Information Society Technologies

MOME
Monitoring and Measurement Cluster – 001990

D03 - MOME Final Project Report

Abstract

The MOME cluster offers a platform for knowledge and tool exchange and for coordination of activities in the field of IP monitoring and measurement between current and upcoming IST projects and other European partners. This document contains the Final Public Project Report of the MOME cluster project [1], highlighting the most important achievements taken throughout the lifetime of MOME. Further it concludes with the documentation of the MOME platform enabling the continuation of collection and dissemination of information about monitoring and measurement tools and data also after the lifetime of the project.

Keywords

MOME, Monitoring, Measurement, Measurement Tools, Standardisation, Measurement Data

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Table of Contents

List of Figures

List of Tables

Executive Summary

This document, Deliverable D03, represents the final project report of MOME, highlighting the most important achievements taken throughout the lifetime of MOME. The MOME project started in January 2004, collecting the requirements from running IST and other European projects. Beginning of 2005, the MOME database went online, containing information about measurement tools and measurement data available throughout the Internet.

This summary contains the main achievements per workpackage, which are described in more detail in the body of this deliverable.

In WP1, the workpackage dealing with interoperability issues of measurement tools was targeted to evaluate and document well-known and useful monitoring and measurement tools, components and interfaces and publish the results. This has been reached by the design and implementation of the MOME interoperability database, now including a total of more than 100 tools. Finally, a major highlight of WP1 was the successful interoperability event co-located with the 63rd IETF meeting in Paris, attracting 44 engineers from 18 companies with 14 protocol implementations.

WP2, dedicated to the collection and dissemination of information related to monitoring and measurement data achieved its objectives by the design and implementation of a measurement meta-database, and the MOME data analysis workstation, which has drawn the attention of the research community as a complement to the efforts in the field of the Internet measurements initiative of the USA led by CAIDA. After one year of uptime of the database, more than 3500 data sets are available in the database.

WP3, dealing with the standardisation process in the field of monitoring and measurement, with the main objectives to build a strong European position in standardisation in the MOME area and to initiate, plan, and coordinate related contributions to the IETF and other bodies, co-ordinated a standardisation team to work out a standardisation plan containing the standardisation requirements of European projects in the area of MOME.

WP4 was responsible for the dissemination of the project achievements and the organisation of workshops and conference sessions. Therefore a web-site, an announcement mailing list and dissemination material for several events have been prepared. The whole infrastructure will be kept available also after the runtime of the MOME project. A workshop series (IPS2004, IPS-MoMe 2005 and IPS-MoMe 2006) has been started, and is planned to be continued by related activities or projects. Outcome of the good dissemination work is the world-wide visibility of the MOME project was e.g. the investigation of the MOME database approach to CAIDA, the world-wide leading research institute on IP monitoring and measurements.

Finally, the valuable contacts established during the lifetime of MOME will be continued in future work of the consortium participants.

1 Introduction

The overall objective of the MOME project was to co-ordinate activities in the field of IP monitoring and measurement by offering a platform for knowledge, tool and data exchange. As depicted in Figure 1-1, the work has been carried out in three columns:

- Measurement Tools
- Measurement Data
- Measurement Standardisation

These columns are based on the dissemination work to build a knowledge exchange platform in the field of IP monitoring and measurement.

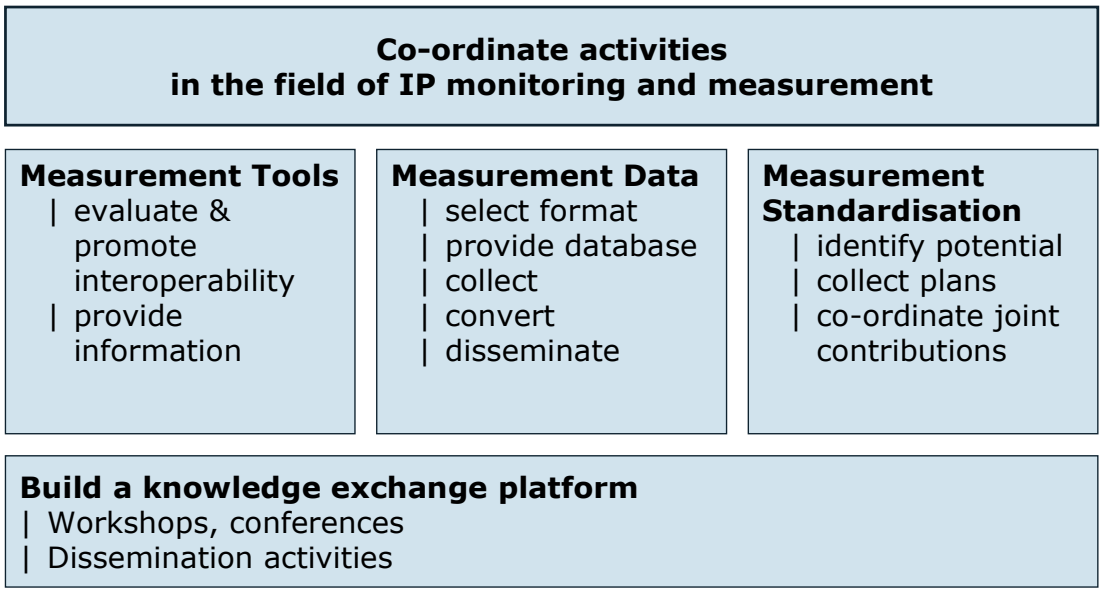


Figure 1-1 The MOME project objectives

The MOME project started in January 2004, with the creation of a first questionnaire, in order to collect the requirements from different projects in the area of IP monitoring and measurement. Based on these results, the design of the MOME database was made, and the standardisation plan has been developed. Early 2005, the MOME database went online, containing an initial set of tools and measurement data. One year later, the database contains more than 100 tools and more than 3500 sets of meta-data, many of them analysed by using the analyse facilities provided by the MOME workstation.

Figure 1-2 shows the logical structure of the MOME workstation. The data repositories for measurement tools and measurement data are accessible via a web-based user interface (WWW-GUI), offering search functions to search for specific attributes of the database entries. The design of the database allows different kinds of measurement data to be stored, either linking to a raw data repository, or only storing e.g. a link to a base URL of a web-site providing measurement data. In case raw data is available, it can be accessed through links stored in the meta-database. The independent raw data repositories are checked regularly, and the data is updated accordingly. Further, registered users can schedule analysis task of measurement data through the web-based user interface. This causes the MOME analysis workstation to automatically download and analyse the measurement data. The WWW-GUI is integrated in the MOME project web-site.

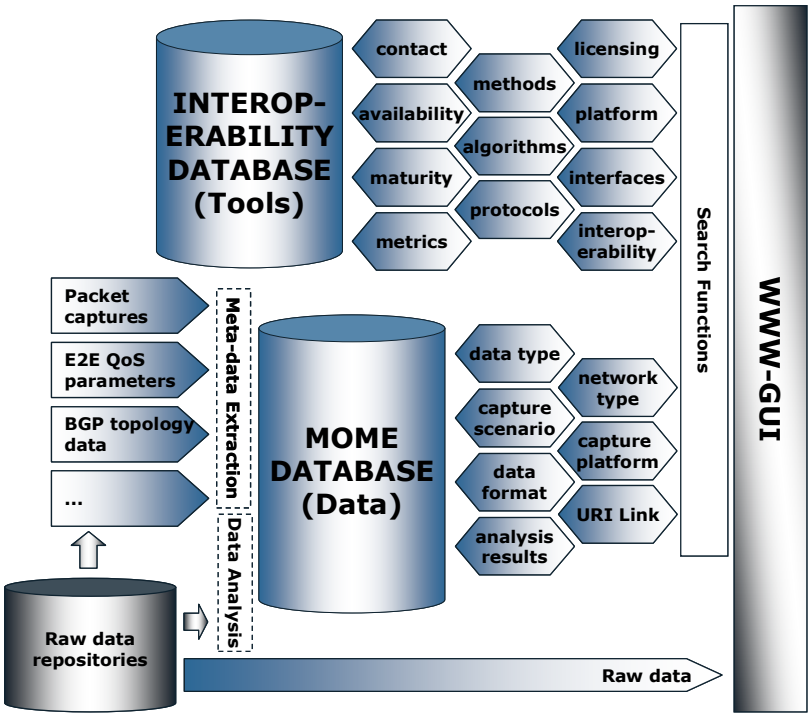


Figure 1-2 MOME Technical Approach

The remaining document is structured as follows: After this short introduction, Section 2 contains the main achievements from the four workpackages of MOME, which are WP1 – Interoperability, WP2 – MOME Database, WP3 – Standardisation and WP4 – Dissemination. Afterwards, Section 3 describes in detail the plans of the MOME consortium about the continuation of the MOME infrastructure, including the MOME web-site with its user interface to the database and the related mailing lists, kept for communication between project partners. Finally, the document concludes with the documentation of the MOME platform enabling the continuation of collection and dissemination of information about monitoring and measurement tools and data also after the lifetime of the project by third parties, but also the description about the deployment, in order to be able to reinstall the MOME system if necessary.

2 Final Report by Workpackage

2.1 WP1 – Interoperability

The goals of MOME WP1 cover topics which aim to foster the interoperability between monitoring and measurement related tools and components developed or used within IST projects.

Monitoring and measurement functions are often needed in applications for tasks such as accounting, QoS-based admission control, traffic shaping, network planning, or incident detection. To make efficient use of existing tools and integrate them it is important to learn about the functions they can provide, the input they work on, the kind of output data they generate and the associated data formats and data transmission protocols. Only with knowledge of these an informed decision can be made.

Often more than one tool needs to be used to implement a solution to a specific goal. In that case one needs to understand which protocols are available to exchange control information and measurement results between tools and which tools support these so they can be used in conjunction. In order to increase interoperability it is vital to understand and support the related and upcoming standards in this area and to support them in case of newly developed tools within projects.

Goals of MOME WP1
The Interoperability workpackage WP1 is targeting to evaluate and document well-known and useful monitoring and measurement tools, components, and interfaces, either externally available or self-developed by IST projects. Information about these tools shall be made available publicly and allow a user to search for specific tool attributes. This will be achieved by providing an open database which can be accessed via the Internet. MOME partners as well as external contributors shall continuously update this knowledge exchange platform by documenting (new) tools and providing user comments. Guidelines in the form of tools selection help will be generated by MOME and published on the web. During the data collection on tools MOME shall thereby evaluate on what protocols and/or tools observed IST-projects would be able to cooperate and to build new contacts between them. In addition interoperability events will be organised for face-to-face interoperability tests on new protocols.

2.1.1 Summary of Workplan

The objectives of MOME WP1 are to:
- collect a detailed overview on existing MOME tools
- collect information about tools developed or used within started IST project
- build a tools taxonomy for categorization
- build an open database for storing and a front-end for presenting data about those tools
- maintain the MOME tools database and fill it with our evaluation results
- provide convenient search on tools, features, and interoperability
- let users extend tool entries, and add comments helpful to other users
- evaluate tools and interfaces from IST projects
- perform interoperability tests
- promote interoperability by disseminating information about tools and their use in projects
- consult projects, and help them choosing protocols and tools
- organise interoperability events to check interoperability between projects

2.1.2 Highlights

The main achievements of MOME WP1 with respect to its objectives are:
- A survey on tools has been performed and was continued throughout the project lifetime.
- A taxonomy for tools (see D11 [2]), has been derived, including coverage of wireless, IPv6, and security tools as well as categories for input, output, and measurement metrics support.
- Generate an overview page documenting the diverse tool categories with tools suggestions.
- Build a framework and the MOME database and the tools database part.

- Over 400 tools have been detected, and more than 100 have been entered by MOME partners and invited maintainers into the tools database. External partners will take over editorship for specific tool database entries.
- Input on use of tools was collected from IST projects via two questionnaires (2004 + 2005).
- MOME organised an Interoperability Event in July 2005 in Paris, covering NETCONF, IPFIX, PSAMP, and NSIS protocols. Forty four (44) engineers representing eighteen (18) companies with fourteen (14) implementations attended the event. Tests were performed in protocol specific groups with four to six implementations per group (see D13 [4]). A 2nd IPFIX test event took place in the beginning of March 2006 in Salzburg, Austria.
- MOME has documented tools in use by IST projects in D23 [7] and in the database. From the following projects tools were developed: BROADWAN (IPANEMA), DAIDALOS (OpenIMP), EUQOS (NetMeter, LLMT, Oreneta, TrTG, TAT), EuroNGI (Distributed Passive Measurement Infrastructure (DPMI), J-OWAMP, Saturne), EVEREST (Oreneta), GEANT/Dante (Taksometro, Mezeuon), LOBSTER (Stager), MESCAL (QARobots). Almost all of these have been documented in the MOME database.
- Dissemination activities of MOME on workshops and concertation meetings show our progress and facilitate new contacts.

