Models of Interconnect Management of Multimedia IP-based Networks

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***Abstract* – The scope of network and service management related to interconnect relationships is limited compared to the need of network and service management within an administrative domain. However there are several crucial inter-domain interworking tasks that should be performed via a management interface, which will not be covered through a signalling or a transport plane interface. In this work some models for realization of interconnect management scenarios are present.**

***Keywords* – Interconnection, Multimedia services, IP – based networks, inter – domain networking, QoS.**

I. INTRODUCTION

Interconnection management tasks are important for efficient network operations and service delivery and assurance, with as little as possible interruptions, decreased time to repair, and efficient usage of resources. Management functionality supporting inter-domain monitoring and verifying of SLA (Service Level Agreement), efficient handling of faults, and interchange of charging data, all represents important functional areas applicable to inter-domain management.

II. ARCHITECTURAL ASPECTS OF INTERCONNECTIONS

A. Assumption and methodology

Capabilities and choices regarding the following contention may have great influence on the specific requirements for interconnect management operations and information flows. Capabilities with respect to the following need to be defined in order to specify the corresponding Interconnect Management requirements and capabilities needed.

- End-user services and QoS (Quality of Services) classes, their permanents, and objectives (SLA's),
- Network performance objectives,
- QoS and SLA measurement methodologies,
- QoS and SLA assurance methodologies,
- Transport plane capabilities and types of connectivity resources including CoS (Class of services), QoS, and resource reservation features, as perceived from an interconnection point of view,
- Constraints and assumptions regarding mapping of end user MMoIP (Multimedia over IP) flows (bearers) onto aggregate flows (tunnels),
- End-user naming scheme and "addressing" plan,
- Addressing scheme and addressing plan for MMoIP bearers (flows),
- Addressing scheme and address plan for tunnel end-points as well as for end-points of interconnect links,
- Routing information dissemination approach,
- Resource usage monitoring, charging and accounting schemes.

Several documents regarding management and OSS (Operation Support System) are applicable as sources for this work. Typically, the sources provide generic descriptions and requirements that need further investigation when analyzing and specifying what are applicable requirements and functionality in a given setting, such as for instance given interconnect architecture. Examples of such sources are: ITU-T M.3010 [1], ITU-T M.3200 [2], ITU-T M.3400 [3]etc.

Also some works in the past years include recommendations, example architectures and functionality definitions according the interconnection scenarios and interface specifications of interconnection management of Multimedia IP – based networks [5], [6].

B. Functional Layers of Management architecture

While in [6] and [7] the functional layers within the two planes are described in some details, the functional content of the management plane is not described in a corresponding detail (Fig. 1).

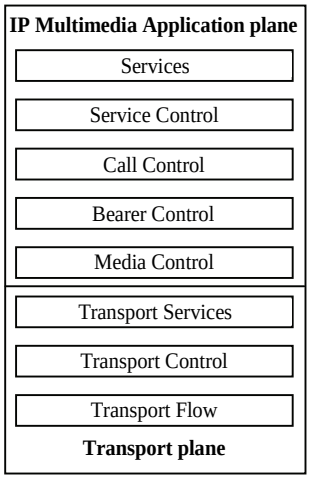

Fig. 1. Figure example

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In general, there are management functionalities associated with each of these functional layers. The complexity and management functionality content for each functional layer hi an interconnect setting will vary where some layers are more challenging from a management perspective than others. Several actors or administrative domains are likely to be involved when providing services. Typically, one makes a distinction between a service provider (SP) and a network operator (NO) where the later owns and operates the network within its domain. The NO can also play the role of a (end-user) SP, or rather be limited as a wholesale provider. However, more actors can be involved, and the exact delineation between an SP and an NO may vary from case to case.

C. Domain definitions and connectivity resources

The extent of an SP does not need to correspond with the extent of an NO. This is illustrated in the figure below.

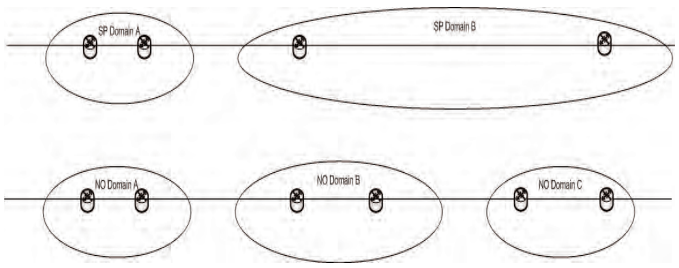

Fig. 2 NO and SP domains

In general, the new IP and MPLS (Multi Protocol Label Switching) packet-based technologies with associated QoS mechanisms such as for instance DiffServ (Differentiated Services) aware MPLS provide opportunities for more efficient network resource utilization than traditional TDM based solutions. However, interconnect and inter-domain network resource and QoS control and management are areas with several challenges.

