

Efficient Upstream Management in Cable-Data System : Weaving OSS, NMS, and Authentication System

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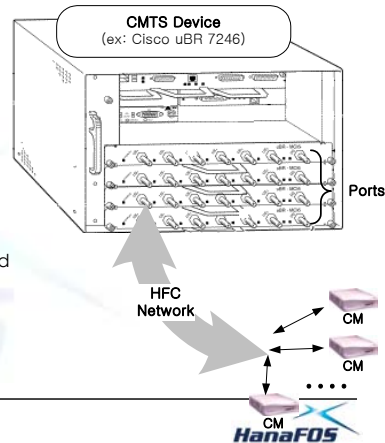
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[Abstract]

Unlike xDSL, HFC's cable-data system lets users share the bandwidth, leading to the necessity of the bandwidth management. Especially upstream from users requires special care, because home-users, often for the reason of marketing, are allowed to use upstream as much as they need within upstream capacity whose port they belong, unless it monopolizes and makes the others suffer. However, monitoring all the user's traffic at all time is next to impossible due to the burden on cable-data devices, and monitoring system itself. The author has researched on flexible and efficient upstream management mechanism, and already introduced an excessive upstream user detection mechanism[1]. This time, by weaving OSS, NMS, and Authentication System functionalities, a newer version of upstream management mechanism is suggested. It solves aforementioned problem in a graceful manner from whole OSS perspective. The mechanism has been implemented, run and proven flexible, efficient in a real cable-data system environment.

Introduction

- Broadband Internet Service using HFC network is widely available
- According to the product a subscriber buys,
 - S/he can reach up to a certain maximum download speed
 - service providers price the product mainly by allowable maximum download speed limit. (ex: 1 Mbps per a subscriber)
- However, upstream speed (for home users) usually has no limit
 - Users that consume excessively upstream will make the others suffer who share the same bandwidth.
 - Thus, excessive upstream users causes bandwidth contention problem.
- CDUMS(Cable Data system's Upstream Mgmt. System) answers all by weaving OSS, NMS, and Authentication System
- Benefits of CDUMS
 - Improves Upstream Port Utilization
 - Lay a ground work for the various service policy
 - Slashes Operation cost by automating manual operations



※ Core part of its configuration are CMTS & CM

- CMTS(Cable Modem Termination System): can monitor both upload and download speed per CM
- CM(Cable Modem): By configuring CM, can control CM speed
- CMTS, CMTS Port and CM
 - CMTS has many ports
 - CMTS Port is the place where user's CM signal finally reaches
 - Each port serves many CMs(up to thousands)
 - Each Port has maximum speed it can deal with

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The popularity of internet has grown up to the extent of reaching every residence. People now not only requires connectivity but also higher bandwidth. One of the major broadband services is the Internet Access Service via HFC(Hybrid Fiber coaxial) network. According to a statistics issued by Korea Telecommunications Operators Association in '02. May, the portion of the cable network Internet access users occupies 34% among total 9,076,299 Korean Internet access users, and it continues to increase. [2]

Core parts of HFC network, from the cable-data system perspective, are CMTS(Cable Modem Termination System) and CM(Cable Modem). By interworking CMTS on network network provider's side and CM on subscriber's side, Broadband Internet access service are realized.

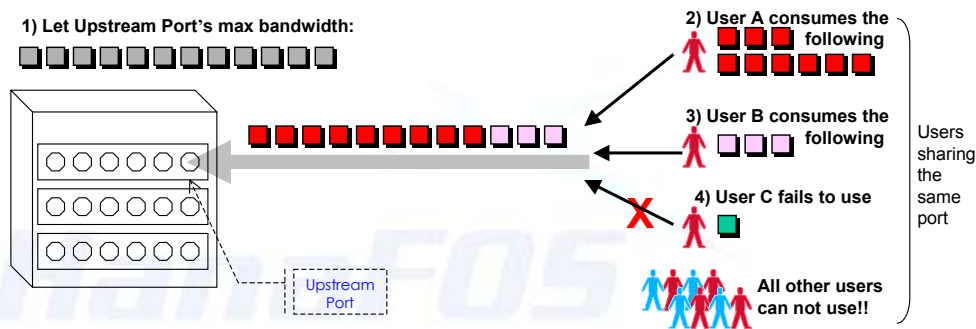
In cable-data system environment, the subscribers(or users) that belong to the same port are to share the same bandwidth. Thus, the bandwidth resource management is essential. A single CMTS upstream port has the bandwidth per channel typically ranges from 2 Mbps to 10 Mbps.[4] The upstream bandwidth(2M ~ 10 Mbps) is relatively low compared to downstream (27 Mbps). Home-users, who signed up for the service for non-commercial purpose, usually generate less upstream traffic compared to downstream traffic, and network providers usually don't limit this much, unless they monopolize the channel and make the others suffer.