2.1.2.1 Tools survey

In order to get an idea of the state of interoperability in the monitoring and measurement tools area, we analysed the existing measurement and monitoring tools. More than 400 measurement related tools were found in various tool repositories and projects websites. A majority of the tools found are freely available. Yet a great number are commercial tools. About 58 tools have been initially selected and reviewed. Those selected tools were categorised and constituted the starting set of tools for the Tools database content.
The preliminary review results were documented in D11 [2]. Tools review was a permanent activity throughout the MOME project lifetime.
Identifying monitoring and measurement tools for wireless and IPv6 networking environments was an important goals achieved with about 19 IPv6 tools and 20 wireless tools available in the MOME database.

To classify the tools under evaluation, a **taxonomy** which specifies the attributes and the characteristics of the tools was defined. Examples of criteria of interest are: Description, Category, Contact, Availability, Supported systems, Active/passive, Control input, Data input, Metrics/functions, Data output, Time scope, Aggregation…

Then, an overview of **standards**, in measurement and data export, for tools interaction was presented. Our tools evaluation work shows that most tools do not adhere to commonly used standards but instead rely on proprietary protocols.

2.1.2.2 Development of the Tools Database

After the tools survey, WP1 was involved in the database system design and implementation. The Tools database stores meta-data about the measurement and analysis tools, as well as information about registered users of the MOME workstation.

The database platform was built from scratch (see D12 [3]). WP1 was also responsible for running preliminary system tests on the platform and provide a system user manual.

The database can be reached via commonly used web browsers.

The first release of the Database was launched at the open MOME workshop IPS-MOME 2005 (March 14-15, 2005) in Warsaw, Poland.

2.1.2.3 Maintenance of the database

The database functionalities were continuously updated and enhanced. This includes enhancements on the user registration (invitation eMail), introduction page and categories overview, login procedure,

and maintenance functions such as an improved feedback page, and an automated URL checker for avoiding of stale tools entries.
The Tools database is updated with more tools, including IPv6 tools, wireless tools and tools used within IST projects.

2.1.2.4 Dissemination of the Tools database

All MOME partners regularly promoted the database at various events as explained in section 2.4.

2.1.2.5 MOME Interoperability Event

One of the WP1 major achievements in the second year of the project is the Interoperability Event organized, in Paris, France, on July 28-30, 2005, in cooperation with the IST Eurolabs project and the ETSI Plugtests Service.
The interoperability tests covered monitoring and measurement protocols such as IPFIX, NSIS, and NETCONF.
This event brings together developers to remove ambiguities and misinterpretations in the protocol standard, as well as in their implementations. Numerous enhancements have been incorporated into the different software implementations. In addition, feedback and questions for clarification have been collected and documented. These were presented during the IETF's working group's meetings in the week from August 1st to August 5th, 2005. On the whole, the event has provided unquestionably advances to the standardization process and allowed IST projects to work together on the same standards.

The following 6 EC projects have participated to the event: 5 EC FP6 IST projects (6QM, Eurolabs, EuQoS, DIADEM Firewall, ENABLE, and Daidalos II) and the EC EUREKA Celtic Project "VIDIOS".
Other interoperability events are planned e.g. the upcoming IPFIX Interoperability event during the IPS-MoME 2006.

2.1.3 Lessons learnt

2.1.3.1 Tools Interaction

The opportunities for interaction between tools in the area of traffic measurement and analysis were investigated. This is to show in which combination different tools can interact and what kind of information is exchanged during the process.
The interoperation of tools requires well-defined interfaces and agreed data structures between them. Unfortunately, in practice, tools interaction is achieved with different levels of sophistication because most tools do not comply with any standardized data formats, or standardized exchange protocols. In fact, tools rely on proprietary protocols, on proprietary command line interfaces or GUIs, and produce proprietary data output.
Moreover, the ability for remote control and data export is missing in most tools. Consequently, interaction with other tools is not always doable.

The following conclusions were drawn from the evaluation of tools interoperability:

- Interoperability is an underrated issue, often chances lay unused
- Most common denominator is the tcpdump tool for capturing traffic into data input files for other tools or the libpcap live packet capture library
- Some tools produce output directly suitable for visualisation tools such as gnuplot or rrdtool
- Conformance to standards such as IPFIX or PSAMP is not a goal in freely available tools
- A number of tools claim conformance to IPPM metrics (yet this was not verified)

2.1.3.2 Lack of standardization in tools

It can clearly be seen that the non-standard solutions are often prone to error due to lack of exhaustive documentation. Such approach is also problematic since data formats and exchange protocols may

change without further notice thus breaking the conversion routines when updating one of the involved software tools to a newer version.

When using tools which are compliant to a standard these problems are much less dominant because documentation is publicly available. Standards are also often designed to be backward compatible when a new version is deployed. Unfortunately the barrier to implement conformance to a standard is often quite high because some standards have a wide scope and supporting them in a tool can mean a considerable implementation effort. The big advantage is that it is possible to use any tool (e.g. select one of the plotting tools) from a set of conformant tools and choose the one best suited for processing the existing data sets.

2.1.3.3 Survey of MoMe IST Projects: Inter-project collaboration and overlaps

MOME identified more than 70 IST projects from which were selected a list of projects showing solid monitoring and measurements objectives. Two rounds of questionnaires were sent to those projects, the first in 2004 and the second in 2005. The latter was refined with the measurement chain (described in D23 [7]). Besides the analysis of their approaches in MoMe, inter-project cooperation was investigated.

The study shows that there are some areas in which overlaps exist. Overlaps in protocols are easily justifiable, since the protocols can carry data with quite different semantics. This is the main area for inter-project collaboration. Parallel implementation for newly developed protocols is valuable since different programmers can detect other protocol pitfalls and shortcomings. This approach also avoids a software "monoculture", i.e. only relying on one specific realisation of a protocol. Such approach can increase overall computer system safety.

Certainly, the exchange of information between European projects about measurement tools and assumed test scenarios is highly desirable. The analysis of the questionnaire answers and project deliverables allows us for pointing several projects that produced especially valuable results that could be studied by other projects working in similar or complementary research areas.

From our experience and the observations we made we can conclude that for the goal of fostering the common use of monitoring and measurement tool four preconditions are vital:

- a clearly targeted (and limited) application area for each tool
- clear, accurate documentation (function, installation, configuration, use)
- a company or community which keeps this tool up-to-date and provides support
- dissemination, i.e. public accessibility of tools, their documentation, and preferable use case examples. It is strongly suggested to publish such tools information clearly on project websites and to make use of open program databases for registering own developed tools, e.g. MOME, Souceforge, Freshmeat, Sourcewell.

If such preconditions are met then reuse or common use of monitoring and measurement tools can be facilitated no matter what their originating source is.

2.2 WP2 – MOME Data

2.2.1 Summary of Workplan

The objetives of the workplan of WP2 were:

- To define a database model according to the data formats selected by WP1
- To provide a workstation where the MOME database would be stored and measurements could be sampled and analysed
- To provide a Web interface to the MOME database
- To maintain the database throughout the lifetime of the MOME project

- To make sure that the collected measurement data includes packet traces, end-to-end performance measurements and network topology information.

2.2.2 Highlights

The main achievement of WP2 is the availability of the MOME database itself. It represents a platform for exchange of measurements between projects, which didn't exist before and which has drawn the attention of the research community [13] as a complement to the efforts in the field of the Internet measurements initiative of the USA led by CAIDA [14].

The OWAMP integrated tests were made possible by the collaboration of MOME and the EuroNGI project. This integrated tests included tool interoperability tests and worldwide measurements.

2.2.2.1 MOME Data Analysis Workstation

The implemented MOME Data Analysis Workstation, described in D22 [6], allows for performing selected analysis tasks on the measurement data annotated in the MOME database. The analysis results are available to all users and provide additional information about the contents of particular measurement data set.
Several external data analysis tools were integrated into the MOME system with the help of special adapters. They can be used for performing analysis tasks on packet-level traces stored in the formats of libpcap and DAG. However, notice that new analysis tools, aimed at supporting different analysis tasks and data formats, can be quite easily added.
The supported data analysis tasks include calculation of the empirical statistical parameters, like: average packet inter-arrival time, average packet size, packet size histogram, average packet rate and average bit rate. Additionally, the graphs illustrating the distribution of average bit rate per-transport protocol (TCP, UDP) and per application (identified by the port numbers) can be produced. Furthermore, the system allows for plotting the bit rate of traffic from the trace as a function of time. Together, these statistical parameters and graphs give the MOME database users basic information about the volume and type of traffic in particular measurement data set.

2.2.3 Lessons learnt

While the situation regarding tools for these environments is, generally speaking, good, it is not that encouraging regarding the availability of network traces for both environments. The main factors which explain the situation are:

- **technological:** research projects dealing with wireless communication in the IST realm are working on the physical layer (i.e. Radio communications). MOME is working at the IP layer.
- **legal reasons**: there is no legally sound framework which could give the researchers the confidence to publish the data without facing legal consequences (i.e. Violation of data privacy)
- **marketplace**: mobile operators monitor and measure their network, but these data are highly confidential, since they reflect the strengths and weaknesses of their network and could be used against them by competing operators.

To promote the exchange of measurement data, MOME has identified two aspects which need a thorough explanation to potential contributors:

- **Control over data**: the publisher wants to remain in control of the data, possibly limiting the people who can be granted access to them. Controlling when the data are published and having the possibility to withdraw those data from public access are critical to many people.
- **Anonymisation**: due to legal constraints, the data which are published have to be anonymised in such a way, that the source and destination can't be traced back. This requires in many cases to restrict the traces to IP packet headers with anonymised source and destination IP addresses.

While the latter is a requirement the publisher has tackle before publishing the data, the first is a critical trust building factor which needs to be taken care of in the decision process to publish data. These conclusions are aligned with studies performed by other projects, like LOBSTER, which conducted a user requirement survey for an Internet measurement device. The result of this survey is publicly available in [8].

2.2.3.1 Impact of change from database to meta-database

The MOME database proposed in the Technical Annex was conceived as an integrated machine with massive storage space dedicated to local storage of measurement traces and a database describing those locally stored measurement traces. This initial design decision was based on a thorough study of the state of the art as of the moment the MOME project proposal was written. MOME was, at that point, a state-of-the-art measurement repository in line with other similar projects.

During the design phase (as documented in Deliverable D21 [6]) a trend was observed in other measurement and monitoring projects, namely in the Cooperative Association for Internet Data Analysis (CAIDA) [14], which proposed a layered approach, similar to the approach proposed in the Technical Annex, but including the possibility of referencing external data repositories.

This slightly enhanced database layer, which contains information about specific measurements stored in local or remote repositories, is referenced to in the specialised literature as meta-database, since it is a database which holds data about data[1]. The MOME project also adopted this naming convention.

Technically speaking, integrating external data repositories is implemented by the use of Universal Resource Locators (URI) [15] instead of local filenames.

Politically speaking, this enhancement opened the MOME database to external data sources, making it a truly open exchange platform for Internet measurements, as recognised in [13].

2.2.3.2 Availability of data from wireless/mobile providers, impact on strategic decisions of mobile operators

We suspect that almost all mobile and wireless operators collect network traces for network management purposes. But all these projects are classified as highly confidential, since the traces can be used to derive network behaviour and strengths and weaknesses of their network.

Two projects using traces from mobile networks in Austria have been identified. One is led by the MIT and shows the real time evolution of the mobile network of Mobilkom Austria (A1) in the town of Graz. Despite the final objective of this project being artistic and not scientific, the restrictions imposed on the project on anonymisation and use of trace data is quite heavy. Data are only collected from volunteers and traces are not available for public use. Also in Austria, the Austrian national project METAWIN aims at collecting and analysing packet-level traces from a commercial UMTS network operator (Mobilkom Austria). The project has collected large amount of anonymised traces, which are stored in a proprietary format. However, the traces are not available for public, since the data is regarded as business critical by the operator.

The situation regarding data collected from wireless LAN environments is similar. MOME identified several instances of limited trace collection activities, mainly in university campuses in the USA [16]. The access to this data is heavily limited due to privacy concerns, and most of the significant information fields in the packet field had to be removed. There is no authentication information at all, nor any information beyond the TCP/UDP layer. There is no information regarding anonymisation.

2.2.3.3 Usefulness and availability of routing data

MOME has identified two projects which collect and publish routing information from the backbone of the Internet: RIPE's routing information service and the Oregon Routeviews project. The

1 The term 'meta' is also used in a similar context in meta-compilers, which are compilers that generate compilers.

availability of this data is helping a lot of projects to develop interesting tools (BGPlay) which show the an approximation to evolution of the connectivity provided by the routing infrastructure of the Internet.

The IETF has recognised the importance of this data and the Global Routing Operations working group [17] has standardised the binary format used by the routing repositories [18] and provides guidelines to operators [19], on how they should export routing data to the routing repositories in order to make them more useful.

Based on the experience of the INTERMON project, which found instances of QoS events on end to end communications paths on the Internet which could be related to Interprovider Routing Events, MOME decided to include the possibility of referencing routing information.

