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가상회선 서비스를 위해 보호 관리 기능을 갖는 사전 예약 프레임워크

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Advance Reservation Framework with Protection Management for Virtual Circuit Services

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요 약

한국의 대표적 연구망인 KREONET은 사용자 가상회선 서비스를 위해 사전 예약 기반의 네트워크 서비스 에이전트인 DynamicKL 시스템을 개발하여 왔다. DynamicKL은 오픈 그리드 포럼 (OGF)에서 네트워크 자원 제어 서비스를 위해 정의한 표준인 네트워크 서비스 인터페이스 (NSI) 및 그래픽 유저 인터페이스 (GUI)를 이용하여 예약, 할당, 해제, 종결, 조회 가상 회선 서비스를 제공한다. 또한 사용자에 의해 앞서 생성된 가상 회선과 예약들에게 가상회선 별로 보호 절체 관리 기능을 제공하기 위해 RICE 인터페이스를 갖는다. 본 논문은 DynamicKL 프레임워크 안에 구현된 가상회선 별 보호 절체 관리 기능을 가상 회선 서비스 관리 이슈 중 하나로 소개하고 이는 선진 연구망에서 개발한 다른 사전 예약 프레임워크 들과 비교하여 관리 및 안정성이 확보된 가상 회선 서비스를 제공하는데 기여한다. 관리자는 RICE 인터페이스를 사용하여 주회선 링크 장애시 백업 링크 안에 주 가상회선 들의 성공적인 보호 절체 유무 및 주회선 링크 복구 후 주회선 링크 내부에 주 가상회선 들의 성공적인 재생성 유무를 감지 할 수 있다.

Key Words : Advance reservation, Network Service Agent (NSA), Network Service Interface (NSI), Dynamic provisioned network resource, DynamicKL, Virtual circuit protection, Primary link, Secondary link, Link failure

ABSTRACT

The most representative research network in Korea, KREONET, has developed DynamicKL, an advance reservation based Network Service Agent (NSA) for user driven virtual circuit services. DynamicKL provides reservation, provisioning, release, termination, and inquiry web services for network resources by using an open standard network service interface (NSI), as well as web services for network resources by using a GUI interface. In addition, it has the RICE interface to support a protection management function per VC for virtual circuits and reservations. In this article, a protection management per VC for provisioned VCs and reservations is addressed in the DynamicKL framework, as a contribution to the VC protection management issue, which results in more manageable and reliable VC services compared to other advance reservation frameworks. An administrator can detect successful or unsuccessful VC protections in the event of a primary link failure and successful or unsuccessful VC retrievals after a primary link repair, by using RICE.

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Ⅰ. Introduction

Most advanced research networks have developed and deployed advance reservation based network resource provisioning systems for big data transfers to support various application areas, for example, DRAGON, OSCARS, DRAC, AutoBHAN, EnLIGHTened, PHOSPHOROUS, and G-Lambda,[1-7]. They have their own framework for only network resources or for both grid and network services. Some of them have a standard interface for multi-domain services and the others have their own interface.

The Network Service Interface (NSI) developed by the Open Grid Forum (OGF) is a standard interface for network resource reservation and control in intra or inter-domain[8-10]. An NSI based resource reservation and provisioning system can improve productivity for data intensive research projects, for example, reserving and alocating available network resources (i.e., virtual circuits) automatically for large-scale data applications between multi-domains, such as Large Hadron Collider (LHC) in the field of High Energy Physics (HEP). G-Lambda A/K (the latest version of G-Lambda), OSCARS, AutoBHAN, and OpenDRAC (the latest version of DRAC) have been implementing the standard NSI interface in their frameworks.

Dynamically provisioned network resources such as VCs are recognized as extremely useful capabilities for many types of network services. However, to date the majority of approaches to such services do not address a number of required management issues such as protection management per VC, which provide manageability and reliability guarantees in advance reservation frameworks for VC services.