However, monitoring all the user's traffic 24 hours is nearly impossible. Doing so results in putting enormous burden on operating CMTS devices, and the monitoring system itself. I have already suggested a mechanism that detects excessive upstream users[1]. Yet still, it requires manual decision making, operation, customer care. As much more enhanced version, the paper introduces a highly flexible and efficient upstream management mechanism that solves aforementioned problem, by weaving OSS, NMS, and Authentication System functionalities.

The mechanism was implemented, has been run at a Korea major CLEC, and proven beneficial in device resource(CMTS) management, operation cost reduction, marketing strategy. subscriber management.

CMTS Port has limited bandwidth...

- Sharing the same port(bandwidth) leads to **Bandwidth Contention**
 - Downstream can be easily controlled by configuring CM configuration file as given in product policy
 - Upstream usually has no limit unless home users excessively abuse the line
 - * **Home users** means who buys the line for non-commercial purpose
- Excessive upstream traffic
 - Endangers CMTS performance(Lowers Port Utilization, leads to **busy port**)
 - Make the line unavailable to the others who share the port
 - * We define **EUU**(Excessive Upstream User) as the user who generates excessive upstream traffic and at the same time makes the other suffer



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CMTS has many ports(upstream ports and downstream ports separately). The counter part of CMTS port on the user side is CM. Thus the cardinality between CMTS port and CM is one to many.

As told, a single CMTS upstream port has the bandwidth that typically ranges from 2 Mbps to 10 Mbps, and shared by the home-users who are provisioned to the port. Thus, there is possibility that a few monopolize the bandwidth.

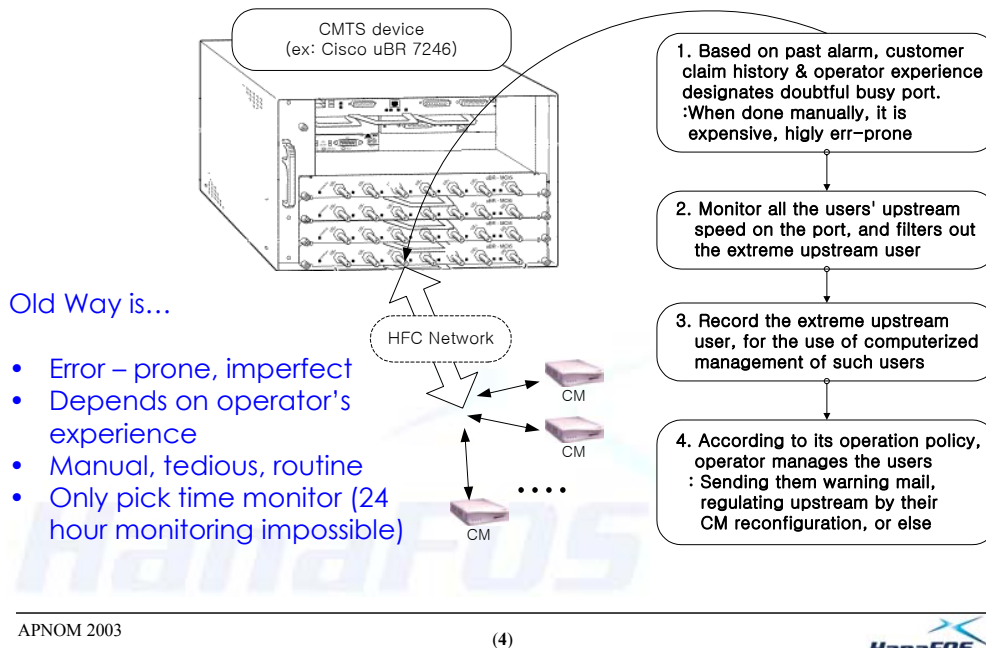
If it occurs, the port gets into the **busy** state. If it becomes busier to reach up to panic level, existing users get to experience extremely slow speed. Worse than that, the other users who belong to the same port, but currently not generating any traffic won't be able to use Internet when they want.