2.2.3.4 Privacy and legal issues on measurement data

MOME invited Mr. Andrew Cormack to the TNC 2005 session, pointing out the legal and privacy issues on collecting and distributing measurement data. From the European point of view, the following main laws have to be considered: The European Convention on Human Rights, Article 8, the Data Protection Directive (95/46/EC) and the Privacy and Electronic Communications Directive (2002/58/EC). The key principles for both, the users and the law are a clear purpose, proportionality, openness and control.
It was further pointed out, that the essential questions for every project, activity or action collecting and publishing measurement data are:

- Why am I doing this?
- Is the risk if I don't do it greater than the harm if I do?
- Can I do it in a less harmful way?
- Does my national law allow me to do it for that purpose?
- How long do I need to keep the data for?
- How will I protect the data and the user?
- Do I need to inform and/or get consent from the user?

If these answers are known, the collecting and publishing is probably legal. The full presentation as well as the video stream of Mr. Cormack's talk is available at the conference website of TNC2005 at http://www.terena.nl/events/tnc2005/.

2.3 WP3 – Standardisation

2.3.1 Summary of Workplan

WP3 focus was on standardisation requirements identification and contributions co-ordination in the Monitoring and Measurement area for IETF and other bodies. This WP was running from the very beginning of the project and was lead by NEC.

The main objectives of the project were:

- to build a strong European position in standardisation in the MOME area,
- to initiate, plan, and coordinate related contributions to the IETF and other bodies.

These objectives were planned to be achieved by a thorough analysis of the requirements raised in the discussions of the relevant standardization working groups (IPPM, IPFIX, PSAMP, and RMON IETF working groups).

As an output of this requirement analysis the WP3 was indented to identify MOME related findings and results as well as shortcomings and missing contributions within the working groups. Plans for joint and co-ordinated contributions were planned to be built and monitored as well as recommendations for participating IST projects.

It is important to consider that, when standardization is considered, variations to plans are to be taken into account because of the ever evolving nature of the working groups and of their requirements. A

measure of success in this case is the ability of the co-ordination action to take decisions in order to adapt to the changing needs of the major standardisation players in the working groups preserving the ultimate objective of building a strong European position in the MOME area.

2.3.2 Highlights

The highlights here reported are in chronological order to better give an overview of the temporal evolution of WP3 activities throughout the project lifetime.

2.3.2.1 Standardisation Plan

After the identification of standardization requirements in the MOME area as an output of a careful analysis of the above cited working groups a standardisation plan and recommendations document was written. In this document an overview of standardization activities concerning IP monitoring and measurements in various standardisation bodies was given. For each body, known contributions from IST projects were described and opportunities for participation were listed.
The standardisation plan identified two main actions to be performed in order to achieve the objectives:

- establishment of a standardisation team to better co-ordinate efforts;
- submission of MOME-initiated standardisation contributions (Internet Drafts) on the topics identified as most promising;
- investigation of standardisation requirements in the MOME area.

2.3.2.2 Standardisation Team

After the identification of contribution candidates, in December 2004, a mailing list (mome-ietf-team@ist-mome.org) for coordinating contributions to IETF in the MOME area was established and major standardisation players were invited to join to discuss their plans for contributions in a jointly manner. Because of the sensitivity of the information exchanged over the mailing list, it was decided to store the archive in a protected area of the web-site were only members could have access to. The total amount of traffic exchanged over the mailing list was anyway not high because of the previous consideration. Private mails were anyway exchanged in order to co-ordinate interested people based on standardisation expertise and intentions. The total number of the standardisation team members subscribed to the list was 28. The subscribers were involved in several IST projects, namely: Scampi, 6QM, Ambient Networks, Daidalos, Enthrone, Geant2, Lobster and Eurolabs.

List of MOME-initiated standardisation contributions
The list of MOME-initiated Internet Drafts submitted to the IPFIX, NSIS and IPPM IETF working groups by the Standardisation Team members was:

- Inter-Domain Data-Exchange Questionnaire
  http://www.ietf.org/internet-drafts/draft-boschi-data-exchange-quest-01.txt, October 2005
  http://www.watersprings.org/pub/id/draft-boschi-data-exchange-quest-00.txt, July 2005
- IPFIX Implementation Guidelines
  http://www.ietf.org/internet-drafts/draft-boschi-ipfix-implementation-guidelines-00.txt, October 2005
- Use of IPFIX for Export of Per-Packet Information
  http://www.ietf.org/internet-drafts/draft-boschi-export-perpktinfo-01.txt, October 2005
  http://www.watersprings.org/pub/id/draft-boschi-export-perpktinfo-00.txt, June 2005
- Framework for Metering NSLP
  http://www.ietf.org/internet-drafts/draft-fessi-nsis-m-nslp-framework-02.txt, October 2005
  http://www.watersprings.org/pub/id/draft-fessi-nsis-m-nslp-framework-01.txt, July 2005
  http://www.watersprings.org/pub/id/draft-fessi-nsis-m-nslp-framework-00.txt, February 2005
- How to store traceroute measurements and related metrics
  http://www.ietf.org/internet-drafts/draft-niccolini-ippm-storetraceroutes-02.txt, October 2005
  http://www.watersprings.org/pub/id/draft-niccolini-ippm-storetraceroutes-01.txt, July 2005
  http://www.watersprings.org/pub/id/draft-niccolini-ippm-storetraceroutes-00.txt, February 2005

This list reflects the final plan which deviated from the original one because of the following reasons:

- Draft on IPFIX MIB module was not submitted yet because the IETF area director strongly suggested waiting until IPFIX standard is completed.
- Draft on multi-to-multi measurements was dropped because already submitted by other researchers.
- Draft on IPFIX implementation guidelines was submitted based on input derived from the MOME Interoperability Event organized jointly with the Standardization one.
- New drafts resulted from discussions within the MOME standardisation team and not included in the initial plan:
  - Draft on NSIS Signaling Layer Protocol (NSLP);
  - IPFIX Extension for per-packet export.

Standardisation Requirements Analysis

After discussions among the Standardisation Team members on the MOME area current standardisation status, IP traffic anonymisation was pointed out as the topic where a major research and standardisation effort is required. In fact the availability of Internet traffic traces is crucial for research activities and for testing network applications under realistic conditions. However, in most cases traces are not made public for privacy and security reasons.
A first step towards this activity is the identification of requirements here reported by distinguishing between primary and secondary requirements. Primary requirements are general ones, independent of the specific application. Secondary requirements are those that depend on the specific use made of the anonymised traces and are divided into requirements on packet header anonymisation and payload anonymisation.

Primary requirements

1. The privacy of monitored users should be protected. Examples of sensitive information are: accessed web pages, credit card numbers, passwords, peer-to-peer connections, etc.
2. Information about internal network infrastructure, like number of subnets, number of connected hosts, operating systems etc should not be retrievable from public anonymised traces.
3. Requirements 1 and 2 can be met by anonymising/removing IP addresses, time-to-live, IP identification numbers and payloads (in case of IPv4). The way this is achieved depends on the secondary requirements.

Secondary requirements

1. Anonymisation of IP addresses is achieved by mapping each address to a random 32 bit address;
   a. if traces are only needed to study packet arrival times or packet length distributions, then no other specific requirement has to be met
   b. a one-to-one IP address mapping, i.e. each IP address is mapped to one and only one 32-bit value, is required in many cases, for instance if flows have to be detected. One case where simple one-to-one mapping is not suitable, while prefix preserving methods perform well, is the case where packet sampling is based on hashing, i.e. a number of fields and possibly part of the payload are selected and if the corresponding hash values falls in a certain range, then the packet is sampled. IP addresses, being invariant on the path, are typically included in the fields that are used for hashing the packet. However, it is important, for the method to be successful, that the variability of the IP addresses across multiple packets is preserved. For instance, NLANR [11] traces are anonymised, by assigning sequentially new addresses to newly observed IP addresses. This is not acceptable for hash based packet sampling.
   c. In some cases the IP address anonymisation has to be prefix preserving, i.e. if two original IP addresses share a k-bit prefix, their anonymised mappings will also share a k-bit prefix. This is the case for routing performance analysis or clustering of end systems. Prefix preserving methods are described in [9] and [10]. Prefix preserving methods are also suitable for hash based packet sampling.
2. Payload anonymisation:

a. Payloads are typically simply completely or partly stripped from the anonymised packets. However, research on application level protocols would require this knowledge not to be completely lost. Especially for intrusion detection research, researchers are obliged to synthetically forge attack traces to test their techniques. In [12] a method is proposed to anonymise packet headers and payloads at the same time.

Despite the relevance of the topic being largely recognised, IETF is currently not willing to standardise anonymisation because many issues are still to be investigated. A candidate working group for research on anonymisation is therefore IMRG WG of the IRTF but so far no contribution has been submitted so far.

Standardisation event
The MOME Standardization event was organized in collaboration with the IST EuroLabs project (http://www.ist-eurolabs.org/) and it was held in Paris, France, on 31st of July 2005, right before the 63rd IETF meeting. The MOME Standardization event was co-located with 63rd IETF meeting in order to better catch audience interested in the standardization in the Monitoring and Measurement area. The final program for the Standardization event contained 6 presentations from invited key researchers in the Monitoring and Measurement area of the IETF as well as from MOME partners currently active and with a solid knowledge of both IETF and ITU standardization procedures.
As an output of the discussions undertaken at the standardisation event an update of the standardisation plan was produced because some of the identified items were not interesting anymore to the IETF working groups. This demonstrates the promptness of MOME co-ordination in catching the latest development and strategies in the monitoring and measurement area.

List of additional contributions
The subscribers of the mome-ietf-team@ist-mome.org mailing list additionally submitted 8 Internet drafts in the area of traffic measurement to the IPFIX, PSAMP and NSIS IETF working groups. They are here reported divided by working group.

IPFIX
Architecture for IP Flow Information Export
<http://www.ietf.org/internet-drafts/draft-ietf-ipfix-architecture-09.txt>

Information Model for IP Flow Information Export
<http://www.ietf.org/internet-drafts/draft-ietf-ipfix-info-11.txt>

IPFIX Applicability
<http://www.ietf.org/internet-drafts/draft-ietf-ipfix-as-06.txt>

IPFIX Aggregation
<http://www.watersprings.org/pub/id/draft-dressler-ipfix-aggregation-01.txt>

Use of IPFIX for Export of Per-Packet Information
<http://www.ietf.org/internet-drafts/draft-boschi-export-perpktinfo-01.txt>

PSAMP
Sampling and Filtering Techniques for IP Packet Selection
<http://www.ietf.org/internet-drafts/draft-ietf-psamp-sample-tech-07.txt>

Definitions of Managed Objects for Packet Sampling
<http://www.ietf.org/internet-drafts/draft-ietf-psamp-mib-05.txt>

NSIS
NSLP for Metering Configuration Signaling
<http://www.watersprings.org/pub/id/draft-dressler-nsis-metering-nslp-02.txt>

Collaboration among different projects can be seen from the fact that authors of the above cited drafts were not belonging to a single project but were from more than one project. Moreover, in order to increase the quality of contributions and the European recognition in the area, interested authors who have shown interests and expertise were invited to contribute to the drafts by MOME co-ordination even if they were not belonging to any IST project. Among these 12 drafts, 4 (in italics) were MOME-initiated contributions and the remaining 8 were supported and co-ordinate by MOME actions (for example addition of authors was suggested by MOME project and merging of contents with other drafts was performed).

2.4 WP4 – Dissemination & Exploitation

2.4.1 Summary of Workplan

Dissemination and Exploitation is the responsibility of WP4, which ran throughout the project and was led by TERENA. It was responsible for the dissemination of the project results and achievements.

The main objectives of this work package were:

- to design, manage and update the project website for dissemination of information and internal project use,
- to disseminate gathered measurement data to the community via a simple web-based interface to enable statistical data analysis and to exchange MOME-related documents and tools with other IST projects,
- to organise workshops and conference sessions to build a monitoring and measurement knowledge exchange platform for other IST projects and researchers,
- to liaise with other relevant fora,
- to raise public awareness by project participation at the CeBIT and publications.

These objectives were planned to achieve by building and maintaining a high quality website that incorporates the MOME database, creating mailing lists for dissemination and internal project purposes, organising workshops and conference sessions yearly as well as liaising with European NRENs, universities, research institutes and commercial organisations through different foras and presenting the MOME project in the various events and publications.

It is important to remember that communication is not an exact science and is intangible in many ways which can make it difficult to measure success. However, some measures for success were written in the Technical Annex (TA) and were met during the project's lifetime.

2.4.2 Highlights

Project website

The objective of WP4 is to disseminate and exploit the results of the MOME project and to make the benefits and achievements known to relevant target groups, including other IST projects, NRENs and ISPs, researchers, and other actors interested in network monitoring and measurement issues. For any IST project, and arguably for any activity these days, a website is the most effective method of disseminating information. As it is accessible to anyone with internet access, this effectively means that information is available on a worldwide basis. For this reason, the development and maintenance of a high-quality website was one of the major activities in the MOME project.

The key issues that were considered in selecting, structuring and writing content for the MOME website are the following:

- To provide a comprehensive description of the work that is being conducted within the project's activities.
- To successfully reach the audiences that may have an interest in MOME – potential users of the MOME database, other IST projects, network monitoring researchers.
- To maintain a high profile for content.

The MOME public website was created in the first months of the project to enhance the external visibility of the project. During the lifetime of the project the website has been updated and maintained on day-to-day basis thus ensuring that up-to-date information was always available to the visitors of the webpage. To help visitors finding the latest changes, two sections were created – "Hot Topics" and "Latest News" to inform about recently published deliverables, upcoming events, additions to the MOME database, etc.

