Content Aggregators

A Content Aggregator can now really focus on building a robust collection of contents which would be of interest to a wide section of the audience for times to come. It's a case of one time investment and all time return – as each content will generate some revenue with each usage.

A Content Aggregator would primarily concentrate on contents for specific language and genres. He would increase the reach of the content by having it subtitled in various languages and by creating synopsis, trailers, preview books etc. He can promote his contents by putting hyperlinks for the same along with other related contents. He will also make versions of each video content available in HD, SD and LD resolution so that it can cater to a wide variety of display devices.

Content Aggregator will normally encrypt all his contents using AES-128 bit code which is an industry proven standard and keep the "content-key" in a secure storage. He would make the encrypted content freely available for distribution to Head-end Servers and iSTBs. The content key will be provided via the iCSP to the requesting iSTB after it has been encrypted by the public key of the iSTB. The public key of the iSTB, can be found from the iRD which had certified it. The Content Aggregator can have mirror servers to ensure that there is no bottleneck in delivery of the keys via the iCSPs in that region.

A Content Aggregator will normally introduce premium content, such as a new movie, as a "Pay content". The Pay content will have an associated rental price for rental duration. This price can be different for different countries. The Content Aggregator can daily review the usage statistics as provided by the iCSPs, and decide on reducing the rental price with time to maximize the revenue. When the user interest for the premium content wanes the same can then be made available as Library content.

Each Library content will earn from the iSTB Library Fee in proportion to the time spent on viewing it vis-à-vis other Library contents. The Video contents will earn by sharing the Video Library Fee while the Audio contents will earn by sharing the Audio Library Fee.

The Content Aggregator can release "Pull Ads" to the Head-End servers. The Pull Ads, would be long Ads, as required for say, demonstrating a product. The Pull Ads would be retrieved by an iSTB user either through a search or by clicking on its hyper-link while viewing another content. Pull Ads will be charged based on the file size of the Ad and number of iSTBs which saw it in the month. As the charging is not based on the duration of viewing, the Advertiser doesn't have to worry about a run-away budget. The Content Aggregator has to open an Escrow Account with the iRD, guaranteeing availability of this money for distribution to other eco-partners. He can then be flexible in his schemes for charging the advertisers. For instance, he can confine the usage of an ad to a given budget by monitoring its daily usage and stopping it in time.

The Content Aggregator can also release "Spot Ads" to the Head-End servers. These are overlaid normally during the Advertisement interval marked in a TV channel. These Ads are made in 15 second increments, such that an integral number of them can fit in an Ad interval. The Advertisor has to now pay on the basis of the cumulative time the Spot Ad was shown on an iSTB. As in the case of Pull Ads, the Content Aggregator would be accountable for the revenue to the iRD while he can charge the advertiser the same in a flexible manner. He can, in addition, restrict the Spot Ad to Head-end Servers in a particular region to maximize the reach to an intended audience.

Although the Spot Ads are “Push Ads”, they are pushed only based on the categories preselected by an iSTB user. The Content Aggregator is thus responsible for putting the appropriate Category Tags along with the Push Ads in order that the Ad can reach its intended audience. The Head-end Servers would push the Ads on a random basis and will ensure that additional visibility cannot be got just by classifying an Ad in additional categories. Increasing the probability for display can happen only through releasing more Ads for the same product.

Advantage to a Channel Aggregator

A Channel Aggregator can now reach out to a world-wide audience through the Head-end Servers; no longer would he be geographically limited. The iCDN ecology will provide him with many more revenue streams.

The Channel Aggregator would encrypt his channels and provide the keys in the same manner as the Content Aggregator. He will, for extra security, use a key-pair and change one of the keys every 12 hours or so. The iSTBs will pre-fetch the key-pair every time it is changed to avoid delays during a channel change. The Channel Aggregator will also keep an archive of all the changed keys from the beginning of his operation. This is necessary as an iSTB will record the channel only in its encrypted form and will need the key for it when it has to play it back.

As in the case of the Content Aggregator, a Channel Aggregator can also provide HD, SD, and LD versions of the channels. The LD version would be useful on mobile devices (DVB-H) or on a low-bandwidth connection.