The upstream bandwidth exhaustion has been illustrated as the above

As shown item 1 in the figure, the 12 blocks represents the bandwidth that the CMTS port P can handle at once. At the time t , user A and B took up all the bandwidth. Especially user A takes up unfairly large bandwidth portion and made the rest suffer(We call him/her "extreme upstream user, ie. **EUU**"). It is fair to say there's none left available at the time t due to the extreme upstream user. If there are any other users who want to use internet like C, or who were already using Internet, they will be unable to use it until the part of resource is released. If t lasts short, it might be bearable. When the t lasts long, user's patience runs out.

Besides, the upstream bandwidth exhaustion becomes overload of the CMTS itself, and make the CMTS port busy giving CPU overload to the device. It is considered as a signal that it can soon endanger Cable-Data System operation.

Typical Upstream Mgmt Mechanism



Before explaining the CDUMS mechanism, it is helpful to explain how extreme upstream data are managed in a real environment.

Since the chart shown above is self-explanatory, there's not much to add. Of course, there is plenty of rooms to improve in processing each step. Yet, the main ideas are substantially the same. For instance, step 2. can be done using software tool that accesses CMTS device and monitors, filters out extreme upstream user. [3]

However, the mechanism shown above has many loopholes. First, it relies on on past alarm record, customer claim history and operator experience in order to find out doubtful busy port. These jobs call for tedious operation work, error-prone output, and expensive operation cost. Under such mechanism, operator cannot promptly respond to upstream bandwidth exhaustion.

Secondly, it can not monitor all the CMTS devices at all times. Operators are too busy to monitor 24 hours every CMTS whether they have a busy port or not.

Thirdly, it will lose service fairness, because individual experience of operator can tell him/her monitor on one's own way. Losing service consistency directly lead to customer complaint.

Furthermore, the mechanism above yields low port utilization, imperfect extreme upstream user management, and many more.

Introducing CDUMS

- Typical way revisited
 - Depends on operator's experience: lazy operator lets EUUs prosper -> Service quality differ according to the operator where it belongs
 - Error – prone, imperfect: While calculating upstream speed of each doubtful user, copy & paste errors occurs, calculation mistakes occur...
 - Manual, tedious, routine: No operators welcome the routine. It is nothing more than simple but repetitive upstream scan mechanism
 - Only pick time monitor (24 hour monitoring impossible): what if the EUU monopolize upstream during non-busy time
- Operators wonders....
 - How can I detect the busy port fast?
 - What are the rules that define EUU?
 - Is there a way to control EUU real time?
 - Can I automate EUU notification to OSS?
 - ※ Previously I have suggested EUU auto-detection mechanism at KNOM03
- CDUMS answers all
 - **CDUMS** is the core part of the effective upstream management scheme
 - **CDUMS** stands for **C**able-**D**ata system's **U**pstream **M**anagement **S**ystem
 - CDUMS solves the problems in a graceful way by weaving NMS, OSS and Authentication System

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From the typical upstream management scheme, the operators who are tired of routine upstream scan mechanism naturally raised the following questions

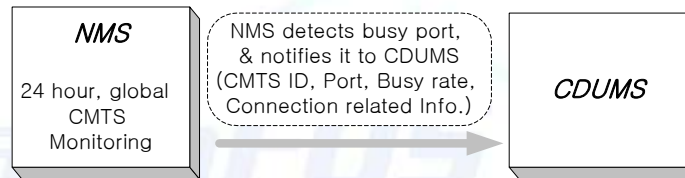
- How can I detect the busy port fast?
- What are the rules that define EUU?
- Can I automate EUU notification to OSS?
- Is there a way to control EUU real time?
- How can I minimize the load that I give to CMTS?
- Can I automate EUU control mechanism?

Simply the new solution suggested gives satisfactory answers to all the questions by weaving NMS, OSS, Authentication. Here, it will explain each step in detail how to interoperate with other systems: NMS, OSS, Authentication. For the purpose of simple, easy reference, the paper will call the core part of the solution as CDUMS (Cable-Data system's Upstream Management System).