The MOME website contained information about the project objectives, technical approach, work packages, project partners, related cites as well as about all the activities of project. All MOME organised events and upcoming measurement and monitoring related events were accessible form the Calendar and Events page.

After the first year of the project the MOME database was developed and made accessible from the general project website. The MOME database provided knowledge exchange platform about measurement tools and measurement data. Details about the MOME database are documented in the Annex of this document.

A separate section about Standardisation was created to reflect project's involvement and contributions in the standardisation activities. The MOME-initiated and other submitted standardisation drafts were accessible from this page.

All the public deliverables, published papers and press releases were available from the Publications part of the website.

Extensive information and direct links were available to other IST projects participating in the MOME cluster. MOME partners have investigated other projects' approach regarding IP monitoring and measurement, as well as the measurement objectives, chain, setup, tools and analysis. Information about these projects was available from Cluster pages.

Mailing lists
The MOME project has created a public mailing list **mome-announce**@ist-mome.org where all interested people could subscribe to receive regular updated on the MOME activities. The announcements archive was also publicly available on-line for those not willing to subscribe to the mailing list. 72 people were subscribed to this mailing list in December 2005.
Another mailing list – **mome-public**@ist-mome.org was also created for experts in monitoring and measurements to exchange ideas and opinions. This list was open for posting to all subscribers.

Private area
The establishment of a **private area** for project management purposes was also one of the requirements of WP4. The project consortium collectively determined what features would be required and developed a specification at their first meeting.

The design brief was to develop a web-based system that integrated document sharing facilities, mailing list archives, contacts databases and remote management. Individual logins were also necessary to allow different types of user rights to be allocated. Finally, the system needed to be extensible so that features could be added as necessary. TERENA used an in-house developed project management system to create the private area which met the MOME needs.

Statistics
In December 2005 there were ~22000 total visits to the MOME webpage and ~14500 unique visitors. Around 2150 visitors have visited the MOME webpage repeatedly. The highest numbers of visits to the MOME webpage was in July 2005. Probably visitors were obtaining information abut the MOME workshop which was held in June 2005 and about the upcoming Standardisation and Interoperability events.

Workshops and conference sessions
The MOME project has organised three workshops and two conference sessions.

The first MOME workshop IPS 2004 was organised together with the IST-INTERMON project to disseminate MOME and associated activities. The motivation of IPS 2004 was to serve as integration forum for various players working on inter-domain monitoring, modelling and simulation concepts and toolkits. IPS 2004 took place on 23-23 March 2004 in Budapest, Hungary hosted by BUTE. There were 50 participants from 15 countries in the workshop. The workshop featured 2 tutorials and 6 invited speakers. 25 papers were presented about various measurement, monitoring, simulation and inter-domain related issues.

The MOME Session was organised at the TERENA Networking Conference (TNC) 2004 on 8 June 2004 in Rhodes, Greece. This session outlined the importance and challenges of traffic monitoring and measurement issues and provided an insight to the achievements of the projects participating in MOME (e.g. INTERMON and SCAMPI). Experience report on the use of measurements in operational networks of Uninett completed the session programme. It also provided an opportunity for feedback from the European research networking community. The MOME Session was run as a parallel session of the conference and attracted a total of 41 participants.

The second MOME workshop IPS-MOME 2005 was held in Warsaw, Poland, on 14-15 March 2005, by the Institute of Telecommunications, Warsaw University of Technology, in cooperation with the IST MOME project. The final technical programme for the IPS-MoMe 2005 contained 31 presentations including 2 keynotes, 2 invited papers and 27 papers carefully selected by reviewing process on the basis of 42 submissions. The program consisted of 8 sessions dedicated to the following topics: traffic measurements and modelling, measurement methods, simulation and measurements in the IST EuQoS project, monitoring and measurement tools and systems, performance evaluation, QoS architectures and mechanisms, traffic engineering and simulation tools. There were 70 participants at the workshop, representing 12 countries.

The MOME Session was organised also at the TNC 2005 that took place in Poznan, Poland on 7 June 2005. A panel session was organised with the motto: “Researchers Openness, Operators Secrets and Legal Framework: How monitoring evolves in Future Networks?” The goal of this session was to trigger discussions about the future of the network monitoring. There were 5 invited speakers in the session. Each of them made a short presentation about his viewpoint and then the discussion followed. The session attracted about 50 participants and was highly rated. Many people have said how useful the panel session was and that they would have liked to continue the discussions longer.

At the TNC 2005 the MOME Session was a concluding session of the network monitoring track at the conference. Before the MOME session there were two other sessions, organised by the LOBSTER project, devoted to the network monitoring:

- Network Monitoring for the NREN community
- Technological advances in Network Monitoring

The MOME and LOBSTER projects actively collaborated on organising the whole track and contributing to each others sessions.

The third MOME workshop was organised on 27-28 February 2006 in Salzburg, Austria, by Salzburg Research in cooperation with the MOME project. The Call for Papers for this workshop was issued in August 2005. People were invited to submit papers about performance models, simulation, monitoring and measurements. The technical programme for IPS-MoMe 2006 contained 18 paper presentations in 5 sessions, selected from 34 submissions, two keynote speeches, two invited talks and also offered two selected tutorials. IPS-MoMe 2006 attracted 63 participants from 19 countries.

MOME organised also a standardisation and an interoperability event. If the MOME workshops and conference sessions at the TNC mainly targeted the NREN community and researchers, then these

events have target different people. Both, the standardisation and the interoperability event had significant participation from industry and ISPs. More information about these events is available in chapters 2.1 and 2.3. All MOME organised events have given a significant contribution towards promoting the project's goals and results, as well as improved the project's visibility.

Other dissemination activities
The MOME project has participated in various events and conferences to inform the community about the MOME achievements and to encourage people to use the MOME database. Project participants have given presentations as well as distributed the MOME leaflets, demonstrated the MOME platform and promoted MOME results through discussions and comments. The list of events with MOME participation:

- 5th Concertation Meeting of IST-FP6 Communication and Network Technologies projects and associated clusters – 22-23 September 2005, Brussels, Belgium
- MOME Standardisation Event – 31 July 2005, Paris, France
- MOME Interoperability Event – 28-30 July 2005, Paris, France
- 2005 Tyrrhenian International Workshop on Digital Communications (TIWDC) – 4-6 July 2005, Sorrento, Italy
- First European Workshop on End-to-end QoS in the Internet - 21-22 June 2005, Paris, France
- IST project coordinators Info event – 14 June 2005, Brussels, Belgium
- TERENA Networking Conference 2005 – 7 June 2005, Poznan, Poland
- BROADWAN workshop – 24 May 2005, Brussels, Belgium
- 2nd MOME workshop IPS 2005 – 14-15 March 2005, Warsaw, Poland
- Concertation meeting, BroadBand for All cluster meeting – 8-9 March 2005, Brussels, Belgium
- 62nd IETF meeting – 6-11 March 2005, Minneapolis, MN, USA
- BroadBand Europe 2004 event - 9 December 2004, Brugge, Belgium
- TERENA Networking Conference 2004 - 8 June 2004, Rhodes, Greece
- Mobile Summit 2004 - 27-30 June 2004, Lyon, France
- EuroNGI project workshop 7 June 2004, Zakopane, Poland
- CeBIT exhibition - 18-24 March 2004, Hanover, Germany
- 1st MOME workshop - 22-23 March 2004, Budapest, Hungary

Several papers about the MOME project activities and results have been written and submitted. These papers have been later presented and printed. The list of papers:
- "The MOME Workstation as a Platform for Automatic Analysis of Measurement Data" - paper was presented at the "2005 Tyrrhenian International Workshop on Digital Communications" in Sorrento, Italy by Jarek Sliwinski, WUT;
- "An advanced measurement meta-repository" - paper was presented at the IPS-MoMe2005 workshop;
- "Monitoring and Measurement activities in European projects" - paper was presented at the BroadBand Europe 2004 event;
- "Multi-disciplinary Inter-domain Monitoring: The benefits of the INTERMON project for Service Providers" - paper was presented at the BroadBand Europe 2004 event.

An external comment on MOME have been published in the "ACM SIGCOMM Computer Communication Review - Volume 35, Issue 5 (October 2005)", about The Internet Measurement Data Catalog.

2.4.3 Achievements

The MOME project has met all the criteria that were set in the Technical Annex to measure the success of the dissemination of the project.

MOME has organised conference sessions at the two TERENA Networking Conferences, attended by around 50 participants. The project has organised three workshops that were attended by 50, 70 and 63 participants.

Four current EC projects (i.e. LOBSTER, Eurolabs, 6QM, DAIDALOS) have joined the MOME Cluster, which is the most active form of collaboration. There are 25 associated projects in the MOME cluster, i.e. MOME partners have investigated these projects' approach regarding IP monitoring and measurement, have found it relevant to the MOME cluster and discussed the collaboration opportunities. These projects have contributed to the measurement tools and measurement data databases.

The public website was designed and written from scratch and has an average of 1000+ visitors a month. Number of visits to the MOME webpage has been growing during the life time of the project starting with around 580 visits per months and with 1600+ visits per months at the end of the project.

The MOME project has printed posters and flyers about the project and distributed them in various events including Mobile Summit 2004, CeBIT exhibition, and Concertation meetings thus ensuring to reach the MOME target audience – other IST projects, as well as scientists and network administrators.

The MOME project has used direct e-mailing via the mome-announce@ist-mome.org mailing list to inform about the MOME news. The number of subscribers has reached to 72 in December 2005.

WP4 has been responsible for five deliverables. All of them have been completed and submitted on time.

3 MOME database after project lifetime

The main contribution of the MOME project is the MOME database. The database along with the MOME website will be maintained indefinitely by TERENA. TERENA has participated in other IST projects and have been keeping on-line other project's websites even 5 years after they have ended, e.g. SCIMITAR (http://www.scimitar.terena.nl/), TEQUILA (http://www.ist-tequila.org/), SERENATE (http://www.serenate.org/), etc.

In case of any major changes TERENA would inform the former project partners about the take down of the server at least 6 months in advance which would give sufficient time to move the MOME infrastructure to another institution.

The MOME public mailing lists will also be kept alive. The mome@ist-mome.org list will be used by the project partners too keep in touch, to discuss newest developments in the area and possible new project proposals. The mome-announce@ist-mome.org list will be used to inform all subscribed people about upcoming events relevant to monitoring and measurements as well as other issues. The mome-public@ist-mome.org mailing list will be a knowledge exchange platform for all interested parties.

Contributions of measurement data will be continued by running and upcoming projects. The MOME project has received proposal from Euro-NGI and upcoming COST action that they would be very interested to continue using the MOME platform, particularly to submit and analyse measurement data.

Coding and maintenance of the MOME database will be continued on demand by MOME partners. Carsten Schmoll, Kenan Polat from FHG will continue working on measurement tools part, Felix Strohmeier from SRF – on measurement data and Jarek Sliwinski from WUT – on data analysis. There will be information in the webpage how to contact the maintainers in case of any problems or wishes. A separate developers' mailing list can be set up on demand.

It is anticipated that the MOME database will continue to be promoted at relevant events (e.g. Concertation meetings, TNC 2006) even after the end of the project.

As mentioned earlier, CAIDA has expressed interest in the MOME work. The MOME project partners will contact CAIDA to discuss potential collaboration and to exchange links to data and ideas about new features.

4 Appendix I - Documentation

4.1 Software

The deliverables D1.2 (Chapter 5), D2.1 (Chapter 4) and D2.2 (Appendix A) describe in more details the database software choices. This section will summarise the software used for the database implementation.

The software specifications for the MOME database system include:

4.1.1 Operating system

Debian 3.0 Linux was chosen as the operating system for the database platform. We run Linux kernel version 2.6.8-1-686-smp to make full use of the dual CPU Intel(R) Xeon(TM) CPU (3.06GHz) system. The dual CPU system works nicely to serve database requests in parallel with processing of trace data. During the lifetime of the server no outages other than planned maintenance downtimes were observed.

4.1.2 Web server software

To allow an easy access to the database by all commonly used web browsers, the front end software selected was Apache web-server (Apache 2.0.54-5) with mod_php5 and apache_ssl. PHP (5.0.5) was used to generate the web pages. Further, the code needs the PEAR classes HTML/Table.php and Config.php

4.1.3 Database Management System

The open source database software MYSQL (MySQL 4.1.11a-4) is used together with with phpMyAdmin 2.2.3 as as the database management system (DBMS).
The database functions are implemented using the PHP language and realise the access to the database (connection), the operations on the database (MySQL queries) and providing the HTML pages as output. The latter are the GUI functions which enable the access to the meta-repository via a public web server, compatible with all commonly used web browsers.

4.1.4 DBMS user interface

The MOME Database uses a Web based user interface to allow easy user access. All DBMS operations are hidden from the user. The PHP pages on the apache web server implement the Graphical User Interface (GUI) providing access to all functionalities of the MOME Workstation. The functionalities of the MOME platform have been continuously enhanced since its first release.