D. Inter – office interconnect

The following will point out different types of connectivity entities (connection-less or connection-oriented) that are important to identify for subsequent identification of management capabilities needed. In order to get a conceptual view of these different transport plane network connectivity resources that are applicable to an interconnect relationship several figures are provided below.

Figure 3 identifies and illustrates three kinds of connectivity resources:

- An (end-to-end) end-user MMoIP flow (bearer). Such an end-user flow is most likely associated with an end-user application. The end-user flow can potentially be also an aggregate flow. However, this is transparent to the service providers and network operators. It is assumed that some end-user flows may request an SLA that requires monitoring of the individual end-user identifiable flow across multiple domains.

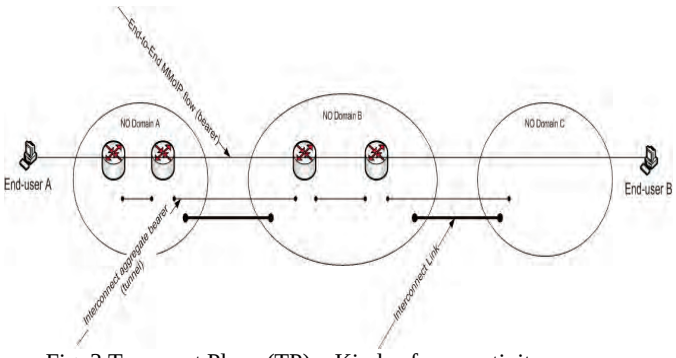

Fig. 3 Transport Plane (TP) – Kinds of connectivity resources – inter – office interconnect

- Tunnel(s) or aggregate bearer(s) that can support or carry several MMoIP end-user flows. Properties and features associated with such tunnels are further elaborated below. This is typically a preferred solution hi an inter-office case. (See main part of the document.)
- Interconnect link that extend between two neighbors NO domains and will typically aggregate several aggregate bearers (tunnels). It is assumed that this is connection oriented packet based or circuit based. Several hierarchical levels of interconnect links can be possible.

In order to avoid statically assignment of resources at a very fine granularity it is assumed that the bearer tunnels are MPLS packet-based. Such a tunnel can have various properties according to the needs of the interconnection relationship. Although MPLS is used for interconnect bearer tunnels. this still leave open to the network operator the choice of technology inside its domain. It is assumed that there is a set of service classes (CoS) available that are applicable to bearer tunnels. There must be an inter-domain coordinated way of mapping MMoIP flows onto tunnels to obey QoS properties. While in general admission control of MMoIP flows will be done per flow per session this will not result in per flow per session resource reservation on network elements (transport plane forwarding devices) providing interconnect network resources. Typically tins will be done on an aggregate basis.

There are several ways of dealing with resource reservation related to bearer tunnels. But in any case, bearer tunnels are an important means of SLA related monitoring and a durance. The following bearer tunnel resource reservation (i.e. some kind of bandwidth reservation) schemes are assumed as possible options:

- No per bearer tunnel resource reservation. Resource reservation can potentially be done at a more aggregate level, e.g. with respect to interconnect links.
- Resource reservation per tunnel (as agreed between interconnected domains) where the network operator maintains reservations at an aggregate level. Thus, no per tunnel resource reservation on network elements (transport plane forwarding devices) providing the tunnel interconnect network resources.
- Resource reservation per tunnel (as agreed between interconnected domains) where the resources are reserved also on network elements providing tunnel interconnect network resources.

The network operator can use (class based) DiffServ aware MPLS in the first two cases, while the last case per LSP (Label Switching Path) resource reservation is used. In any case, in addition to using MPLS LSPs to support SLA monitoring and assurance. MPLS LSPs are also used to ensure stable and predictable routing of IP flows. It is important to ensure that IP packet are directed to the expected interconnect border nodes where both NATing (Network Address Translation) and firewall functionality can be performed.