We present DynamicKL (Dynamic circuit based advance reservation system of KRLight) based on web services, which consists of the NSA (Network Service Agent) system and a web portal server. In particular, DyamicKL provides the RICE web service interface for the protection management per VC for virtual circuits (VCs) and reservations in the event of a link failure, as well as the NSI and GUI web service interfaces for reservation, provisioning, release, termination, and inquiry. Protection management in DynamicKL is provided per VC for provisioned VCs and reservations in case of a link failure, a feature that contributes to managing failure and protection status information per VC in a primary and backup VC reservation DB. This capability constitutes a dominant, important difference from other advance reservation systems. With this capability, an administrator can detect when backup VCs are successfully or unsuccessfully working as active paths to protect primary VCs and primary VCs are successfully or unsuccessfully retrieved as active paths after a primary link repair. Because a primary and backup reservation DB separately manage failure information per each primary/ backup VC, it is possible to establish VCs and to terminate reservations in backup links for provisioning and termination requests of reservations with a primary link failure, by delivering NSI provisioning messages with backup interface information.

In this paper, the DynamicKL with protection management per VC is addressed in detail. VCs can be reserved, provisioned, released and terminated through NSI web service messages between the NSA and web portal server. Protection management function per VC is implemented to provide more manageable and reliable VC services by using the RICE web service interface, which differentiates this approach from other advance reservation frameworks.

Ⅱ. DynamicKL Framework with Protection Management

2.1. DynamicKL System Block

DynamicKL consists of a web portal server and a network service agent (NSA), as shown in Fig. 1. The web portal server provides a web-based user interface for users to make advance reservations. It has a primary and backup VC reservation DB, a network topology DB, and a user account DB, and provides an AAA (Authentication, Authorization, and Accounting) module for the basic user

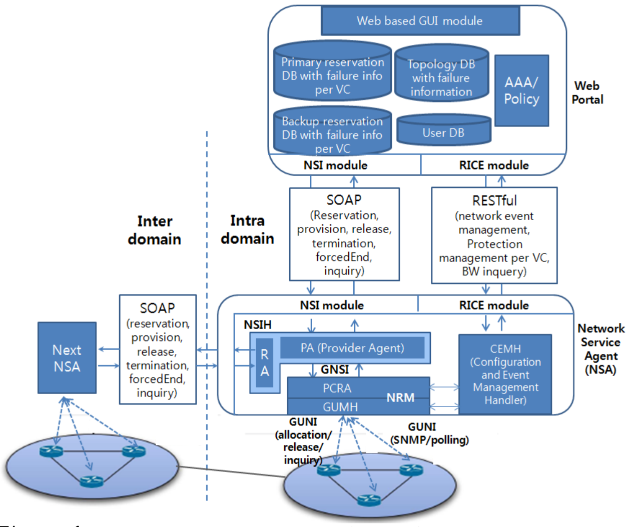

Fig. 1. DynamicKL framework with a protection management per VC.

authentication and authorization process. Primary and backup reservation DBs separately manage failure and protection status information per each primary and backup VC. The NSA system consists of an NSI Handler (NSIH) with a Provider Agent (PA) and an RA (Requester Agent) to support network resource service in intra or inter domain, a Path Computation and Resource Admission (PCRA) and a G-UNI Message Handler (GUMH) to manage network resource in intra domain, and a Configuration and Event Management Handler (CEMH), as shown in Fig. 1. The web portal server interfaces with the NSIH through the Network Service Interface (NSI) and the CEMH through the RESTful web service Interface for Configuration and Event management (RICE), respectively.

The NSIH executes advance reservations based connection management in intra or inter-domain with the NSI interface. Also, the PA in the NSIH interfaces with the PCRA through the GNSI interface for connection management for intra domain network resources. The PA delivers requested reservation information to the PCRA through the GNSI interface and the PCRA performs path computation and an admission control for local network resource reservation. The PCRA reflects node or link failure information received from the CEMH in network topology information and has a primary and backup VC reservation table managed with ResvID. By using them, the PCRA controls admission for new VC reservation request. The PCRA interfaces with the GUMH for the creation and release of virtual circuits on a network path requested by a user. The GUMH exchanges control messages for creation, release and inquiry of primary and backup virtual circuits with network devices through the Grid User Network Interface (GUNI). The GUMH receives network failure/repair events by SNMP trap messages from network devices. To detect a router (node) failure event, periodic polling messages from the GUMH are received at network devices. VC protection/retrieval events can be detected by using a Query_VC GUNI message from the GUMH. The CEMH provides a management plane with network event and VC protection/retrieval event information received from the GUMH through RICE API messages. The CEMH internally interfaces with the PCRA, to initialize and apply network topology information received from the web portal server, and to request renewal of network topology and backup/primary VC reservation table information. Also, the CEMH internally interfaces with the GUMH, to detect network event information from network devices and to request VC protection/retrieval information inquiry.