CDUMS 1: Detection of the busy port

※ Same as the mechanism previously suggested [1]

- Who are first to know the presence of a busy port? => **NMS**
 - NMS monitors 24 hour all time
 - NMS has got the functionality monitoring every CMTS port performance
 - NMS notifies the detection of the busy port to CDUMS
- Busy port real time notification gives benefits
 - Activates EUU Monitoring System at real time
 - Not a single busy port go unnoticed
 - Operators don't need to care
 - : Operators! Stop scanning **doubtful busy port!!!**
- NMS gives the following info to CDUMS
 - Busy Port Information : CMTS ID(CMTS IP), Port Index, Port Usage
 - CMTS Connection Info such as SNMP read community or telnet login id/password



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The first thing to do is to find the busy port. Since there is no need to worry if the port has got enough resource to handle CM traffics. Thus in manual way, operators used to scan port status in the peak time. Based on the past alarm and performance history, operators know when is highly likely to have busy ports. However this method is imperfect, tedious, err-prone, and misses many busy ports. That's why the author suggested busy port auto detection method in the previous research[1]

The method started from the idea that it is **NMS** who is first to know the presence of a busy port. Since NMS monitors 24 hour all time, and has got the functionality monitoring every CMTS port performance. Thus, I let NMS notify the detection of the busy port to CDUMS

This simple idea is good because it enabled perfect and real time busy port detection. By including NMS, not a single busy port go unnoticed, and operators don't need to worry about busy port detection.

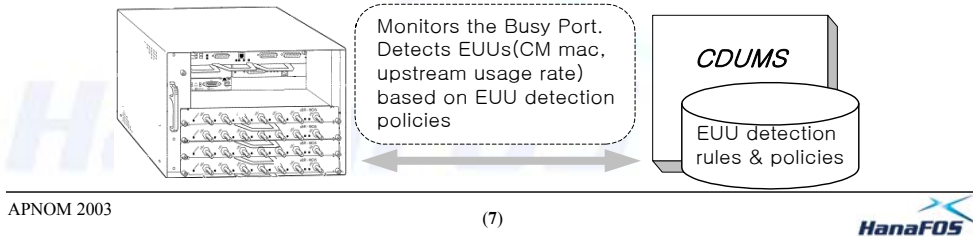
When NMS discovers a busy port, it gives CDUMS the following information

- Busy Port Information : CMTS ID(CMTS IP), Port Index, Port Usage
- CMTS Connection Info such as SNMP read community or telnet login id/password

CDUMS 2: Detection of EEU

※ Same as the mechanism previously suggested [1]

- As soon as CDUMS are notified of the busy port from NMS...
 - CDUMS connect to the CMTS where the busy port belongs
 - Scan all the user upstream status on the busy port
 - After a monitoring interval, calculates all the users upstream speed
 - Finally draws EEU's CM Mac address, avg upstream speed that has been detected.
- How to query the upstream info from CMTS
 - Depends on the interface device offers
 - SNMP may be good because it is a standardized way of managing nw device
 - Sometimes, using proprietary command interpreter works fast and simple if there are only one vendor of devices.
- CDUMS uses the following info to detect EEU
 - Busy Port Information : CMTS ID(CMTS IP), Port Index, Port Usage
 - CMTS Connection Info such as SNMP read community or telnet login id/password
 - EEU detection rules and policies : EEU upstream threshold, Detection period, Port busy status before and after the monitoring, etc.



Since we know the port that could be overloaded, it is time to find EEU. CDUMS connect to the CMTS where the busy port belongs, scan all the user upstream status on the busy port, and finally draws EEU's CM Mac address, average upstream speed that has been detected.

CDUMS uses the following info to detect EEU.

- Busy Port Information : CMTS ID(CMTS IP), Port Index, Port Usage
- CMTS Connection Info such as SNMP read community or telnet login id/password
- EEU detection rules and policies : EEU upstream threshold, Detection period, Port busy status before and after the monitoring, etc.

Amongst the information CDUMS uses, the most important factor is to find EEU upstream threshold, Detection period. If EEU upstream threshold is too low, then so many EEU's will be detected so that there's no point of management. EEU upstream threshold should be not too high, not too low. Detection period is not exception. It should be long enough to assume that the user is continuously generating the extreme upstream. If it is too long, busy port can reach up to a panic mode.

