MESCAL

Management of End-to-end Quality of Service
Across the Internet at Large

IST-2001-37961

D0.1: Project Presentation

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Abstract:	MESCAL aims to propose and validate scalable, incremental solutions that enable the flexible deployment and delivery of inter-domain Quality of Service (QoS) across the Internet. This involves developing: templates, protocols and algorithms for establishing Service Level Specifications (SLS) between Internet Service Providers (ISP) and their customers, including their peers; scalable solutions for inter-domain Traffic Engineering (TE) based on enhancements to the existing Border Gateway Protocol (BGP) routing protocol and associated route selection logic. MESCAL will consider both unicast- and multicast-based services and ensure that the proposed solutions are applicable to both IPv4 and IPv6.
Keywords:	MESCAL, QoS, SLS, BGP, TE, INTERNET, ISP, IP, MULTICAST, IPV6, IPV4

France Telecom Research and Development	FTR&D	Co-ordinator	France
Thales Research and Technology	TRT	Principal Contractor	UK
University College London	UCL	Principal Contractor	UK
The University of Surrey	UniS	Principal Contractor	UK
Algonet SA	Algo	Principal Contractor	Greece

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1 OBJECTIVES

The MESCAL (Management of End-to-end Quality of Service Across the Internet at Large) project's key objective is to propose and validate scalable, incremental solutions, enabling flexible deployment and delivery of inter-domain QoS across the Internet at large, with the following sub-objectives:

- To develop business models, based on current commercial practice and emerging business scenarios, describing the roles of and relationships between the stakeholders involved in providing QoS-based services across domains.
- To specify a generic, multi-domain, multi-service functional architecture for the flexible deployment and delivery of inter-domain QoS-based services.
- To develop templates, protocols and algorithms for the specification, negotiation, subscription and invocation of QoS-based IP services between customers and ISPs and between peer ISPs.
- To enhance existing inter-domain routing protocols and algorithms and to investigate new approaches to convey QoS information to enable scalable inter-domain traffic engineering solutions.
- To examine the impact of:
  - IPv6 on inter-domain traffic engineering and to ensure that the TE solutions proposed by the project are applicable to both IPv4 and IPv6 infrastructures.
  - both unicast- and multicast-based services on inter-domain TE.
  - inter-domain aspects of SLS management and TE on corresponding intra-domain aspects, and vice versa, and to investigate the co-operation required between them
- To adopt a policy-based approach to service provisioning and network operation and investigate policies for SLS negotiation, admission, and inter-domain TE.
- To evaluate and validate the devised algorithms and protocols through simulation and testbed prototypes.
- To contribute to international standardisation efforts, especially the IETF, and to participate in other consensus-forming activities in the IST programme.

2 DESCRIPTION OF WORK

In today's Internet, there are numerous relationships between a multitude of stakeholders who are each responsible for part of the provision of end-to-end connectivity and value-added services. Service and content providers rely on connectivity services provided by what could be termed a loose federation of organisations, which together provide end-to-end connectivity across the global Internet. No single organisation is responsible for vertical integration, in terms of applications over service providers over network connectivity, or horizontal integration, in terms of global geographical coverage.