The number and kinds of bearer tunnels that one domain has interconnecting to other domains may vary. One domain may have only one tunnel to each of its neighbor network operators, which in turn provide interconnect transit services to the other domains. On the other hand one network operator may have several tunnels to each of its neighbors. Tunnels can go to different service providers being served by a neighbor network operator or tunnels can transit network operators to network operators with no interconnect link neighborship. These various kinds of tunnels are illustrated in Figure 4. In order to select different routs for the MMoIP flows they can be mapped onto different tunnels where the tunnels reach the same destination following different routes.

We also note that neighborship or interconnect relationship are relative terms. Both functional layers as shown in Figure 1 as well as the kind of connectivity resource involved will classify the interconnection relationship. Correspondingly, the devices involved in interconnection are of different kinds and may reside on various locations within an operator or provider domain.

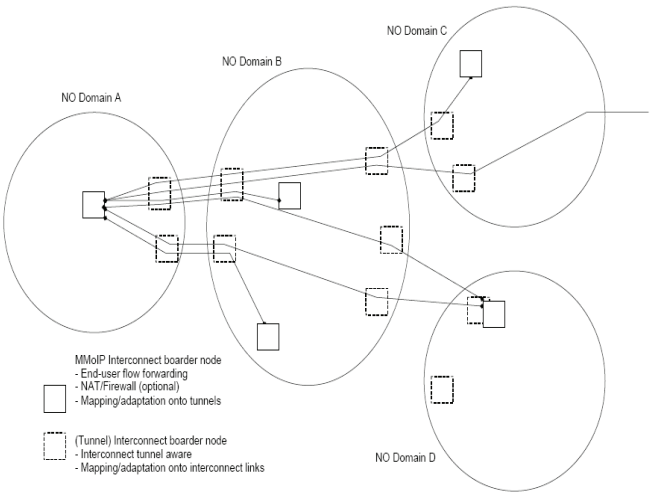

Fig. 4 Examples of aggregate bearers (bearer tunnels) – inter–office interconnect

It is expected that the tunnels as such are rather long lived, while their properties and associated bandwidth or resource reservation may vary depending different traffic patterns varying over time of day or over weeks or months. Several solutions for establishing such inter-domain tunnels exist. Typically one distinguishes setting up tunnels by signalling vs. by management or by a combination of the two ways. However, when looking at the "by management approach" we note that there is an emerging trend that the management and control of network resources and connection (tunnels) are not handled by traditional OSSs but by special purpose servers that can be more or less distributed according to scalability needs. In this sense one may use the notion of network resource control and management (NRCM) as a separate functional plane or layer. This functional plane is separated from the network elements and control plane components of the network elements. NRCM will typically provide functionality as identified belonging to the transport services and transport control functional layers. Policy-based configuration and management is an integral concept of such a functional plane.

Functionalities and capabilities of such a functional layer are crucial as these will enable and assure the QoS and service classification capabilities of the involved network domains provided that a consistent and coordinated mapping from MMoIP flows onto tunnels exist. In the following functionalities and solutions of NRCM will be covered to some extent both in this section and in subsequent sections.

The figure below illustrates the set up of a tunnel crossing two transit domains. It is assumed that NO domain B and C should not know where the tunnel terminates as this may provide undesirable knowledge about traffic patterns of other domains.

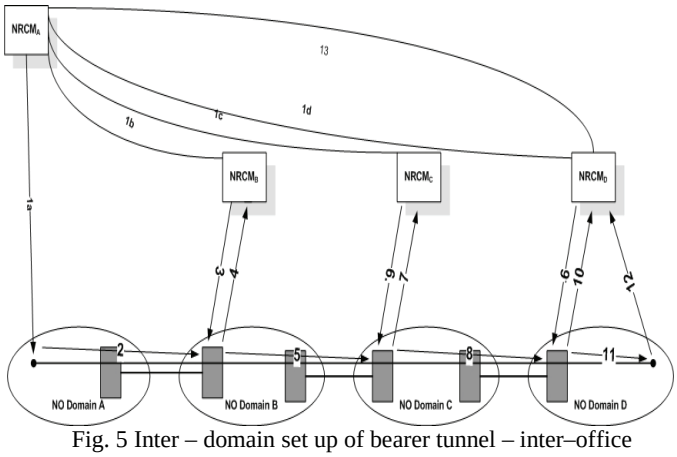

Fig. 5 Inter – domain set up of bearer tunnel – inter–office interconnect

This illustrates a setting where both signalling and "management" (both control plane and management plane) is involved in the set up. Often this is called soft-permanent connection set up. Taking a closer look at interaction (1b) and (3) the identifier provided by NO A is an abstract identifier Telling that the tunnel should go to domain C (or a particular abstract location in NO C). Then NRCMB must find an egress port leading to an appropriate ingress poit in NO C. This may require negotiation between $NRCM_B$ and $NRCM_C$. Whether resource reservation in the network elements is part of the set up should be optional.