※ How to query the upstream info from CMTS?

There are two implementation methods that could be applied.

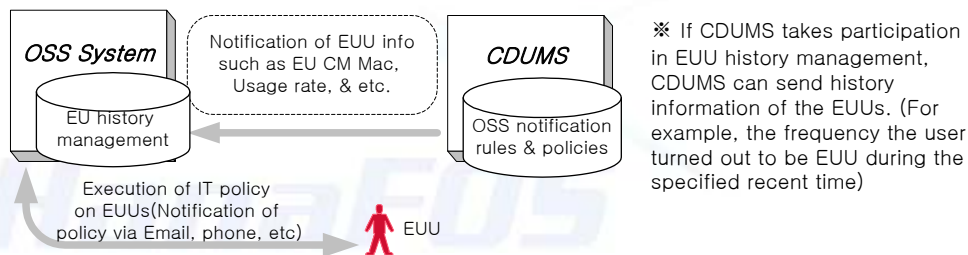
First one is SNMP. SNMP is good because it is a standardized way of managing network device. However, using SNMP could be quite burdensome because the functionality requires retrieving each and every user's traffic counter values on a given port. It leads to numerous SNMP getNext packets.

The other way is to use the proprietary command line interface. In case of CISCO CMTS, operators can retrieve all the individual users' traffic counters at once using one simple CLI command. Thus, in case of a single vender device network, CLI is less burdensome to both CMTS and CDUMS.[4][5]

However, it becomes a different story if there are many different types of CMTS devices. CLIs are likely to differ according to the vender, and may not have the proper functionalities.

CDUMS 3: Notification of EEU to OSS

- EEU has to be informed or warned of consequences of the heavy use
 - CDUMS only know EEU CM Mac, ie, EEU contacts are unknown to CDUMS
 - Usually OSS has got the detail customer information (email address, phone no, address, etc including customer CM mac)
 - ※ If OSS hasn't got such info & another IT system has, CDUMS works with the IT system
- Possible OSS management after being notified
 - Inform the EEU's of the consequences
 - Reflect it to the billing if they are supposed to be
 - Manage the EEU history for further customer information management
- CDUMS gives OSS EEU info
 - EEU info: CM Mac, upstream usage rate, detection time, amount of traffic EEU used during the monitoring period. Port usage rate before and after at the detection time.



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All the information that CDUMS can find out about EEU was their CM mac addresses and upstream speeds when detected. In other words, CDUMS does not know user's email address, phone number, or any other means to reach the EEU. For proper operation of EEU, users who were found out to be EEU, may have to be warned, and have to be informed of possible upstream speed limitation that may be drawn to them.

In doing so, OSS (or any other information system that possesses customer information including CM mac address, and is responsible to contact, informs customers, if you will) may be the right one to do the job. Moreover, if the EEU detection has got to do with SLA, OSS will definitely need the information.

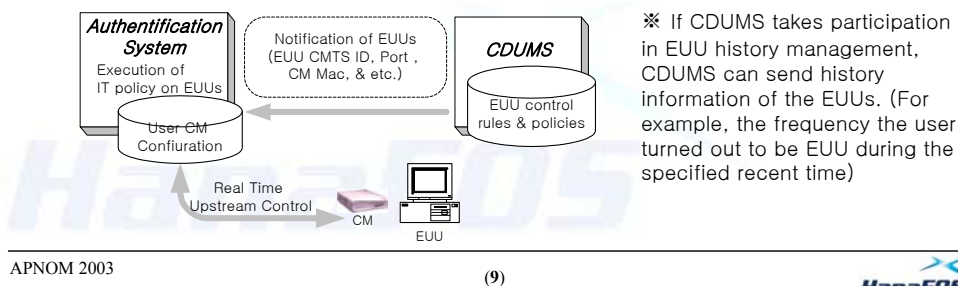
According to the company policy, OSS may need to keep track of the EEU records.

CDUMS gives the following information to OSS.