Figure 4-1 shows the current view of the MOME platform user interface.

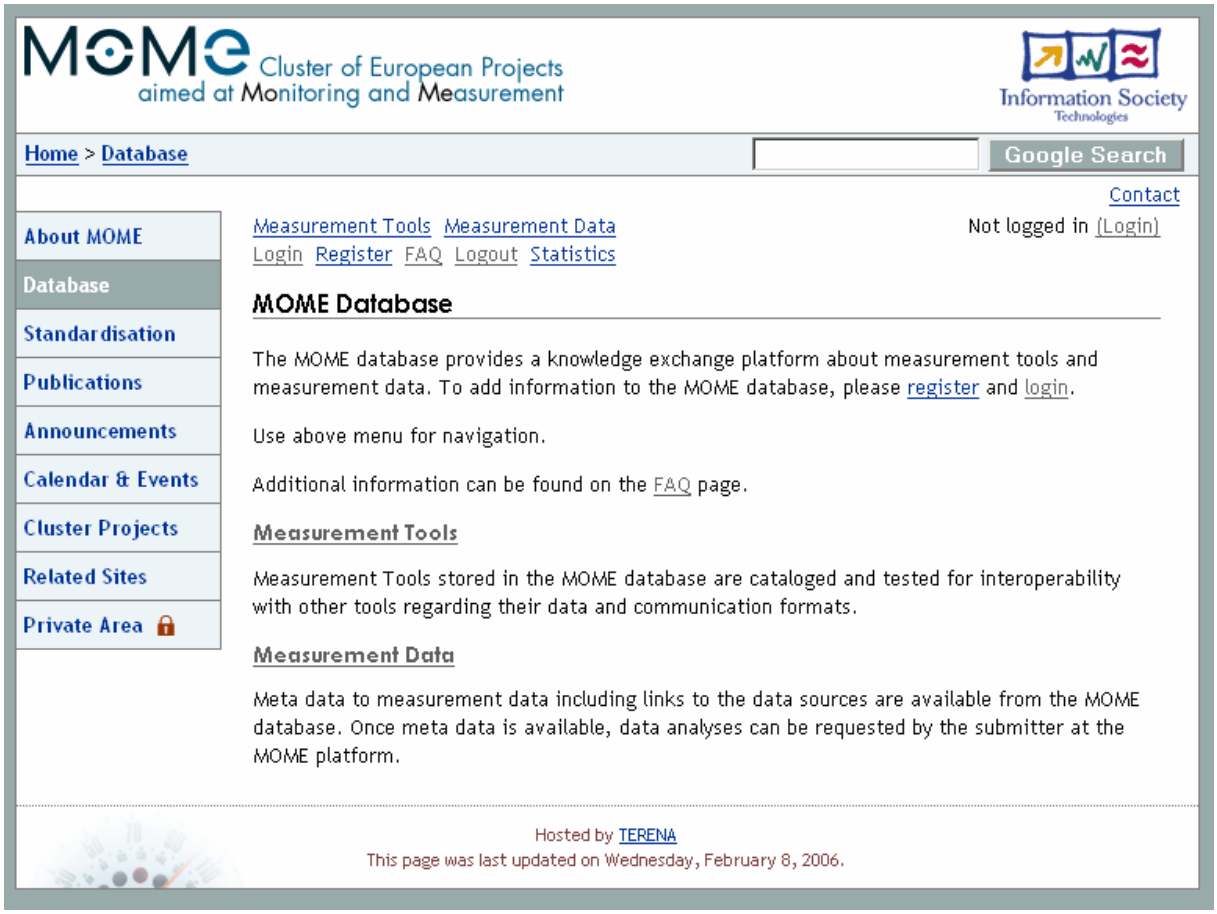


Figure 4-1 : MOME database welcome screen

On the left side the normal MOME site menu is shown. The entry “Database” lets the user access all database functions on the right side. Tools as well as traces database are integrated within the MOME site and adhere to the same look and feel.

Most functions (overview, search, feedback) are available to every visitor of the website. Some functions require a (free) registration. These include adding tools/trace entries, editing them, and adding comments to existing entries. Some functions require admin status in addition to being logged on, e.g. user and maintainer management. Login is possible at every time in the top right corner.

4.2 Database

4.2.1 Contents

The MOME database is a crucial part of the MOME architecture. The MOME database stores metadata about measurement data and tools as well as information about registered users of the MOME workstation, and several other kinds of internal data required for the operation of the MOME system.

4.2.2 Final table design

Deliverable D21 [5] defined a preliminary version of the MOME measurement database. The MOME tools database was defined as part of Deliverable D12 [3]. The two databases were integrated to form a single MOME database, which was described in D22 [6]. The current document shows the final structure of the MOME database giving a full definition of each database table.

4.2.3 Tables and Structure

The MOME database consists of 19 tables as described in the following table.

Table name	Table description
AnalysisRequests	Information on automated analysis of traces
Comments	Comments submitted by a user on a specific tool
CommonAttributes	Common attributes for all measurement data entry types
FlowTraceAnalysis	Results of analysis tasks applicable to the flow traces
FlowTraceAttributes	Additional attributes for the flow traces
HttpAnalysis	Results of analysis tasks applicable to the HTTP traces
HttpAttributes	Additional attributes for the HTTP traces
PacketTraceAnalysis	Results of analysis tasks applicable to the packet traces
PacketTraceAttributes	Additional attributes for the packet traces
QoSAnalysis	Results of analysis tasks applicable to the QoS results
QoSAttributes	Additional attributes for QoS results
RoutingAnalysis	Results of analysis tasks applicable to the routing data
RoutingAttributes	Additional attributes for the routing data
Tests	Tool testing data
Toolmaintainer	Relates tools to users that maintain the tool information
Tools	Information on measurement, analysis, etc. tools
UserAttributes	User information of registered MOME users
Uses	Relates measurement data to the tools that were used to produce the data
WebRepositoryAttributes	Web-based data repository information

Table 4-1: The MOME database tables

The database stores information about packet trace, flow trace, http trace, routing information, and QoS attribute measurements and the respective analysis jobs and results, measurement tools, their interoperability, and registered users of the system.

A detailed description of the fields of the MOME database tables follows in alphabetic order. The attributes for particular database tables are specified as follows. The “Attr. name” field denotes the name of the attribute in the database structure, while “Datatype” corresponds to its type. The mandatory attributes (marked with “Y” in the “Mand.” column) have to be filled by a user, who submits the meta-data entry. The “Description” field defines the meaning and use of the given attribute.

4.2.3.1 The AnalysisRequests table

This table stores information about the automatic analysis requests of measurement traces.

Mand.	Attr. Name	Datatype	Description
N	RequestId	UNSIGNED INTEGER	Unique identifier
N	UserID	UNSIGNED INTEGER	Starter of the analysis task
N	TraceId	UNSIGNED INTEGER	The measurement trace to be analysed
N	DateStart	DATETIME	Start time of the task
Y	DateEnd	DATETIME	End time of the task (filled after completion)
N	Status	ENUM	Any one of 'pending remote', 'pending local', 'analysis in progress', 'complete', 'error: file not found', 'error: wrong file format', 'error'

Mand.	Attr. Name	Datatype	Description
N	NotificationType	ENUM	'mail' or 'none'
N	AnalysisType	VARCHAR(10)	Type of analysis performed

Table 4-2: The AnalysisRequests table

4.2.3.2 The Comments table

The comments table is available to allow users to add short text to each tool entry (even when they have not made it themselves). Contents from this table are shown as part of the detailed tools information view. Only registered users may comments to a tool entry. A tool comment can be seen as a brief version of a documented test. It should motivate users to participate in sharing their experiences with listed tools.

Mand.	Attr. name	Datatype	Description
Y	CommentID	INTEGER(11)	Unique identifier for an entry
Y	UserID	UNSIGNED INTEGER	Link to user who created this entry
Y	ToolID	INTEGER(11)	Link to tool entry
Y	EntryDate	DATE	When entry was created
Y	Comments	LONGTEXT	The comment text itself

Table 4-3: The Comments table

4.2.3.3 The CommonAttributes table

The CommonAttributes table stores information common to all types of measurement traces.

Mand.	Attr. Name	Datatype	Description
Y	Id	UNSIGNED INTEGER	Unique identifier for an entry
Y	SubmitterUserID	UNSIGNED INTEGER	Id of the person who submitted the data
Y	DataSetName	VARCHAR(255)	Identifier of the raw data set
Y	DataType	ENUM	Any one of 'PacketTrace', 'FlowTrace', 'Routing', 'WebRepository', 'HTTP', 'QoS', 'application-level trace'
N	FileSize	BIGINT	File size in bytes
Y	StartTime	DATETIME	Date and time of measurement start
Y	EndTime	DATETIME	Date and time of measurement end
Y	Description	TEXT	Short description of the data set
N	AppendedNotes	TEXT	
N	AssociatedData	TEXT	
Y	DataLocation	TEXT	URL with the location of file with actual data
N	FileCompression	VARCHAR(255)	None, or: zip, gzip, tar,…
N	MD5Sum	TEXT	MD5 hash sum of raw data file
Y	SubmissionDate	DATETIME	Date, when entry has been added
Y	LastUpdate	DATETIME	Date, when entry has been updated or verified
N	Tool	VARCHAR(255)	Name of the tool which generated the data
N	Status	ENUM	Any one of 'analysis pending', 'analysis in progress', 'analysis done', 'not yet scheduled', 'aborted', 'done with error'
N	DataAvailability	ENUM	Any one of 'online', 'local copy', 'unavailable'
N	DataLocationLink FailureCounter	UNSIGNED TINYINT	Counter for the failure to access the data location URL

Table 4-4: The CommonAttributes table

4.2.3.4 The FlowTraceAnalysis table

This table contains analysis results for flow traces.

Mand.	Attr. Name	Datatype	Description
Y	FlowTraceAttributes CommonAttributesId	UNSIGNED INTEGER	The unique id of the flow this analysis result belongs to
N	AvgFlowIntTime	REAL	Average time between flow arrivals
N	AvgFlowTime	REAL	Average duration of a flow
N	AvgFlowPkt	REAL	Average number of packets per flow
N	AvgFlowBytes	REAL	Average number of bytes per flow
N	AvgFlowArrivalRate	REAL	Average flow arrival rate in flows/s
N	AvgTrafficRate	REAL	Average traffic rate in bit/s

Table 4-5: The FlowTraceAnalysis table

4.2.3.5 The FlowTraceAttributes table

This table contains measurement data for flow traces.

Mand.	Attr. name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The unique id of the flow in the CommonAttributes table
Y	NetworkType	VARCHAR(255)	Trace collection environment, typical values: LAN, WAN
Y	CollectorLocation	TEXT	Location of the collector (country, city, institution)
Y	TrafficType	VARCHAR(255)	Operational network traffic(0), artificial test traffic(1)
N	LinkProtocol	VARCHAR(255)	Ethernet, VLAN, ATM, POS, WLAN,…
N	LinkSpeed	UNSIGNED INTEGER	In bits per second: 100M, 155M,…
N	CaptureMode	VARCHAR(255)	Capture by router (NetFlow), packet trace+analysis of flows,…
N	FilterRules	VARCHAR(255)	None, or only specific flows…
N	NumberFlows	UNSIGNED INTEGER	Number of captured flows
N	TraceAnonymisation	VARCHAR(255)	None, or: IP address removed, IP address scrambled, IP address and TCP port scrambled,…
N	CapturePlatform	VARCHAR(255)	linux, bsd, windows, DAG, router…
Y	DataFormat	VARCHAR(255)	IPFIX, NetFlow, IPDR, other (URL to format description)
N	AdditionalInfo	TEXT	Additional information on network and trace collection scenario

Table 4-6: The FlowTraceAttributes table

4.2.3.6 The HTTPAnalysis table

This table contains analysis results for http traces.

Mand.	Attr. Name	Datatype	Description
Y	HTTPAttributes CommonAttributesId	UNSIGNED INTEGER	The unique id of the http trace this analysis result belongs to
N	AvgHTTPReqIntTime	REAL	Average time between flow arrivals
N	AvgHTTPResponsePkt	REAL	Average response size in packets
N	AvgHTTPRespBytes	REAL	Average response size in bytes
N	AvgHTTPRequestRate	REAL	Average request arrival rate in flows/s

Table 4-7: The HTTPAnalysis table

4.2.3.7 The HTTPAttributes table

This table contains measurement data for http traces.

Mand.	Attr. Name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The unique id of the http trace in the CommonAttributes table
N	CollectorLocation	TEXT	Location of the collector (country, city, institution)
N	FilterRules	VARCHAR(255)	None, or only specific flows…
N	NumberEntries	UNSIGNED INTEGER	Number of recorded entries
N	TraceAnonymisation	VARCHAR(255)	None, or: IP address removed, IP address scrambled, IP address and TCP port scrambled,…
N	CapturePlatform	VARCHAR(255)	linux, bsd, windows, DAG, router…
N	DataFormat	VARCHAR(255)	Description, or URL to format description
N	AdditionalInfo	TEXT	Additional information on network and trace collection scenario

Table 4-8: The HTTPAttributes table

4.2.3.8 The PacketTraceAnalysis table

This table contains analysis results for packet traces.