To accommodate appropriate SLA monitoring and assurance as well as resilience and fault management there is a need to monitor and manage both the tunnel from an end-to-end perspective as well as the various intra-domain and inter-domain sections that the tunnel traverses. Several methods and mechanisms are candidates, for these purposes. It is a goal to select appropriate means while keeping the CAPEX and OPEX low.

III. MANAGEMENT FUNCTIONALITY

By analysing potential FCAPS functionality as identified in for instance M.3400 for each ICM functional layer, ICM functional requirements should be identified and appropriately structured. The next step is then to consider various alternative management entities and relationships between such entities, to reach a functional specification of the different interfaces. Protocol neutral information modeling may be used as a specification approach. Then, on a bilateral basis, the exact management protocol profile may be chosen from a set of standard protocol profiles.

Depending on the volume and complexity of management transactions, it is possible that some management tasks can be done manually. At a later stage, when the volume increases, automation by an OSS-OSS interface can be introduced.

There are several main management functional areas that could be applicable and need further investigation. In the following a brief (initial and preliminary) description of ICM functionality will be provided according to the structure identified in Figure 1. This structuring of the management capabilities needs further analysis and assessment. Some of the capabilities are applicable when considering multi-media services in general and not limited only to the voice service component.

It is assumed (below) that the MMoIP internetworking arena will be dynamic and evolving. It is important to support an evolutionary and step-by step approach where first, simple QoS-enabled connectivity services can be offered across domains. Then, more functionality and service features can be added step-by-step as experience is gained and the solutions mature. In order to allow such a vision in a cost-efficient manner it is important that management functionality exist to announce and discover changes to protocol or service capabilities, across the numerous interconnect relationships. This should be supported at each functional layer. It is a goal to allow different domains to develop their network and services differently, and one domain can have interconnect relationships to different other domains each supporting different capabilities.

Likewise, it is important to have efficient means of establishing a new interconnect relationship e.g. a new interconnect link, and efficiently updating or changing the configuration and knowledge of how features are interconnected. As interconnect topology and traffic patterns change it should for instance be possible to dynamically announce changes to routing policies. Routing policies are applicable at different layers, from routing of send requests, routing of call requests, routing of MMoIP flows, to routing of interconnect tunnels and links.

In Section II above it is discussed how bearer tunnels, in typically in the inter-office case, provide flexibility, efficient resource utilisation, and a means of ensuring SLA and QoS features. It is assumed (below) that CoS/QoS can be consistently mapped between the different functional layers and across domains. It is assumed that this is not a static mapping and different CoS/QoS schemes may be used internally within different domains, and CoS/QoS capabilities may evolve differently from domain to domain. Thus, this creates a need for efficiently supporting announcement and negotiation of CoS/QoS capabilities and mappings used for each (group of") interconnect relationship.

An alternative to this flexible scheme is to have static international agreements and no management system support for announcement and negotiation of service and CoS/QoS capabilities. A cost-benefit analysis may be needed to conclude on the preferred strategy. The functionality identified below assumes the dynamic approach.

However, in any case there is a need for some resource reservation scheme. As pointed out in Section II above, this can be done in several ways with different levels of granularity. Depending on the chosen scheme the management systems or Network Resource Control and Management systems will be involved in different ways.

SLA assurance is a crucial and challenging area. Procedures and international agreements must be developed to enable SLA assurance at various network levels and layers and corresponding SLA conformance reporting. Depending on the chosen scheme the management systems or Network Resource Control and Management systems will be involved in different ways.

IV. CONCLUSION

In this paper the approach represented in [5][6] is being followed further with recommendations according domains set up and interconnect scenarios for MMoIP networks interconnection. Some models are presented and future definitions are given. Also some management functionality requirements according interconnection of Multimedia networks are introduced.

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