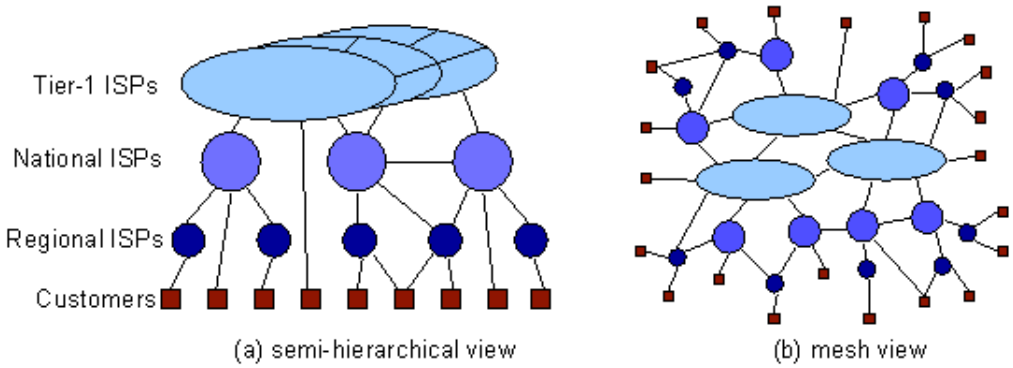

Figure 1: Many autonomous systems are involved in end-to-end service provision

A major limitation of the Internet is its lack of service level guarantees due to its basic design for best-effort packet delivery. The introduction of the IP Differentiated Services framework and subsequent research and standardisation efforts, represent significant progress on solving the problem of QoS delivery in a single domain for unicast traffic. However, inter-domain communication and information access is the rule rather than the exception, and extensive deployment of QoS-based services will not take place unless they can be offered across domains. The provision of end-to-end QoS is a wide-open research issue whose solution will transform the Internet to the global multi-service network of the future.

MESCAL views two major aspects as essential to the deployment and delivery of inter-domain QoS-based IP services: the definition of QoS-based connectivity services to be provided by stakeholders; and second, the means to engineer network resources to meet agreed performance and capacity targets for the contracted services. Together, these two dimensions aim at providing the means for a dynamically configurable Internet, with service requirements driving traffic engineering to meet end-to-end service demands.

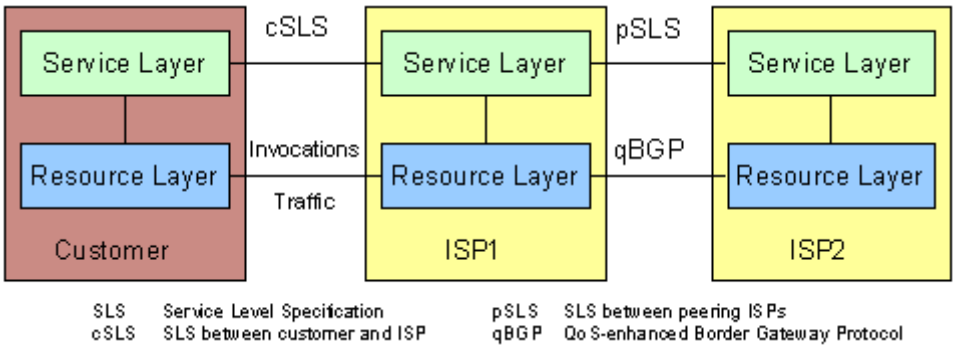

Figure 2: Inter-domain interactions at service and resource layers

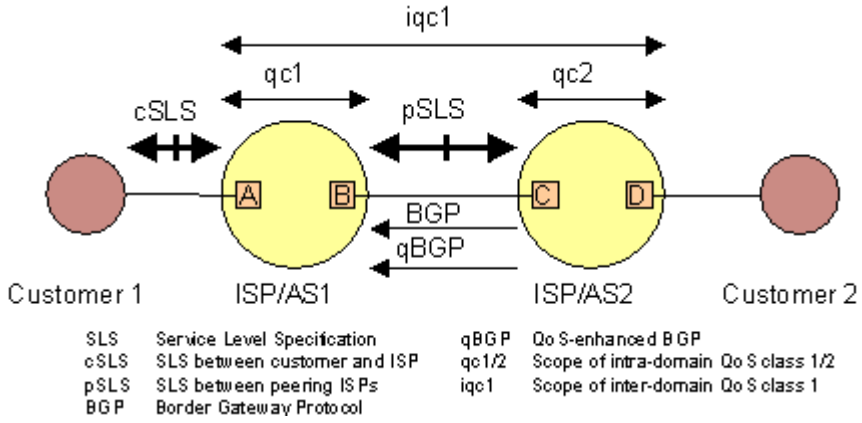

Figure 3: Building inter-domain QoS classes from intra-domain capabilities

3 OVERVIEW OF EXTERNAL LIAISON WITHIN AND OUTSIDE OF IST PROGRAMME

In order to avoid duplicated research efforts and to take advantage of other related work, studies that will be conducted within the context of the Mescal project will closely follow the work achieved within a set of external activities (like IST projects, IETF and IRTF activities) which deal with some of the Mescal's research items. A temporary and non-exhaustive list of these activities is provided in annex A.