A Channel Aggregator maintains an Electronic Program Guide (iEPG, in XML file format) for each of the channels in the Head-end servers. An iEPG would give information about the coming programs for at least one week. Each iEPG will give along with each program, synopsis, multimedia previews and links for getting additional information.

A Channel Aggregator can designate a channel as a Pay Channel, in which case he can specify the rates separately for each country. Even the non Pay Channels will now be able to earn, by sharing the Library Channel Fees, in proportion to their usage.

A Channel Aggregator can also designate any program as a “Pay Program”, and can specify rates for viewing it during the specified number of days. This Pay Program can be in a Pay channel or even in a Library Channel. The iEPGs will indicate the Pay programs, and the iSTB will inform a user about the charges when the user wishes to record or view it. A user won’t have to worry about getting inadvertently charged for the embedded Pay program in a free running channel as the Pay program will get blanked without a prior consent. A Pay program key will be different from the key-pair used for normal decoding of the channel and will have to be fetched separately.

A Channel can earn additional revenue, through the Time Shift TV (TSTV) recordings at a Head-end server. The iEPG will allow a user to go back in time for at least a week and see any of the earlier programs. Each channel (even the Pay Channels) will earn from the TSTV Library fees in proportion to the time spent on viewing their recordings. Even the channel programs, played back through PVR or NPVR features of the iSTB, will participate in the TSTV Library Fees.

The iSTB as such will ensure that each recorded channel program will be accounted for and will generate revenue from the TSTV Library fee. This will happen even if the program is transferred from another iSTB, via a USB memory stick.

Additional earnings can accrue to a Channel Aggregator by his marking Ad intervals, and making them available for replacement by Spot Ads shown by an iSTB. Each channel will share the Spot Ad revenue from an iSTB, in proportion to the Ad intervals used. A channel can indicate that it doesn't want the live Ads to be replaced so that it can earn from the fused Ads too.

A Channel program can now also earn through Voting by its audience. The Voting can be solicited during a live event as well as a recorded event whose results would be announced in a later episode. The program will be able to earn a portion of the Voting fee given by each of the voters.

A Channel can also conduct an Instant TRP for finding out how many iSTBs are watching it at that moment. Based on this, it can charge different spot rates for the live ads.

A Channel Aggregator can, of course, edit and release some of the popular programs as separate Video contents in the manner of a Content Aggregator. This way the best programs in a Channel can continue earning through the Video Library Fee.

Advantage to the Content Service Provider

Content Service Provide is the most visible member of the iCDN ecology. Like a Mobile Service Provider, he registers a new iSTB, and hand-holds with it subsequently for authenticating it, accounting its usage and billing it on a prepaid basis. It allows an iSTB to tap the iCDN services throughout the world, on a roaming basis, from the Head-end servers. It also fetches the keys needed for decrypting the encrypted contents and channels, from the respective Content and Channel providers.

A Content Service Provider uses a "Fees" file provided by the Revenue Distributor of the country for calculating the monthly billing of an iSTB based on the usage. For international Roaming, it will use the Fees file, as provided by the Revenue Distributor of that region. It is required to deposit the billing amount every month with the Revenue Distributor so that the same can then be distributed to other eco-partners.

An iCSP can register an iSTB through its internet portal. It will provide it a unique STB-ID. If an iSTB is to be re-registered with a new iCSP , the latter can preserve its original STB-ID thereby ensuring number portability. Since the prepaid model requires a user to make an advance payment, it will act as a deterrent for arbitrary switching of a user to another iSTB. At the time of registration, the iCSP provides a unique public key to the iSTB which the iSTB uses for sending all the encrypted usage logs to it. This ensures that no other party will be able to fake the usage of an iSTB.

If an iSTB has an internet browser, the iCSP will ensure that it point to its portal after the Registration. The iCSP portal will allow a user to check his usage and make prompt payments through the Payment Gateway in the portal. The user can also go through the indexes for the popular contents and channels. He can also access the websites of the Content and Channel Aggregators through the links provided on the iCSP's portal.