The NSI (Network Service Interface) is a standard interface for network resource reservation and control between inter domains defined by OGF (Open Grid Forum), in partnership with the Global Lambda Integrated Facility (GLIF) organization. The GNSI is an interface between NSIH and PCRA used for the reservation and connection management of the local domain. The GUNI is an interface for VC creation, release and inquiry. The RICE is an interface for network event management, especially for protection management per VC.

2.2. Interfaces in DynamicKL

2.2.1. NSI interface

NSI messages [8][9][10] for network resource control are shown in Table I. A request message from the RA is delivered to the PA. The web portal server plays a role of the RA for user VC services. The PA sends a confirmation or failure response message to the RA as identification of success or failure for a request message from the RA. A NSI message is delivered through Simple Object Access Protocol (SOAP). All of the NSI messages have a correlation ID as an identifier for a request and response message and a request message has a next NSA address for inter domain VC service.

A *reserveRequest* message is used to request a VC reservation. A reservation request message has following factors: globalReservationId, connectionId (CID), service parameter and path information. A starting time, an end time and a bandwidth are included in service parameter. Direction (bi-direction as a default), addresses of source/destination nodes are included in path information. A *reserveConf* message is used to response for a reservation request. [8][9][10]. For provisioning of a reserved VC identified as a CID, a *provisionRequest* message is used. For release of a provisioned VC, a *releaseRequest* message is used and a *releaseConf* message is used for response. Also, a *terminateRequest* message is used for termination of a reserved or a provisioned VC and a *terminateConf* message is used for a response. Finally, a *queryReqeust* message is used for inquiry of a reserved or provisioned VC and a *queryConf* message is used for response. A *forcedEndRequest* message is used to notify RA that PA administratively terminated a reservation [8][9][10]. If any service for reservation, provisioning, release, termination, and inquiry has failed, PA sends a failure message to RA.

2.2.2. GNSI interface

GNSI is an interface for a network resource reservation service defined by the GLIF (Global Lambda Integrated Facility) organization[11]. GNSI messages implemented for resource reservation service is as follows. *GreateResourceResv* is used for resource reservation and *ProvisionResourceResv* is used to allocate a reserved network resource. *ReleaseResourceResv* and *ReleaseResourceProv* are used to release a reserved resource and a provisioned resource, respectively. *GetResourceProperty* is used to return attribute information corresponding to a reserved resource. The *GetAllReservedResources* message is used to inquire about an available BW between a requested reservation starting time and a requested reservation end time in a designated network path [11]. To provide interoperability between the NSI and GNSI interfaces, a CID2ResvID mapping table is used in NSIH.

2.2.3. GUNI interface

The GUNI is an interface for VC creation and release for a reserved resource. *Activate_VC* and *Deactivate_VC* messages are used to create and release primary and backup virtual circuits on are quested network path, respectively. *Query_VC* is used to inquire about secondary (backup) VCs working on active or non-active (standby) status, in the event of a primary link failure, and primary VCs working on active or non-active status, in case of a primary link repair. Each message includes information to create and release and inquire VCs by telnet access to each network device. To receive SNMP trap messages from network devices in the event of network failures, SNMP trap based GUNI interface is also applied to GUMH.

2.2.4. RICE interface

We designed and implemented the RICE for the application of network topology information to the NSA, BW inquiry for a specific path with a reservation duration, and network event management, especially for protection management per VC for provisioned VCs and reservations with a link failure. The RICE API messages for protection management per VC will be described in detail in section III.