Mand.	Attr. Name	Datatype	Description
Y	PacketTraceAttributes CommonAttributesId	UNSIGNED INTEGER	The unique id of the packet trace this analysis result belongs to
N	AvgBitRate	REAL	Traffic rate, averaged over entire trace duration, in bit/s
N	AvgPktIntTime	REAL	Average packet inter-arrival time in sec
N	AvgPktSize	REAL	Average packet size in bytes
N	AvgPktRate	REAL	Average packet arrival rate in pkt/sec
N	PktSizeDist	LONGBLOB	Histogram of packet sizes
N	ProtocolDist	LONGBLOB	Bandwidth usage per-protocol
N	ApplicationDist	LONGBLOB	Bandwidth usage per-application
N	Rate10ms	LONGBLOB	Series of rates (in bit/s), calculated over 10ms intervals
N	Rate1s	LONGBLOB	Series of rates (in bit/s), calculated over 1s intervals
N	Rate3min	LONGBLOB	Series of rates (in bit/s), calculated over 3min intervals
N	RateVar10ms	REAL	Variance of bit rate calculated over 10ms intervals
N	RateVar1s	REAL	Variance of bit rate calculated over 1s intervals
N	RateVar3min	REAL	Variance of bit rate calculated over 3min intervals
N	EffectiveBw	LONGBLOB	Effective bandwidth, calculated assuming different available bandwidth and buffer
N	RequiredTB	LONGBLOB	Values of token bucket parameters, required for traffic in trace
N	HurstParam	REAL	Value of Hurst parameter, evaluating self-similarity

Table 4-9: The PacketTraceAnalysis table

4.2.3.9 The PacketTraceAttributes table

This table contains measurement data for packet traces.

Mand.	Attr. name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The unique id of the packet trace in the CommonAttributes table

Mand.	Attr. name	Datatype	Description
Y	NetworkType	VARCHAR(255)	Trace collection environment, typical values: LAN, WAN
Y	CollectorLocation	TEXT	Location of the collector (country, city, institution)
Y	TrafficType	VARCHAR(255)	Type of traffic, typical values: Operational network traffic, artificial test traffic
N	LinkProtocol	VARCHAR(255)	Link protocol: Ethernet, VLAN, ATM, POS, WLAN,…
N	LinkSpeed	UNSIGNED INTEGER	In bits per second: 100M, 155M,…
N	CaptureMode	VARCHAR(255)	Ethernet snooping, optical splitters, direct capture by router,…
N	FilterRules	VARCHAR(255)	None, or: only TCP packets, only packets with specific port number, only packets belonging to specific flow…
N	NumberPackets	UNSIGNED INTEGER	Number of captured packets
N	RecordedData	VARCHAR(255)	IP header, TCP/IP header, entire packet, timestamp, packet size+timestamp,…
N	TraceAnonymisation	VARCHAR(255)	None, or: IP address removed, IP address scrambled, IP address and TCP port scrambled, payload removed,…
N	CapturePlatform	VARCHAR(255)	linux, bsd, windows, router, DAG,…
N	DataFormat	VARCHAR(255)	Libpcap, DAG, tcpdump, PSAMP, sFlow, fr, clr, tsh, other (URL to format description)
N	AdditionalInfo	TEXT	Additional information on network and trace collection scenario

Table 4-10: The PacketTraceAttributes table

4.2.3.10 The QoSAnalysis table

This table contains analysis results for QoS attributes.

Mand.	Attr. Name	Datatype	Description
Y	QoSAttributes CommonAttributesId	UNSIGNED INTEGER	The unique id this analysis result belongs to
N	AvgDelay	REAL	Average delay (OWD or RTT, depending on which is measured)
N	MinDelay	REAL	Minimum measured delay
N	MaxDelay	REAL	Maximum measured delay
N	10DelayPerc	REAL	10- percentile of delay
N	90DelayPerc	REAL	90- percentile of delay
N	DelayDist	LONGBLOB	Histogram of measured delays
N	AvgIPDV	REAL	Average delay variation
N	MinIPDV	REAL	Minimum delay variation
N	MaxIPDV	REAL	Maximum delay variation
N	LossRatio	REAL	Packet loss ratio

Table 4-11: The QoSAnalysis table

4.2.3.11 The QoSAttributes table

This table contains measurement data for QoS attributes.

Mand.	Attr. Name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The unique id in the CommonAttributes table

Mand.	Attr. Name	Datatype	Description
Y	NetworkType	VARCHAR(255)	Public Internet, private network, testbed network,…
Y	MeasurementType	VARCHAR(255)	Active,passive
Y	Metrics	VARCHAR(255)	OWD, RTT, jitter, loss, throughput, etc…(multiple metrics possible)
Y	SenderLocation	VARCHAR(255)	Location of sender probe (or observation point in case of passive measurements)
Y	ReceiverLocation	VARCHAR(255)	Location of receiver probe (or observation point in case of passive measurements)
N	SenderPlatform	VARCHAR(255)	linux, bsd, windows, router…
N	ReceiverPlatform	VARCHAR(255)	linux, bsd, windows, router…
N	TimestampSynch	VARCHAR(255)	None, or: NTP, GPS,…
N	NumberValues	UNSIGNED INTEGER	Number of recorded singleton measurements
Y	DataFormat	VARCHAR(255)	Additional information on measurement scenario
N	AdditionalInfo	TEXT	Text or URL to format description

Table 4-12: The QoSAttributes table

4.2.3.12 The RoutingAnalysis table

This table contains analysis results for routing information.

Mand.	Attr. Name	Datatype	Description
Y	RoutingAttributes CommonAttributesId	UNSIGNED INTEGER	The unique id this analysis result belongs to
N	RoutingTableSize	UNSIGNED INTEGER	The number of entries in the routing table
N	RoutingUpdates	UNSIGNED INTEGER	Number of update records in a file

Table 4-13: The RoutingAnalysis table

4.2.3.13 The RoutingAttributes table

This table contains measurement data for routing information.

Mand.	Attr. Name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The unique id in the CommonAttributes table
Y	RoutingProtocol	ENUM	Any one of 'BGP','RIP','OSPF'
Y	RecordedData	ENUM	'routing table', or 'update packets'
Y	CollectorLocation	VARCHAR(255)	Location of the collector (country, city, institution)
Y	DataFormat	ENUM	'Zebra', or 'TCPDUMP'

Table 4-14: The RoutingAttributes table

4.2.3.14 The Tests table

The tests table stores documentation of test results with tools that are available in the tools part of the MOME database. Here registered users can enter what tests they have made and what results have been reached.

Mand.	Attr. Name	Datatype	Description
Y	TestID	INTEGER(11)	Unique identifier for test entry
Y	UserID	UNSIGNED INTEGER	Link to user who is entry submitter
Y	ToolID	INTEGER(11)	Link to tool used
Y	EntryDate	DATE	When entry was created
Y	ToolVersion	VARCHAR(40)	Which tool version has been tested

Mand.	Attr. Name	Datatype	Description
Y	OperatingSystem	INTEGER(11)	On what operating system
Y	SystemDetails	VARCHAR(255)	Details about system under test
Y	Results	LONGTEXT	Detailed test results
Y	Hardware	VARCHAR(255)	What hardware was in use, e.g. network card
N	Network	VARCHAR(255)	(Fast) Ethernet, ATM, SDH, etc.
N	Traffic	VARCHAR(255)	Textual traffic description

Table 4-15: The Tests table

4.2.3.15 The ToolMaintainer table

This table defines the maintainer of each tool.

Mand.	Attr. Name	Datatype	Description
Y	UserID	UNSIGNED INTEGER	The user maintaining the tool
Y	ToolID	INTEGER(11)	The tool maintained

Table 4-16: The ToolMaintainer table

4.2.3.16 The Tools table

This table lists all meta-data entries stored about a tool in our database including interoperability information. It is the main table for the tools and interoperability part of the MOME database. For each tool which has been observed and evaluated by MOME partners there is an entry in the database. Registered users may also enter new entries into that table via the web interface of the MOME database using the add tool page.

Mand.	Attr. name	Datatype	Description
Y	ToolID	INTEGER(11)	Unique numeric identifier
Y	Name	VARCHAR(255)	Tool name
N	Version	VARCHAR(40)	Tool's version
N	EntryDate	DATE	When entry was made
N	LastModified	DATE	When last edit occurred
Y	Description	LONGTEXT	Free text describing tool
Y	HomePageURL	VARCHAR(255)	Link to tool homepage
N	ContactURL	VARCHAR(255)	Link to author if available
N	RelatedURLs	LONGTEXT	More links
N	Category	SET	Any combination of 'Packet Capturing', 'Traffic Flow Measurement', 'Packet Monitoring', 'Connection Monitoring', 'Application-level Monitoring', 'Service Monitoring', 'Accounting', 'Intrusion Detection', 'Sniffing', 'Performance Monitoring', 'Connectivity Checking', 'Route Detection', 'Topology Detection', 'Traffic Visualization', 'Traffic Generation', 'Bandwidth Measurement'
N	ControlInput	SET	Any combination of 'config file','command line','GUI','scripting language','telnet','ssh','web GUI','database','API binding','SNMP'
N	DataInput	SET	Any combination of 'live interface','tcpdump packet file','other packet file','raw data files','csv text data files','text via stdin'

Mand.	Attr. name	Datatype	Description
N	Metrics	SET	List of what traffic characteristics the tool computes, any combination of 'packet capture','flow detection','available bandwidth','bottleneck bandwidth','protocol analysis','bandwidth','one-way-delay','round-trip-delay','jitter/delay variation','throughput','packet loss','connectivity', 'used bandwidth','bulk transfer capacity', 'link capacity','utilisation','reordering','volume/accounting', 'topology detection','hop count','packet sizes','asymptotic dispersion rate'
N	DataOutput	SET	Any combination of 'text files','binary files','to stdout','graphs/images','report documents','via SNMP','via Web interface (http)','via IPFIX','GUI'
N	TimeScope	VARCHAR(255)	Real-time, seconds, minutes, …
N	FilterAttributes	SET	Any combination of 'phys. interface','MAC address','ethertype','IP addresses','IP header attributes','TCP/UDP ports','TCP flags','application level'
N	Aggregation	VARCHAR(255)	If available, how data are aggregated
N	Sampling	SET	Sampling schemes, any combination of 'n-out-of-N','uniform probabilistic','non-uniform probabilistic ','systematic count-based','systematic time-based','deterministic filtering'
N	Availability	SET	Any combination of 'open source (GNU)','open source (other)','closed source (commercial)','closed source (not available)'
N	License	SET	What license(s) the tool is available with, any combination of 'Academic Free','Apache','Apple Public Source','Artistic','BSD','Common Public','Eclipse Public','GNU General Public','GNU Library or "Lesser" General Public','IBM Public','Intel Open Source','Mozilla Public','PHP','Python','Qt Public','Sun Public','Zope'
N	HWSupport	SET	What hardware the tool runs on, any combination of 'Alpha', 'ARM', 'MIPS', 'PPC', '(Ultra)Sparc', 'x86', 'Zaurus'
N	OSSupport	SET	What operating systems are supported, any combination of 'AIX','BeOS','BSDI','Cisco IOS','Cygwin','DEC OSF/1','Digital Unix','FreeBSD', 'HP-UX','Irix','Juniper','MacOS','MacOS X', 'NetBSD','NextStep','OpenBSD','OpenVMS', 'OS/2 2.x','QNX','SCO Unix','SGI','Sinix','Solaris', 'SunOS','Tru64 Unix','Ultrix / DecStation','Unix/Linux','UnixWare','Win2k', 'Win95','Win98','WinCE','WinMe','WinNT', 'WinXP','Zaurus'
N	ConformMetrics	SET	What standardised metrics are supported, 'IPPM-xyz' or none
N	ConformProtos	SET	What standardised protocols are supported, any combination of 'SNMP', 'IPFIX', 'SSH', 'HTTP', 'LDAP', 'NetFlow', 'SFlow'
N	Interop	SET	What other tools this one can be used with, any combination of 'tcpdump', 'gnuplot', 'mrtg', 'rrdtool', 'mysql'
N	SendSchedules	VARCHAR(255)	What is schedule of data export is available
N	Features	SET	Additional tool information, any combination of 'active measurement','passive measurement','offline nanalysis','online analysis','IPv4 support','IPv6 support','configurability at runtime'
N	HomePageURL LinkFailureCounter	UNSIGNED TINYINT	Counter for the failure to access the homepage URL
N	ContactURL LinkFailureCounter	UNSIGNED TINYINT	Counter for the failure to access the contact URL
N	RelatedURLs LinkFailureCounter	UNSIGNED TINYINT	Counter for the failure to access the related URLs

Table 4-17: The Tools table

4.2.3.17 The UserAttributes table

This table stores all information about registered users of the complete MOME database system. Entries are created upon user registration. Each record can only be modified by the respective user. Users may add links to their homepage as well as to other work here.