An iSTB is supposed to send usage logs to its iCSP every 12 hours. Each usage log contains an encrypted cyclic number, which is used by the iCSP to detect any attempts at manipulating the log. iCSP sends an encrypted acknowledgement after receiving a valid log from an iSTB. An iSTB can at most play contents for 24 hours, without receiving this acknowledge. This way an iCSP ensures that no iSTB can be used without it being billed. Even in case of a power-failure, iSTB would ensure that usage record of content is not in error for more than 5 minutes. The iCSP can debar a defaulting iSTB such that it will be denied service by any Head-end.

An iCSP is also able to provide usage statistics to other eco-partners on a daily basis. This it calculates based on the logs sent by iSTBs every 12 hours. Thus a good enough prediction of previous days usage can be made by the next day afternoon.

An iCSP is also responsible for collating the encrypted votes received from the iSTBs and forwarding the results to the appropriate Channel Aggregator. It does the same for the instant TRP results forwarded by the iSTBs.

The log file sent by an iSTB contains just the usage statistics and doesn't have any pricing information. This allows the iCSP to use the prevailing policy at any time to calculate the billing without any change required in the reporting format of the iSTBs.

An iCSP uses the "iFee" file maintained by the Revenue Distributor for referring to the applicable monthly fees while calculating the usage billing for iSTBs. The Fee file specifies the Library Fees for TV Channels, Radio Channels, Video Contents, Audio Contents and TSTV channels. It also specifies the monthly rates for the Pay Channels. The Fee file also specifies the fees for each Vote, TRP fee, Spot Ad Fee (per 15 second Spot), and Pull Ad Fee (per Megabyte).

An iCSP is informed by the Content Aggregators regarding the price and the time durations for their Pay contents. Similarly, Channel Aggregator informs it about a Pay

program. The iCSP preserves this information in its database, so that it refers to the correct pricing when it is calculating the bills for each iSTB.

The iCSP not only bills the user, it also calculates the amounts to be collected from other eco-partners. For instance, the instant TRP fee is charged to the Channel Aggregator. The Ad Fees are charged to the respective Content Aggregator.

The iCDN ecology allows differentiation in monthly fees to be made depending on the geographical location in which the iSTB is being used. There can be thus different Fee files for Metros, towns, and rural areas. An iCSP can find out from the IP address of an iSTB as to which geographical region it is being used and apply the corresponding fee structure for it. The same is done for allowing international roaming in which case the Fee file has to be of the corresponding country.

An iCSP uses the geographical location information of an iSTB to advice it on the presence of nearby iHead-end Servers which can provide service with good bandwidth. Simultaneous use of multiple Head-ends is not a problem as the iCSP will generate revenue sharing data for the Head-ends based on the relative downloading of bytes for them. The iCSP ensures that Broadcast Head-ends share the revenue coming from downloading of broadcast contents, such as channels. The Demand Head-ends will share the revenue from download of unicast contents.

Although one iCSP can take care of the whole country practically, more are needed to ensure service quality through competition and a wide choice to users. With the wide spread service an iCSP has to deploy more mirror servers in different regions to maintain responsiveness to the iSTBs.

Advantage to the Head-Ends

The Head-ends and last-mile costs for an IPTV network were prohibitive in the past, compared to the ARPU which could be realized. Special purpose video streaming servers were needed, whose cost depended on the number of users which were simultaneously served. Most operators could only cater to only a small fraction of the user base at any given time. The Quality of Experience suffered due to the limitations may eventually lead to overall disappointment from the users' perspective.

The iCDN architecture eliminates all these limitations by reducing the cost of an Head-end by an order of magnitude. This is possible by deploying plenty of vanilla PC servers with gigabyte Ethernet links for serving contents and channels to the iSTBs. Each PC server can have a bank of low-cost, terabyte SATA drives. A Head-end can start with a modest size and can increase the servers and storage according to increasing demands of users. The Head-end can also push caching servers nearer to users to improve the performance.

By using a Peer-to-Peer transfer protocol in a LAN, a Head-end can dramatically reduce the congestion. Now an iSTB can find out, on a broadcast basis, as to which other iSTBs have the content. It can then fetch portions of the required content from multiple iSTBs having that content. Peer-to-Peer transfers, allow positive scaling with increasing number of users as the content availability in nearby iSTBs also increases.