2.3. Virtual Circuit Reservation and Provisioning by DynamicKL

A user can select source/destination nodes on the topology map and provide source/destination host addresses, which is internally mapped to STP (Service Termination Point) addresses. If a user provides a starting time and an end time of reservation and inquires about a residual bandwidth, a maximum available bandwidth from a source node to a destination node is shown to a user. If a user provides a bandwidth smaller than that, a reservation request is ended. So, users do not have to experience reservation failures when searching for a needed specific BW. 2 backup VCs (i.e., 1 bi-directional VC) in secondary links are internally reserved for protection by DynamicKL, in addition to 2 primary VCs (i.e., 1 bi-directional VC) in primary links by a user request.

For both layer 2 and layer 3 VCs, where reservations are bidirectional, the configuration GUNI messages from an NRM are delivered to both edge routers at the start and end of the intra domain VC on an user provisioning request. 2 backup VCs (i.e., 1 bidirectional VC) in secondary links are internally provisioned for protection, in addition to 2 primary VCs (i.e., 1 bidirectional VC) provisioned in primary links by a user request. Since users can notice primary link or node failure in a topology map, they can reserve VCs on the rest of nodes and primary links, except failure nodes or links.

Ⅲ. Protection Management

Since NSI standardization does not yet address network management issues, such as protection management, we have implemented the RICE, especially for protection management for VCs and reservations with a link failure.

A backup virtual circuit for protection is internally reserved and provisioned by DynamicKL, together with a primary reservation and virtual circuit for a user request. An active path is switched from a primary VC to a backup VC in a dynamic VC service network, in the event of a primary link failure (i.e., a 1:1 path based protection [12] implemented in network devices is used). A protection management function per VC is addressed to provide manageable and reliable VC services, by using RICE.

3.1. RICE API messages for network event management

3.1.1 InterfaceDown

When an interface of a network device has a fault, an SNMP trap message from a network device is delivered to the GUMH in NSA [13]. An *InterfaceDown* message is used to notify a web portal server a fault interface of a network device.

3.1.2. InterfaceUp

When a failure interface is repaired, an SNMP trap message from a network device with a fault interface is delivered to the GUMH. An *InterfaceUP* message is used to notify a web portal server a retrieved interface of a network device.

3.1.3. NodeDown

To monitor a network device with a fault, a periodic polling message from the GUMH is delivered to network devices. A *NodeDown* message is used to notify a web portal server a fault of a network device.

3.1.4. NodeUp

When a network device with a fault is retrieved, it can be monitored by using both an SNMP trap and polling messages [13]. A *NodeUp* message is used to notify a web portal server a retrieved network device.

3.1.5. Primary2SecondarySuccess/Primary2SecondaryFail & Secondary2PrimarySuccess/Secondary2PrimaryFail

Primary2SecondarySuccess and *Primary2SecondaryFail* API messages are used to notify that back up VCs pre-assigned in secondary links currently operate as working paths to protect VCs in a fail ure primary link and at least a backup VC does not operate as a working path, respectively. On th e othe rhand, *Secondary2PrimarySuccess* and *Secondary2PrimaryFail* messages are used to provide notification that all of VCs in are paired primary link (interfaces) are retrieved as active paths, and to indicate that at least a VC is not currently retr ieved as an active path, respectively. The above e vents can be detected by sending *Query_VC* GUN I messages to network devices, after receiving an

SNMP trap message with primary link failure or repair information from a network device.

3.2. Advantages of Protection Management per VC

By using the RICE API messages, an administrator can observe that backup VCs are currently working on active status or not working in the event of a primary link failure, and primary VCs are automatically retrieved or not retrieved after a primary link repair. With these messages, failure and protection status information is managed per VC, as well as per network link. In other words, NSA notifies successful or unsuccessful VC activations as working paths in the backup link and successful or unsuccessful VC retrievals as working paths after a primary link repair, and failure and protection status information per VC (i.e. per CID) in a primary and backup reservation DB is separately managed, as shown in Fig. 2. If protection status information is not provided per VC, an administrator will assume that all backup VCs are successfully operating as working paths in the event of a failure primary link with VCs and that all primary VCs operates successfully as working paths in the event of a primary link repair. We also note that a provisioned VC may not operate on active status, due to unexpected