4 MILESTONES AND EXPECTED RESULTS

The project is structured around four Work Packages:

WP0, *Project Management and Co-ordination of External Liaison,* is concerned with the administrative and technical management of the project, including liaison with other projects and co-ordination of dissemination and standardisation.

WP1, *Specification of Functional Architecture, Algorithms and Protocols,* is responsible for defining a business model and a generic, multi-domain, multi-service IP QoS functional architecture for inter-domain QoS delivery. The main output will be the specification of algorithms and protocols for negotiation and establishment of inter-domain SLSs, inter-domain TE and routing, including the required interactions with intra-domain TE and route computation capabilities to achieve inter-domain QoS delivery.

WP2, *System Design and Implementation,* will enhance experimental routers and simulators to support the inter-domain QoS requirements of the project. Based on the specifications from WP1, WP2 will design and implement the specified algorithms and protocols, as both testbed prototypes and simulation tools/models. WP2 will deliver prototypes and simulators to WP3 in an incremental way to allow experimentation activities to take place.

WP3, *Integration, Validation and Experimentation,* is responsible for setting-up the required experimentation infrastructure and for performing validation and performance evaluation activities on the prototypes and simulators developed by WP2. The testbed experiments are focussed on proof-of-concept validation, while the simulation experiments aim at assessing the performance and scalability of the project's inter-domain solutions.

The following milestones have been scheduled:

M2.1 - July 2003, release of customised routers and simulation tools enhanced with basic capabilities

M2.2 - April 2004, initial release of simulators and testbed prototypes for performance evaluation and validation

M0.1 - July 2004, MESCAL workshop on advances in inter-domain QoS delivery of IP services.

M3.1 - August 2004, feedback of interim results: validation and performance assessment of algorithms and protocols for inter-domain QoS through service-driven traffic engineering.

M2.3 - October 2004, final delivery of simulators and testbed prototypes for inter-domain SLS management, traffic engineering and dynamic routing.

5 LIST OF PARTICIPANTS

- France Telecom R&D, France (co-ordinator)
- Thales Research Limited, UK
- Algonet SA, Greece
- University College London, UK
- University of Surrey, UK

In addition, the consortium will collaborate with Cisco Systems and Alcatel Bell. Cisco is a sponsor of the project and MESCAL will collaborate with Alcatel on standardisation activities.

6 TOTAL COSTS AND COMMUNITY FUNDING

The total estimated eligible costs of the project are **3,330,071 €** (THREE MILLION THREE HUNDRED THIRTY THOUSAND SEVENTY-ONE Euro).

The community will fund the eligible costs of the project up to a maximum of **2,096,009 €** (TWO MILLION NINETY-SIX THOUSAND NINE Euro).

7 PROJECT START AND DURATION

The duration of the project is **30 months** from **01 November 2002**.

8 CO-ORDINATOR CONTACT DETAILS

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9 WEB SITE

A dedicated Mescal Web site has been set-up http://www.mescal.org/ where additional information can be found. Of course, it is intended to regularly update its content depending on the progression of the work.

ANNEX A

FORESEEN EXTERNAL LIAISONS WITHIN AND OUTSIDE OF IST PROGRAMME

A.1 - IST PROJECTS

AQUILA (Adaptive Resource Control for QoS Using an IP-based Layered Architecture)

AQUILA defines, evaluates, and implements an enhanced architecture for QoS in the Internet. The project assumes the DiffServ architecture, which has been extended by AQUILA in order to avoid the statically fixed pre-allocation of resources to users. Dynamic adaptation of resource allocation to user requests is enabled in a way that keeps the overall architecture scalable to very large networks. The main features of the AQUILA architecture can be summarised in the following paragraphs.