Mand.	Attr. Name	Datatype	Description
Y	UserID	UNSIGNED INTEGER	Unique user ID
Y	Username	VARCHAR(255)	Arbitrary username
Y	Password	BLOB	Encrypted password for the user
Y	Email	VARCHAR(255)	Email address of the user
N	Name	VARCHAR(255)	Full name of the user
N	Date	DATETIME	Creation time of the user account
N	Status	ENUM	Any one of 'new','active','suspended'
N	AccessLevel	UNSIGNED INTEGER	Admin or normal user level
N	Homepage	VARCHAR(255)	User's homepage
N	Description	LONGTEXT	Optional descruption of the user
N	Lastlogin	DATETIME	Last time the user logged in
N	Logins	UNSIGNED INTEGER	Number of logins of the user
N	HomepageLink FailureCounter	UNSIGNED TINYINT	Counter for the failure to access the homepage URL

Table 4-18: The UserAttributes table

4.2.3.18 The Uses table

This table builds a link from the traces information stored in the MOME database to tools documented in the MOME interoperability database. It is used to document what tool has been used to capture, process, and analyse a specific trace.

Mand.	Attr. name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The measurement produced using the tool
Y	ToolID	INTEGER(11)	The tool used
N	Type	SET	'Analysis', or 'Measurement', or both

Table 4-19: The Uses table

4.2.3.19 The WebRepositoryAttributes table

This table contains information about measurement data accessible through web pages.

Mand.	Attr. Name	Datatype	Description
Y	CommonAttributesId	UNSIGNED INTEGER	The unique id in CommonAttributes for this entry
N	Baseurl	TEXT	URL of the main page of the repository (if differs from the common URL)
Y	DataProvider	TEXT	Name of the providing institution
Y	MeasurementType	TEXT	Available measurements (delay values, rtts, routes, packet loss, link utilization, …)
Y	RawDataAvailable	ENUM	Raw data available ('Y', 'N', or 'part.')
N	RefreshPeriod	ENUM	Any one of 'Daily', 'Weekly', 'Monthly', 'Yearly', 'Irregularly'
N	BaseurlLinkFailure Counter	UNSIGNED TINYINT	Counter for the failure to access the base URL

Table 4-20: The WebRepositoryAttributes table

4.2.4 The MOME database data model

The following figure gives an overview of the database tables and connections between them.

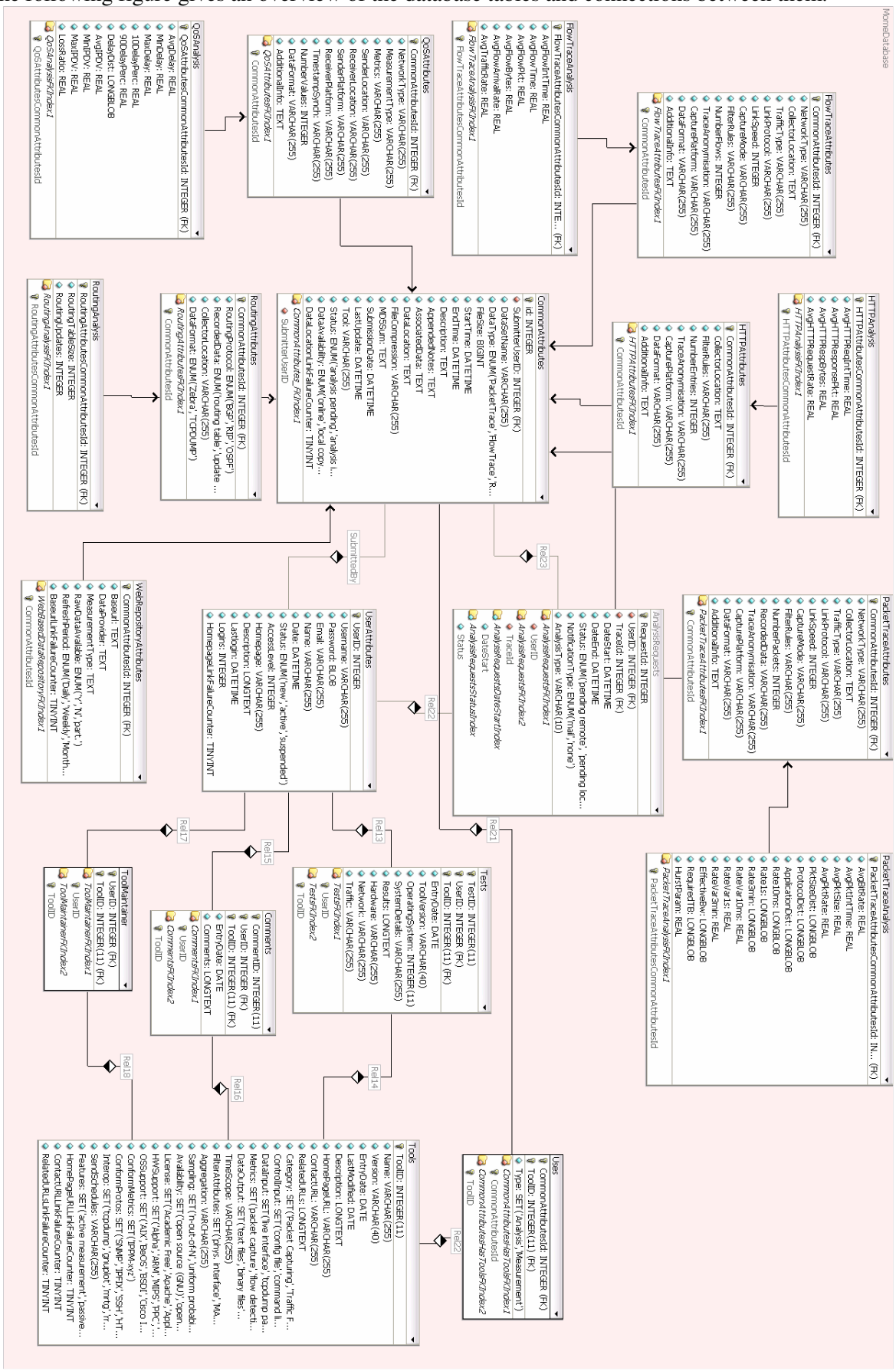


Figure 4-2: The MOME database data model

4.3 Installation

The installation of above mentioned software, including the database and analysis workstation has been performed by TERENA. For installation, recent versions of the software components mentioned in chapter 4.1 are required. Figure 4-3 shows the distribution of their software components among the machines of TERENA, as well as their interfacing. In addition to the MOME database and analysis workstation, the TERENA web-server acts as interface for the user. This enables to integration of the MOME database user interface into the MOME project web-site, but this not a requirement for future installations for the MOME software.

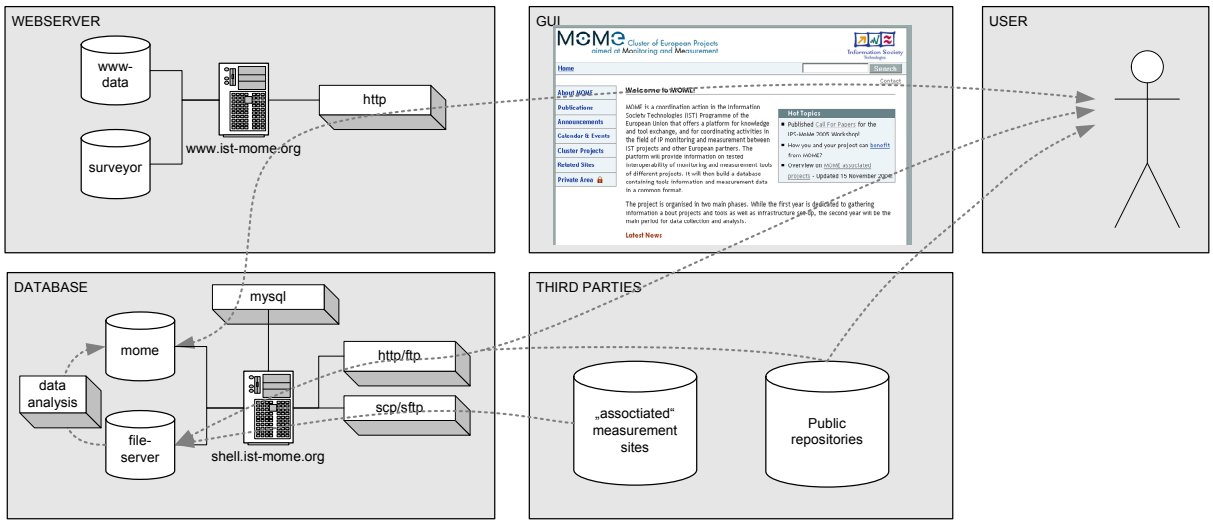


Figure 4-3 MOME System Installation

Based on the location in the MOME system, the installed files are divided into two different groups:

- GUI, installed at www.ist-mome.org: The set of php scripts, html and css files building the interface to the user. This set of files need to be installed to be accessible by the web server.
- Background tasks, installed at shell.ist-mome.org: This includes analysis routines, servers for file uploads, database health check, etc.

The MOME implementation itself consists of a set of scripts and is structured into the following directories:

- **gui**: contains the basic access files to the GUI, including the dispatcher to the different subtasks, taken from the common/analysis/data and tools directory.
- **common**: contains the common classes and files, like user management, etc.
- **analysis**: contains the files for accessing the data analysis features
- **data**: contains the files specifically used for measurement meta-data database handling
- **tools**: contains the files specifically used for measurement tools database handling
- **ext**: contains external included programs and libraries
- **cli**: contains the files used from the command-line interface or cron-jobs, like URL checking, data import scripts, etc.

Due to the separation of the program logic, the HTML framework and the styles (CSS), the implementation, currently integrated into the MOME website, can be easily installed also in the framework of other web-pages.

4.4 MOME Database user manual

In this section, we present a short manual of the MOME database. All users access the database through a web-based front-end. Depending on the type of operations users are allowed to perform on the database, users can be classified into three groups:

- Non-registered users (public users)
- Registered users (reviewers)

- Administrators

In the following, the detailed usage scenarios for the different groups are reported.

4.4.1 Access to measurement tools database

The complete set of operations possible in the database is:

- Add tool entry
- Modify tool entry
- Delete tool entry
- Search database (basic, detailed)
- View list(s)

Table 4-21 specifies the operations that can be performed by each group of users.

Operation **\ Group**	**Admins**	**Reviewers**	**Public (any user)**
Add	YES	YES	NO
Modify	YES (all)	YES (own)	NO
Delete	YES (all)	YES (own)	NO
Search	YES	YES	YES
View	YES	YES	YES

Table 4-21: User Operations on Tools Database

The UML diagram in Figure 4-4 shows an overview of the described use cases:

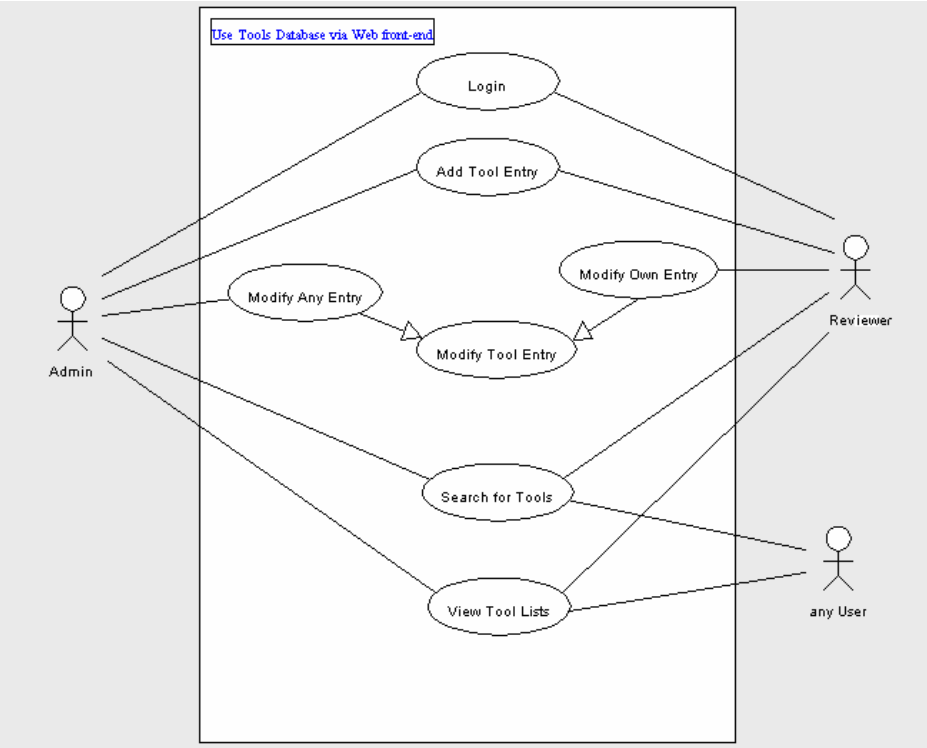


Figure 4-4: Use Cases for Tools Database

4.4.2 Access to measurement data database

The complete set of operations possible in the database is:

- Add measurement data entry
- Modify measurement data entry
- Delete measurement data entry

- Search database
- View list(s)
- Request data analysis

Table 4-22 specifies the operations that can be performed by each group of users.