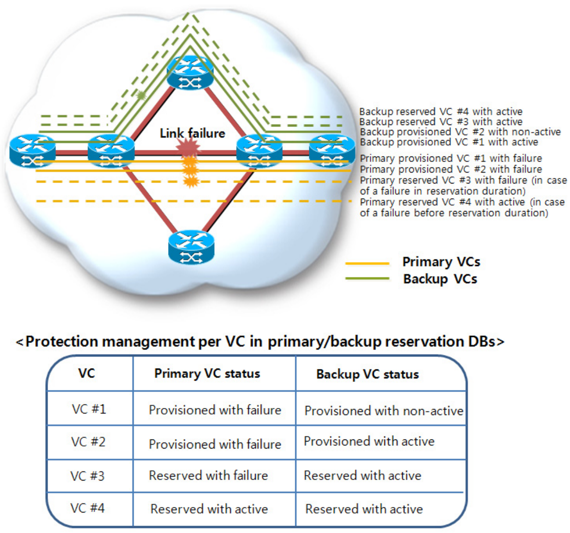

Fig. 2. Protection management per VC in a reservation DB in the event of a primary link failure.

events, such as a network device's configuration intervention by an individual and an OS problem in a network device. In addition, a provisioned VC may be released by an administrator's mistake.

Because primary and backup reservation DBs separately manage failure and protection status information per each primary and backup VC, as shown in Fig 2, DynamicKL can still release and terminate user virtual circuits in backup links, in the event of a primary link failure with VCs. Also, it is possible to establish VCs and to terminate reservations in backup links for reservations with a primary link failure, by delivering NSI provisioning messages with backup interfaces information to network devices. Users wanting to reserve VCs can monitor a failure link or a failure node and create reservations for the rest of links and nodes.

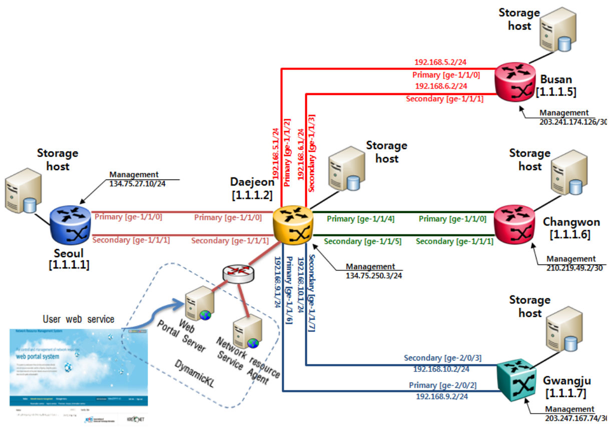

Fig. 3. Dynamic VC service network by the DynamicKL with protection management.

Ⅳ. Demonstration of Protection Management per VC

4.1. Service Network Architecture

To address the growing need for guaranteed bandwidth by large-scale collaborations, such as the LHC in the field of HEP, the KREONET has designed and implemented the dynamic virtual circuit network, which is physically distinct from the IP core network (KREONET). NSI VC services (i.e., reservation, provision, release, termination, and inquiry services) can be made on the dynamic VC service network, which consists of some part of 5 sites in the KREONET, as shown in Fig. 3. Each node is connected with 2 links (a primary and backup link) to provide disjoint path for primary and backup VCs. The dynamic virtual circuit network is engineered to support only dynamic virtual circuits (VCs). A 1:1 MPLS protection scheme was implemented in routers (nodes). The NSA system implemented as web services operates as a server to process request messages and operates as a client for the creation of confirmation messages. The web portal server also operates as a client for request messages and a server for confirmation messages.

Even though a secondary (backup) and primary VC in the dynamic VC network do not have disjointed paths in the event of a node failure, due to the star topology of KREONET core network, they have disjointed paths each other in the event of a link failure. A demonstration for protection management per VC is focused on the event of a link failure.