The Resource Control Layer (RCL) is an overlay network on top of the DiffServ core and provides an abstraction of the underlying layers. The RCL mainly has three tasks: to monitor, control and distribute the resources in the network by the Resource Control Agent (RCA); to control access to the network by the Admission Control Agent (ACA); to offer an interface of this QoS infrastructure to applications by the End-user Application Toolkit (EAT).

The Resource Control Agent, as a generalisation of the concept of the Bandwidth Broker, is a node representing a portion of the IP network, which internally has the same QoS control mechanisms. Resource distribution is performed by the RCA in a hierarchical manner using so-called *Resource Pools*. For this purpose it is assumed, that the DiffServ domain is structured into a backbone network, which interconnects several sub-areas. Each sub-area injects traffic only at a few points into the backbone network. This structuring may be repeated on several levels of hierarchy.

The Admission Control Agent performs local admission control, and is associated with the ingress and egress edge router or border router. The ACA will just allocate and de-allocate resources from its associated share.

The End-user Application Toolkit (EAT) is middleware between the end-user applications and the AQUILA network infrastructure. It aims to provide access to QoS features for Legacy as well as QoS-aware Applications.

AQUILA has adopted Border Gateway Routing Protocol (BGRP) for Interdomain QoS. The basic idea of BGRP is the aggregation of reservations along the sink trees formed by the BGP routing protocol. A BGRP agent is associated with each border router. These agents interact with the AQUILA intra-domain resource control layer in the following way: Inter-domain resource requests are initiated by the ACA associated with the egress border router of the initiating domain and sent to the corresponding BGRP agent; and BGRP agents associated with ingress border routers use the ingress ACA to establish intra-domain resource reservations. Reservations for the same destination AS are aggregated at each BGRP agent which implies that the number of simultaneous active reservations at each domain cannot exceed the number of autonomous systems in the Internet; and the source and destination addresses cannot be carried in the reservation requests between domains, because of the aggregation mechanism.

Although AQUILA is drawing to an end MESCAL will look very closely at their results in the area of inter-domain QoS through BGRP and collaborate with them through discussions in the context of the Premium IP cluster.

Project URL: http://www.ist-aquila.org/

CADENUS (Creation and Deployment of End-User Services in Premium IP Networks)

CADENUS is building an integrated solution for the dynamic creation, configuration and provisioning of end-user services with QoS guarantees in Premium IP networks. Much emphasis is placed on the business processes involved throughout the chain of events, and in this respect the software implementation is based on the commonly used ebXML. Network Management aspects (especially the relationship with the TMForum's Telecommunication Operators Map) and security (at all levels throughout the architecture) are also addressed.

The CADENUS solution is based on an architecture which includes key functional blocks at the user-provider interface, within the service provider domain, and between the service provider and the network provider. The three key components are: Access Mediator, Service Mediator and Resource Mediator. The overall mediation procedure includes the mapping of user-requested QoS to the appropriate service-/network- resources, taking into account existing business processes.

The Access Mediator is the point of access for a user to the CADENUS system. It performs AAA aspects; presents the services to the user; acts both as a registry and as a repository of information pertaining to the user's profile and the services he/she has subscribed to; performs SLA compliance checking.

The Access Mediator may form associations with one or more Service Mediators to which requests are issued. Generally off-line, the Service Mediator supervises the incorporation of new services, their presentation in the "Service Directory", and the management of the physical access to these services via the appropriate underlying network, using the Resource Mediator(s).

The Service Mediator: Performs AAA aspects; Checks for SLA compliance (including monitoring); Quantifies the resource requirements (translates the SLA into an SLS); Supervises service integration, including generating entries into a Service Directory (for subsequent presentation to users).