- EEU CM Mac: OSS or any other system which takes care of customer information can find out the EEU's detail information via CM Mac address.
- EEU usage rate, detection time: EEU's upstream usage rate, detection time, the amount of traffic EEU used during the monitoring period. Port usage rate before and after at the detection time.
- History information of the EEU's: If CDUMS takes participation in EEU history management, CDUMS can send history information of the EEU's. (For example, the frequency the user were turned out to be EEU during the specified recent time)

CDUMS 4: Notification of EEU to Auth System

- You have to do something to the EEU before s/he monopolizes upstream!
 - Detecting busy port, and EEU, notifying him/her to OSS would be in vain, if there is no regulation put on the EEU.
 - EEU's upstream should be restricted real time for other users
- Authentication System(AS) has functionality to control CM upstream speed
 - Usually AS can reset CM, modify its configuration, thus change CM upstream speed
 - ※ If AS hasn't got such capability, CDUMS can perform those functionality instead
- CDUMS gives Authentication System the following info
 - EEU CM Mac (CMTS id, port id in case when either was used for fast search in AS)
 - Any additional info that is necessary to put restriction. (ex: different upstream speed control can be applied to EEU cm according to EEU's upstream usage rate, detection time, the amount of traffic EEU used during the monitoring period, or even port usage rate before and after at the detection time.



For the sake of the others sharing the same busy port, network providers may have to restrict the EEU's upstream real time. How can we put a restriction on EEU? Basically the main idea of doing it is to prepare a CM configuration that has got the modification in the field of CM upstream to under a certain restricted upstream speed, and then apply the new configuration to the CM.

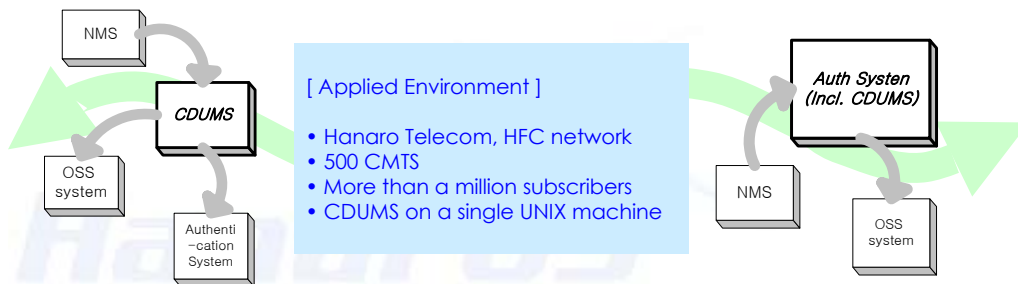
In the cable data system, usually authentication system has got the provisioning functionality. But it can not know which is EEU. Thus, CDUMS notifies the EEU real time, so that authentication system can prevent the disaster that EEU monopolizes the channel capacity and the port soon gets into the panic mode.

CDUMS gives the following information to authentication system.

- EEU CM Mac (CMTS id or port id in case when either of them was used for fast search in authentication system)
- Any additional information that is necessary to put restriction. For example, different upstream speed control can be applied to EEU cm according to EEU's upstream usage rate, detection time, the amount of traffic EEU used during the monitoring period, or even port usage rate before and after at the detection time.
- History information of the EEU's: If CDUMS takes participation in EEU history management, CDUMS can send history information of the EEU's. (For example, the frequency the user were turned out to be EEU during the specified recent time)

Regarding Implementation

- CDUMS has been introduced separately for the sake of clarity & modularity
 - You can implement CDUMS to do more work: Instead of OSS notification, CDUMS can notify the heavy usage event to the EUU, if CDUMS has got the customer information. Likewise, CDUMS may perform real time provisioning of EUU CM instead of Authentication System.
 - CDUMS may be implemented as a part of another system such as NMS. In that case, it seems like NMS does all the EUU-related operations to the outside system such as OSS and Authentication System.
 - In other words, you can combine CDUMS with other systems different ways to achieve the same goal according to the environment given.
- Key to success is to setting the right thresholds: busy port thresholds(before and after), sampling duration, EUU thresholds, etc



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Weaving OSS, NMS, and Authentication System functionalities with CDUMS is the key to the upstream management suggested in cable-data system. The core mechanism explained here is the brief idea of achieving the effective upstream management. For the sake of modularity, CDUMS has been separately dealt. However, in its implementation, you can implement it as a part of another system. The figures above illustrate several implementation cases. For example, instead of OSS notification, CDUMS can notify the heavy usage event to the EUU, if CDUMS has got the customer information. Likewise, CDUMS may perform real time provisioning of EUU CM instead of authentication system. In the case it has been employed in Hanaro Telecom Inc., CDUMS has been implemented as a part of NMS. Thus, it seems like NMS does all the EUU-related operations to the outside system such as OSS and authentication system. In other words, you can combine CDUMS with other systems different ways to achieve the same goal according to the environment given.