The protocol-HTTP is used for sending files to iSTBs, or fetching it from other servers similar to the method adopted in web -based services over the global internet. . This is part of standard software available on a Linux server. Apart from this there are a few command/status oriented protocols between an iHead-end Server and an iSTB, or between iHead-end Server and other servers of eco-partners. Using these protocols, a Content Aggregator can inform about availability of new contents or ask for deletion of some previously sent content.

A Head-end doesn't have to bother about key management and can pass the received files from a Content Aggregator transparently to the requesting iSTB. Similarly, it passes the streaming channels received from a Channel Aggregator directly to the iSTB as multicast channels. A channel recording is, ofcourse, passed as files to the requesting iSTBs.

A Head-end Server provides a Time Shift TV (TSTV) facility, by recording a TV channel in half an hour segments and preserving them for at least a week. These half an hour files are then provided to the requesting iSTB for allowing viewing of the Time Shifted programs. The Head-end Server can make a Network PVR recording directly (against request from an iSTB) or have the same retrieved form another Head-end which has that channel recorded on a TSTV basis.

A Head-end server is essentially serving as a cache for the vast repertoire of contents with the Content Aggregators. The cache will contain the content most required by the iSTBs in its region. As new contents are brought in the least recently used can be evicted.

If a content requested by an iSTB is not present in an iHead-end, it can redirect the request to the concerned Content Aggregator. The Content Aggregator can in turn redirect the request to the nearest Head-end server having that content. A Head-end server can keep a count for the requests coming for an absent content and fetch it itself, if the count crosses a certain threshold.

A Head-end Server can have a special multicast: "Pilot Channel" which is used for transmitting common data to all the iSTBs. The iSTBs will normally be always tuned to the pilot channel. This can be used, for sending a common message to all the iSTBs or for informing the active status of all the other multicast channels. The Pilot channel can also be used for sending common contents/files to all the iSTBs.

Demand and Broadcast Head-ends

Head-ends can be giving contents on "Demand" or can push them to iSTBs through "Broadcast". A Demand Head-end is connected to iSTBs through two-way broadband

network and sends the channels as one-way multicast. A Broadcast Head-end is connected to iSTBs through a broadcast medium, with a weak return path, possibly over internet. A Demand Head-end can serve the iSTBs over networks such as ADSL, PON, Ethernet, WiFi and WiMax. A Broadcast Head-end can serve the iSTBs over broadcast mediums such as Cable, Satellite and Terrestrial.

Broadcast Head-ends would be generally optimized for delivering channels in a parallel to all the iSTBs tuned to them. The broadcast channels can have occasional errors and are not suitable for delivering files with data integrity. This can, however, be achieved by a few repeated broadcast of a data file with the iSTB doing error correction by comparing the repeated transmissions.

An error corrected content delivered through a broadcast channel, will be indistinguishable from a content received through a Demand Head-end. Thus, a Broadcast Head-end can also be used to deliver contents requested by iSTBs as "Video-on-Request" contents. The broadcast Head-end will generally queue up these contents and prioritize them based on the number of iSTBs who have requested for the same.

It is possible for an iSTB to simultaneously download contents/channels from multiple head-ends. It records the number of "Broadcast bytes" and "Demand bytes" downloaded through each head-end for determining how the revenue earned through the Broadcast and Demand contents can be shared. The revenue from the Broadcast contents is shared between Head-ends in the proportion to the Broadcast bytes. The same is the case with Demand content. Note that both the Broadcast and Demand Head-ends are able to deliver Broadcast bytes as well as Demand bytes.

Revenue generated by Broadcast contents would come from the fees for Channel Library, Pay Channels, Pay Programs and iVoting. Revenue generated by Demand contents would come from the fees for Audio/Video Libraries, TSTV Library, Pay Contents and Ad revenues.

A Head-end can thus concentrate on increasing its share of revenues by giving a better bandwidth and downloading experience to the end-users. A Channel provider will now have an incentive to provide a channel at higher data rate (as needed for HD TV) so as to increase his/her revenue share.

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