In the case that several underlying administrative domains are involved, the Service Mediator may (if it is aware of all the administrative domains) sub-divide the request from the Access Mediator into multiple SLSs ("hub" model); else it passes the SLS to the first Resource Mediator and relies on it to pass on a modified SLS to the adjacent domain ("cascade" model).

There is one Resource Mediator per Autonomous System, and one Network Controller for each network technology within that domain. The Resource Mediator is associated with the underlying network and its capabilities for supporting QoS, but the communication between the Service Mediator and the Resource Mediator is generic (i.e. independent of the technology employed by the underlying network). This interface conforms to the TEQUILA SLS. Subsequent reservations are made between the Resource Mediator(s) and the appropriate networks via the Network Controllers.

Although CADENUS is due to end in mid 2003, MESCAL will study their emerging results on SLS splitting and inter-domain service mediation, and collaborate with them through the Premium IP cluster.

Project URL: http://www.cadenus.org/

ATRIUM (A Testbed of Terabit IP Routers running MPLS over DWDM)

ATRIUM aims to develop an advanced testbed for the experiment and the validation of an Advanced Terabit Router - the Alcatel 7770 Routing Core Platform - as both a core and border router, and to offer this advanced testbed to other RTD projects. The project is developing traffic management algorithms and protocols for MPLS based and DiffServ-capable ASs. This includes a generic set of traffic engineering tools and protocols necessary for the interconnection of a DiffServ capable, MPLS-based AS with other ASs with similar capabilities. A generic framework will be realized to efficiently support QoS and fast restoration across interdomain boundaries in MPLS based networks. Members of ATRIUM have published several relevant papers/drafts on inter-domain QoS such as traffic engineering through redistribution communities, inter-domain traffic characterisation and the use of BGP to distribute QoS information.

ATRIUM will end in mid 2003. MESCAL will study the ATRIUM results on inter-domain traffic engineering and may initiate a closer collaboration to exchange ideas on wider inter-domain QoS issues.

Project URL: http://world.alcatel.be/atrium/index.htm

PREMIUM IP CLUSTER

The Premium IP cluster was formed from three core IST projects: AQUILA, CADENUS and TEQUILA. The projects studied/are studying IP Quality of Service support in large IP networks with a similar top level objective: providing Premium IP services over the Internet as a basic step towards the Next Generation Networks of tomorrow. The existence of three projects within the cluster gives the opportunity to tackle the problem from different angles and to highlight different aspects, with the following benefits:

- Investigation of different aspects of the same global problem, e.g. service creation by CADENUS, operational service and resource management interworking by TEQUILA, and resource optimisation by AQUILA.
- Investigation of different solutions for the same problem, e.g. MPLS (off-line) traffic engineering in AQUILA, both MPLS and IP TE in TEQUILA and MPLS and DiffServ in CADENUS.
- To allow the different teams to work together on the same problem and enhance proposed solutions from individual projects. For example, the definition of the IP Connectivity Service Level Specification was first proposed by TEQUILA and then discussed and improved by inter-project collaboration.

TEQUILA (www.ist-tequila.org) completed in 2002 and, being formed by a set of key partners from the TEQUILA consortium, the MESCAL project is building on the TEQUILA intra-domain and SLS management results. In particular the TEQUILA SLS template is being extended for inter-domain usage in MESCAL.

The Premium IP cluster produced a joint deliverable to describe the objectives, architecture, service and resource management approaches of the three projects. The common goal of the projects as well as differences and their complementary approaches were compared. In addition, the document reported on current co-operative activities like Monitoring and Measurement or contributions to IETF, as well as on activities such as collaboration with other IST projects and validation through trials.

Other IST projects were associated with the Premium IP cluster, including: M3I, QoSIPS, DePAuDE, GCAP, FORM, MOEBIUS and SEQUIN.