Whatever implementation given, I can never overemphasize the importance of finding the right thresholds, such as busy port thresholds(before and after), sampling duration, EUU thresholds, etc. In case of Hanaro Telecom Inc. which hires CDUMS, those variables were carefully selected by a month experiment and analysis.

Benefits from CDUMS

- Better Port Usage Rate
 - More subscribers to a upstream port, since network provider had to design port/channel capacity assuming the bad case like some EEU presence before.
 - Improved port usage rate ultimately means more revenue from single users due to the saved network resource.
- More satisfaction of home-users
 - Without it, EEU's monopolizing upstream would have caused others to be unable to use Internet.
 - Since the possibility of that has been taken care of by it, upstreams are more stable, users are happier.
 - Furthermore service providers, by the help of CDUMS, could find malicious EEU's or the user who illegally commercially use the home-user service. The record of EEU becomes very crucial evidence in customer management
- Saving operational Cost: Everything is all automated!
 - Operators were freed from error-prone, tedious routine manual upstream control operations
 - Everything is automated, operators could concentrate more productive works.
 - Service providers could reduce operator resources.
 - Again it contributes revenue increase by the reduction of operational cost.

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By weaving OSS, NMS, and Authentication System functionalities, the mechanism achieved highly efficient upstream management. The mechanism suggested has been implemented, run and proven flexible, efficient in a real cable-data system environment. The following are the benefits.

First, port usage rate has been improved. To be precise, network provider can assign more people to a upstream port. Since network provider has to design port/channel capacity assuming the bad case like n EEU presence before the mechanism. To network provider, improved port usage rate ultimately means more revenue from single users due to the saved network resource.

Secondly, it contributed to the satisfaction of home-users. Without it, EEU's monopolizing upstream would have caused others to be unable to use Internet. Since the possibility of that has been taken care of by it, upstreams are more stable, users are happier. Especially network or service providers could find malicious EEU's or the user who illegally commercially use the home-user service by the help of it. The record of EEU becomes very crucial evidence in customer management.

Lastly, operators were freed from error-prone, tedious routine manual upstream control operations. Since everything related upstream management has been updated, operators could concentrate more productive works, or network providers could reduce operator resources. Again it contributes revenue increase by the reduction of operational cost. The mechanism works much more precisely than the manual management mechanism.

Conclusion & Future Work

- Home-user upstream management is a must in Cable Data System
 - Excessive Upstream Users monopolize upstream, eventually disable the service
 - The old way is imperfect, error-prone, manual, expensive...
- CDUMS brought highly effective upstream management scheme : by weaving NMS, OSS, Auth System in a graceful way
- CDUMS has been run in the real field and ...
 - Lead to better port usage rate, saving network resource
 - Contributed to customer satisfaction
 - Saved operational cost
 - Over all, proven highly effective and cost-saving
- Work to be done...
 - Making CDUMS's EUU detection rules & policies flexible (Rules are to change!)
 - CDUMS Scalability & Load Balancing
 - Upstream record management and linking it with QOS
 - Marketwise, applying upstream control for various home-user service policy

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Home-user upstream management is a must in Cable Data System. Without it, excessive upstream users monopolize the upstream, and eventually disable the service. The old way that depended on manual operation was imperfect, error-prone, manual, expensive. Thus, the paper suggested CDUMS which is highly effective upstream management scheme. It achieves the goal by weaving NMS, OSS, Auth System in a graceful way. It is flexible because it pursuits minimal regulation and maximum favor on the user side while alienating uni-formal upstream regulation. It puts no limit to a home-user unless s/he threatens the others or the CMTS itself.

CDUMS has been run in the real field and proven very effective. In Hanaro Telecom inc. in Korea, CDUMS became essential to manage upstream management.

By employing CDUMS, OSS become much more efficient. It has lead to better port usage rate, saving network resource. It contributed to customer satisfaction and saved significant amount of operational cost. Over all, it has proven highly effective and cost-saving

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