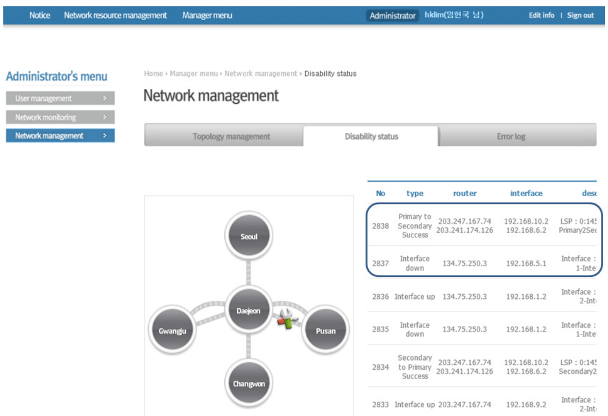

Fig. 4. Protection management GUI for an administrator.

4.2. Demonstration of Protection Management per VC

In this subsection, a demonstration of protection management per VC for VCs with a link failure is demonstrated in the dynamic VC service network. Bidirectional primary VC (2 unidirectional primary VCs) with 100 Mbps BW on a designated network path from a host at Gwangju to a host at Pusan is provisioned by a user request. Also, 2 unidirectional backup VCs on disjoint backup links are internally provisioned for protection of primary VCs by the DynamicKL. A primary link at Daejeon site has a failure event. A protection management GUI for an administrator is shown in Fig. 4. An administrator can notice that a primary link at Daejeon site has failure, by receiving an *InterfaceDown* message. Also an administrator can recognize that backup VCs in secondary links are successfully working on active status to protect primary VCs with a link failure, by receiving a *Primary2SecondarySuccess* API message. A primary reservation DB creates failure information for primary VCs and a backup reservation DB changes status information for backup VCs from standby status to active status. By making use of these API messages, protection management per VC is possible in a primary and backup reservation DB. Fig. 5 verifies that 2 secondary VCs pre-assigned are working on active status, by exchanging signaling messages between network devices after a primary link failure, with the policy of 1:1 MPLS protection scheme implemented in routers. Protection speed provided by routers in the dynamic VC service network is under 50msec, which means time that an active path is switched from VCs in primary links to VCs in backup links. Total RICE API messages notification time between the NSA and web portal server was 2.8sec, including backup VC inquiry time, process time and transfer time of them.

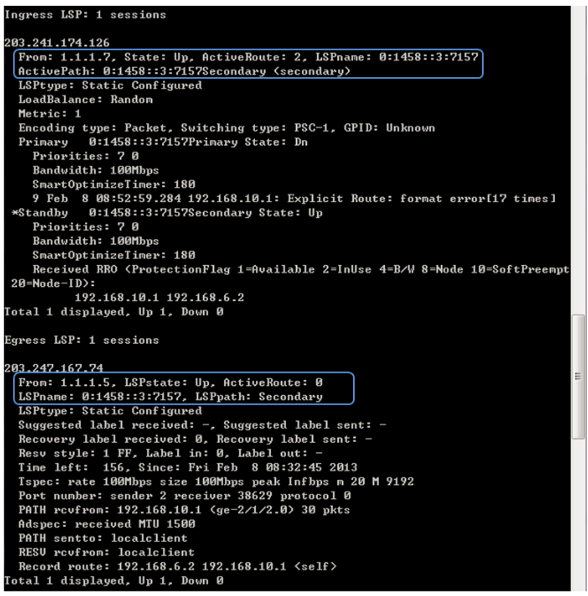

Fig. 5. Secondary VCs working on active status in the event of a primary link failure.

V. Conclusions

DynamicKL provides reservation, provision, release, termination, and inquiry services for virtual circuits by using a standard network service interface (NSI). In particular, it provides protection management per VC by using RICE interface, for virtual circuits and reservations with a primary link failure, which leads to more manageable and reliable VC services, compared to other advance reservation frameworks. With this capability, an administrator can notice successful or unsuccessful VC protections in the event of a primary link failure and successful or unsuccessful primary VC retrievals as active paths after a primary link repair. Because a primary and a backup reservation DB separately manage failure and protection status information per each primary and backup VC, DynamicKL is able to release and terminate user virtual circuits in backup links, in the event of a primary link failure with VCs. In conclusion, DynamicKL could contribute to improve manageability and reliability of VC services.

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