- *M3I* (Market Managed Multiservice Internet) designed and implemented a next-generation system, to enable Internet resource management through market forces, specifically by enabling differential charging for multiple levels of service. M3I ended December 2001.
- *QoSIPS* (Quality of Service and Pricing Differentiation of IP Services) developed technologies for supporting QoS management, service differentiation and price setting of Internet Protocol Network Service Providers. QoSIPS ended July 2002.
- *DePAuDE* (DePendability for embedded Automation systems in Dynamic Environments) includes the design of a new architecture for dependable dedicated (intra-site) and IP (inter-site) mechanisms. DePAuDE is due to complete in March 2003
- *GCAP* studied end-to-end multimedia multicast transport protocol for supporting dedicated or specialised applications having guaranteed QoS requirements. Their QoS architecture was based on IPv6 and DiffServ, and used an active network based technology. GCAP completed in January 2002.
- *FORM* developed services, systems and components aimed at managing outsourced, co-operative, inter-enterprise („interprise“) facilities. FORM completed in April 2002.

- *MOEBIUS* integrated an IP-based, mobile Extranet platform, exploiting state-of-the art technologies in the telecommunication and information technology areas. The platform was used for applications in different sectors, i.e. health care, and remote control, in order to demonstrate the benefits for end users in public health, business and residential environments. MOEBIUS completed in December 2001.
- *SEQUIN* defined and implemented an end-to-end approach to Quality of Service across multiple management domains with a combination of IP and ATM technology. SEQUIN completed in January 2002.

MESCAL is a member of the Premium IP Cluster, although the cluster will probably end by mid 2003 as the other projects terminate.

INTERMON (Advanced architecture for INTER-domain quality of service MONitoring, modeling and visualisation):

The objective of INTERMON project is to develop an integrated inter-domain QoS monitoring, analysis and modeling system to be used in multi-domain Internet infrastructure for the purpose of planning, operational control and optimization.

Project URL:http://www.ist-intermon.org/

SCAMPI (A Scaleable Monitoring Platform for the Internet):

The objective of SCAMPI project is set to develop an open and extensible network monitoring architecture including to develop a passive monitoring adapter initially at 10 Gbps speeds, and other measurement tools to be used for denial-of-service detection, SLS auditing, quality-of-service, traffic engineering, traffic analysis, billing and accounting.

Project URL: http://www.ist-scampi.org/

MoMe (Cluster of European Projects aimed at Monitoring and Measurement)

The focus of MoMe is the enhancement of Inter-domain real-time QoS architectures with integrated monitoring and measurement. The IST projects participants in this cluster are CADENUS, INTERMON, AQUILA, NGNI, and ATRIUM.

Project URL:http://www.ist-mome.org/

IST IPv6 activities: Many IST projects are dedicated to IPv6 or contain work items dealing with IPv6 technology. These projects cover a broad range of IPv6 aspects (like network deployment, QoS and mobility). IPv6-related IST projects are represented in the IPv6 Cluster by individuals from their project teams. The Cluster aims to include all IST projects with an IPv6 component or an interest in IPv6 technology.

Cluster URL: http://www.ist-ipv6.org/

GCAP (Global Communication Architecture and Protocols for new QoS Services over IPv6 networks)

CAP aims at developing for the future Internet two new end-to-end multicast and multimedia transport protocols, embedded in a new global architecture to provide a guaranteed QoS to advanced Multimedia Multipeer Multinetwork applications.

In order to rapidly experiment the proposed solutions, an efficient deployment of the communication software will be developed over an industrial IPv6 layer by using a programmable active network based technology.

Project URL: http://www.laas.fr/GCAP/

GEOCAST (MultiCAST over GEOstationary Satellite)

The objective of GEOCAST is to address the issues raised by the deployment of multicast services over existing and future broadband multimedia satellites.

Such satellites are expected to operate at higher frequency bands (Ka band) and to bear more complex payloads (on-board processing, multiple beams, and optical inter-satellite links...). In order for operators to develop multicasting solutions, it is important to ensure that these satellite constraints are taken into account in the standardisation bodies in order to deliver compliant products and systems for a wide and seamless commercial implementation.

Project URL: http://www.geocast-satellite.com

ICEBERGS (IP ConferEncing with Broadband multimedia ovER Geostationary Satellites)

The objectives of ICEBERGS are the provision of business class and consumer IP based multiparty multimedia conversational services and broadband multicasting services to both fixed, and portable/mobile users, with guaranteed QoS, represents a challenge for next generation networks.

ICEBERGS aims to demonstrate and qualify the service performance with an extensive trial campaign involving both satellite and an Internet segment upgraded to provide QoS support and to contribute to standardisation activities proposing optimised solutions for protocols, interworking techniques and multicast routing in the frame of IETF and ETSI.

Project URL: http://icebergs.tid.es

A.2 - INTERNET ENGINEERING TASK FORCE (IETF)

nsis (Next Steps in Signaling): The main goal of this working group is to develop the requirements, architecture and protocols in order to form a solution for signaling QoS end-to-end spanning across several administrative domains by using the existing signaling protocols as the basis for its work.

Group URL: http://www.ietf.org/html.charters/nsis-charter.html

idr: The Inter-Domain Routing Working Group is chartered to standardize and promote the Border Gateway Protocol Version 4 (BGP-4) capable of supporting policy based routing for IPv4 et and IPv6.

Group URL: http://www.ietf.org/html.charters/idr-charter.html

ospf: The OSPF Working develops and documents extensions and bug fixes to the OSPF protocol, as well as documenting OSPF usage scenarios.

Group URL: http://www.ietf.org/html.charters/ospf-charter.html

ptomaine (The Prefix Taxonomy Ongoing Measurement & Inter Network Experiment): the main goal of this WG is to consider and measure the problem of routing table growth and possible interim methods for reducing the impact of routing table resource consumption within a network and the global Internet.

Group URL: http://www.ietf.org/html.charters/ptomaine-charter.html

v6ops: The IPv6 Operations Working Group (v6ops) develops guidelines for the operation of a shared IPv4/IPv6 Internet and provides guidance for network operators on how to deploy IPv6 into existing IPv4-only networks, as well as into new network installations.

Group URL: http://www.ietf.org/html.charters/v6ops-charter.html

ipv6: This working group focuses on completing the remaining work items not completed in the IPng WG (for example, the Flow Label standardization,...) and providing a home for IPv6 work that spans multiple IETF working groups.

Group URL: http://www.ietf.org/html.charters/ipv6-charter.html

rap: The Resource Allocation Protocol (rap) working group defines general-purpose objects that facilitate the manipulation of policies and provisioned objects available through COPS and COPS-PR. Where appropriate, these include frameworks clarifying the applicability of COPS objects and the best practices for the definition of additional objects defined in other working groups.

Group URL: http://www.ietf.org/html.charters/rap-charter.html

midcom: The Middlebox Communication (midcom) working group studies the protocols available or to be specified to allow application to communicate their needs to the devices in the network that provide transport policy enforcement. The group focuses its attention on communication with firewalls and network address translators (including translation between IPv6 and IPv4).

Group URL: http://www.ietf.org/html.charters/midcom-charter.html

magma (Multicast & Anycast Group Membership): This working group is responsible for developing the functionalities required for group membership reporting and other related actions. Current activities of the working group include development and standardisation of Internet Group Management Protocol (*IGMP*) version 3 for *IPv4* multicast and Multicast Listener Discovery (*MLD*) version 2 for *IPv6* multicast.

Group URL: http://www.ietf.org/html.charters/magma-charter.html

bgmp (Border Gateway Multicast Protocol): Multicast Border Gateway Protocol (*MBGP*) has been proposed as a long-term and scalable solution for Internet-wide inter-domain multicast routing. The *BGMP* working group is chartered to complete the protocol specification and follow it through the Internet standards track.

Group URL: http://www.ietf.org/html.charters/bgmp-charter.html

idmr (Inter-Domain Multicast Routing): This working group was charted to focus on inter-domain multicast solutions and was dis-bound in 2002. Some of the work previously done in *IDMR* has moved to the *MAGMA* working group.

Group URL: http://www.ietf.org/html.charters/idmr-charter.html

msdp (Multicast Source Discovery Protocol): MSDP is a near-term solution for connecting shared trees (e.g., *CBT* or *PIM-SM*) without the need for inter-domain shared trees. The main functionality of *MSDP* is to discover active sources in foreign domains for a particular group. The *MSDP* working group will be charged with standardizing *MSDP*, but it is envisioned that this working group will have a fairly short live span.

Group URL: http://www.ietf.org/html.charters/msdp-charter.html

pim (Protocol Independent Multicast Protocol): *PIM-SM* (*PIM* Sparse Mode) has become the most popular routing protocol for intra-domain multicast. The working group is chartered to standardise and promote the Protocol Independent Multicast Version 2 (*PIMv2*), Sparse Mode and Dense Mode, as a scalable, efficient and robust multicast routing protocol, capable of supporting thousands of groups, different types of multicast applications, and all major underlying layer-2 sub-network technologies.

Group URL: http://www.ietf.org/html.charters/pim-charter.html

ssm (Source-Specific Multicast): Source Specific Multicast has been proposed as a scalable multicast service model as an alternative solution to *IP* multicast (*RFC 1112*). The purpose of the working group is to define source-specific multicast in order to provide unambiguous semantics to the designers of the protocols and host interfaces used in conjunction with source-specific multicast. The working group has submitted Internet draft on *SSM* deployment to *IESG* for consideration as an Informational *RFC*.

Group URL: http://www.ietf.org/html.charters/ssm-charter.html

malloc (Multicast-Address Allocation): Multicast address allocation is an essential part of using IP multicast. Multicast addresses are an even more limited resource than unicast addresses, and must be allocated dynamically if they are to satisfy expected demand. To this end, the *MALLOC* working group defines three protocols which work together to form a global dynamic multicast address allocation mechanism, namely *MADCAP*, *AAP* and *MASC*.

Group URL: http://www.ietf.org/html.charters/malloc-charter.html

msec (Multicast Security): The purpose of the working group is to standardise protocols for securing group communication over the global Internet. Initial efforts focused on scalable solutions for groups

with a single source and a very large number of recipients. Additional emphasis is made on groups where the data is transmitted via *IP*-layer multicast routing protocols (with or without guaranteed reliability). The working group is expected to be dis-bound by 2002.

Group URL: http://www.ietf.org/html.charters/msec-charter.html

rmt (Reliable Multicast Transport): The purpose of this working group is to standardise reliable multicast transport. This working group expects to standardise three protocol instantiations, one each from the following three families: 1) A NACK-based protocol 2) A Tree-based ACK protocol 3) An "Asynchronous Layered Coding protocol that uses Forward Error Correction"

Group URL: http://www.ietf.org/html.charters/rmt-charter.html

A.3 - INTERNET RESEARCH TASK FORCE (IRTF)

rmrg (Reliable Multicast Group): The RMRG purpose is collectively to solve some hard problems about reliable multicast transport protocols. Among the critical topics are:

1. Specializing protocols to their applications given the wide range of the different requirements for reliability (from none to TCP-like byte-streams, with many shades and variations in between).
2. Solving congestion control for RM transports; understanding the interaction among RM transports, unreliable multicasts, TCP applications, and unicast non-TCP applications.
3. Generalizing one-to-many reliable multicast techniques and algorithms for many-to-many protocols.

On the level of the human organization, the RMRG strives to decrease the amount of "ships in the night" research on RM, and to increase the shared grounds of debate among the active researchers in the field.

Group URL: http://www.east.isi.edu/RMRG

rrg (Routing Research Group): The Internet Research Task Force Routing Research group is chartered to explore routing problems that are important to the development of the Internet but are not yet mature enough for engineering work within the IETF. The group will work closely with the IESG Routing Area Director to ensure the free flow of information in both directions and avoid duplication of work with the various IETF working groups.

Group URL: http://www.irtf.org/rrg/