Operation \ **Group**	**Admins**	**Registered users**	**Public (any user)**
Add	YES	YES	NO
Modify	YES (all)	YES (own)	NO
Delete	YES (all)	YES (own)	NO
Search	YES	YES	YES
View	YES	YES	YES
Analyse	YES	YES	NO

Table 4-22: User Operations on measurement data Database

4.4.3 Non-registered users

Below, the usage scenarios for non-registered users are presented.

4.4.3.1 Public access to the MOME databases

Users access the MOME Databases through the "*Database*" link on the public MOME web page (www.ist-mome.org). The main screen (see Figure 4-5) provides links to the two databases: "*Measurement tools*" and "*Measurement data*".
The "*FAQ*" page provides a short introduction to the functionalities of the MOME Workstation. The "*Contact*" link gives the users the possibility to contact the MOME project sending a mail via web form.

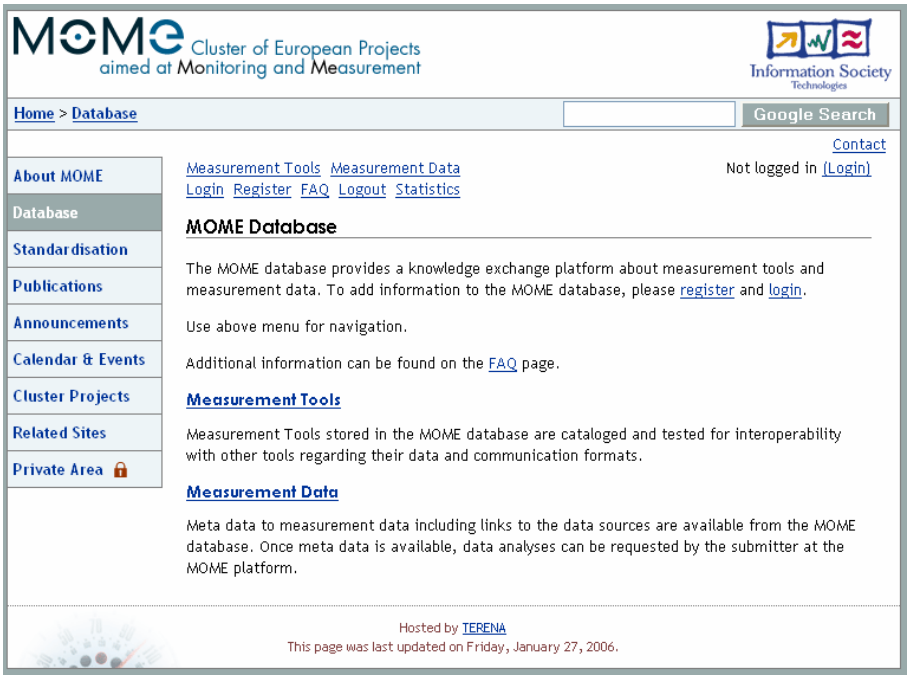


Figure 4-5: Main screen of the MOME Workstation

4.4.3.2 Registering to the MOME system

A Non-registered user, who does not yet have an account in the MOME system, can create it by clicking on the "*Register*" button and providing his user name, valid e-mail address and password. Then, the system sends an e-mail to the new user. If the user confirms the registration by clicking on the link included in the message, the account is activated.

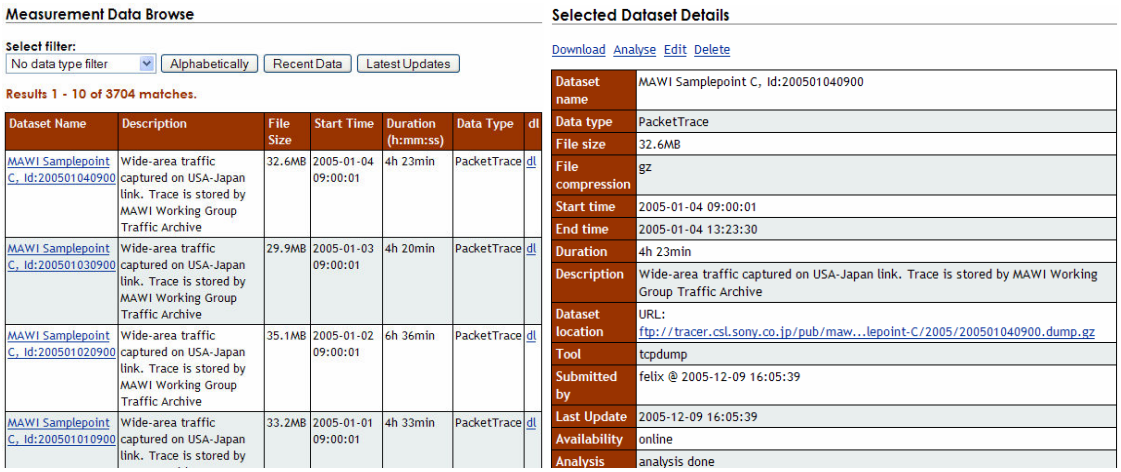
4.4.3.3 Browsing the measurement tools database

After clicking on the link *"Measurement Tools"* the user is redirected to the main Measurement tools Database page (see Figure 4-6). The browsing of the database is aided by a preliminary categorization done already by MOME, the measurement tools are divided in categories depending on their scope (Packet Capturing, Traffic Flow Measurement, Packet Monitoring, etc.). The most interesting tools are already linked at the end of each category for easier user access. The *"Search"* link redirects the user to the page where a user can search for specific Measurement Tools following different criteria. The *"Browse"* link redirects the user page is the page where a user can browse the entire tools list (possible browsing is category-based where all tools are ordered alphabetically). The information a user can retrieve by browsing the tools are: name of the tool, the latest version number of the tool documented, the date when the tool was entered, the last modification date of the entry, a short description of the tool, the home page URL of the tool, some related URLs, the hardware support and the Operating System support for the tool itself. The *"Add"* page is only accessible by registered users for adding tools entries (further modifications of the tools entries are only allowed to the entry creator and to the administrator).

Figure 4-6: Main Measurement Tools Database page

4.4.3.4 Browsing the measurement data database

The *"Browse"* link redirects the user page is the page where a user can browse the entire list of available measurement data. Selecting appropriate filters allows for browsing only data of particular type. The entries can be ordered chronologically or alphabetically. The list of entries shows basic information about each data set: *dataset name*, *description*, *size* of the file with raw data, *start-time* and *duration* of the measurement, as well as *type* of collected data (Figure 4-7a). By clicking on link to particular entry, users can see the "*details*" screen, where all fields describing the raw measurement data set are presented (Figure 4-7b).
After clinking on "more info" the user is redirected to the help screen, which explains the types of measurement data that can be found in the MOME database.



a) b)

Figure 4-7: Browsing the measurement data database: a) overview, b) detailed view

4.4.3.5 Searching the measurement tools database

Each user (both registered and not) can search in the database following specific criteria. The search criteria defined are:

- Name;
- Version;
- Description;
- Home Page URL;
- Contact URL;
- Category (Packet Capturing, Traffic Flow Measurement, Packet Monitoring, etc.);
- Metrics (Packet Capture, Flow Detection, Available Bandwidth, etc.);
- Control Input (Config File, Command Line, Graphical User Interface, etc.);
- Data Input (Live Interface, Tcpdump Packet File, Other Packet File, etc.);
- Data Output (Text Files, Binary Files, To Standard Output, etc.);
- Filter Attributes (Physical Interface, MAC Address, IP Addresses, etc.);
- Availability (Open Source GNU, Other Open Source, Commercial, etc.);
- License (Academic Free, BSD, GNU General Public, etc.);
- HW Support (ARM, PPC, x86, etc.);
- OS Support (Cygwin, Unix, Linux, etc.).

The search returns the measurement tools matching either all the fields entered or any of the fields entered (depending on user selection).

4.4.3.6 Searching the measurement data database

The search function can be accessed by clicking on the "*Search*" button. It is possible to search for meta-database entries with specified values of the following fields: *data type*, *analysis status*, *data availability*. Another fields: *dataset name*, *description*, *appended notes*, *associated data* and *measurement tool* can be searched for occurrence of particular text phrase. Additionally, the user can search for the entries with: *file size*, *start time*, *end time*, *submission date*, or *last update* that is smaller than, equal of greater than particular numerical value.
The search function provides the results in the form of a table with links to all entries matching the search criteria.

4.4.4 Registered users

The registered users not only can browse the databases, but are also allowed to add new entries.

4.4.4.1 Login to the system

The registered users login by entering their user name and password. If the user has forgotten the password, he can ask for re-sending it by e-mail (see Figure 4-8).

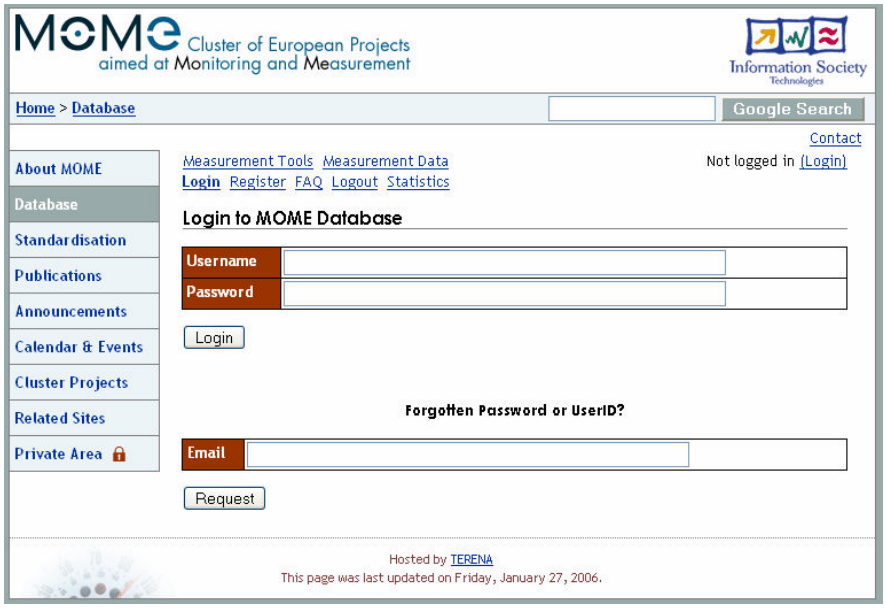


Figure 4-8: MOME Database Login Web Page

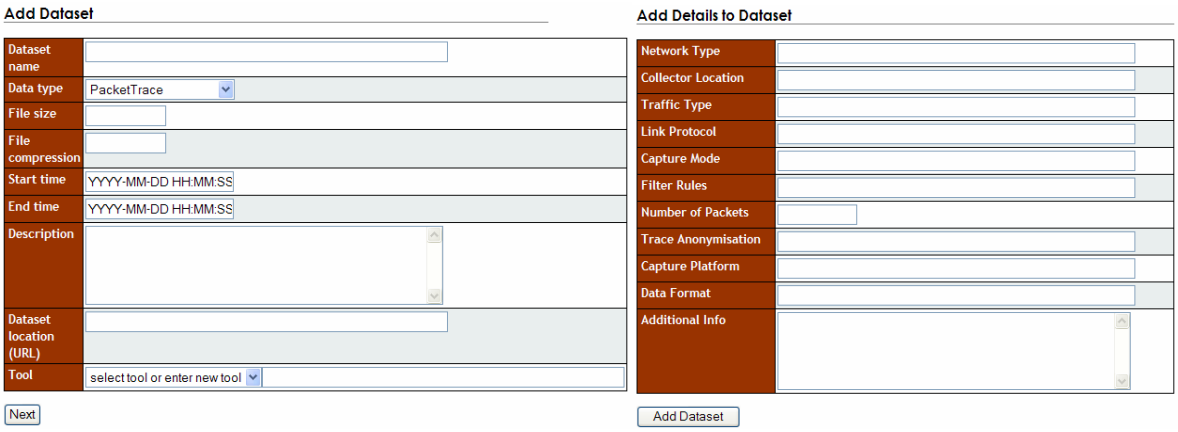
4.4.4.2 Adding new measurement tool entry

The registered user can add new meta-data entry. They can enter all the information for the Measurement Tool, namely:

- Name;
- Version;
- Description;
- Home Page URL;
- Contact URL;
- Category;
- Metrics;
- Control Input;
- Data Input;
- Data Output;
- Filter Attributes;
- Availability;
- License;
- HW Support;
- OS Support.

4.4.4.3 Adding new measurement data entry

The registered user can submit new entry by clicking on the "*Add*" button. After filling-in the general information about the new data set (Figure 4-9a), like e.g.: *name*, *data type*, *start-time* and *end-time* of the measurement, he must click on the "*Next*" button and then can enter the detailed information on the measurement scenario (Figure 4-9b).



a) b)

Figure 4-9: Adding new meta-data entry: a) general information, b) detailed information

4.4.4.4 Requesting data analysis

The registered user can request the analysis of previously submitted measurement data by clicking on the "*Analysis*" button on the "*detailed view*" page. Then he can select requested operation among the available tasks. One must remember that each tool is applicable for specific data type and data format, which is indicated on the list of available tasks. Currently, the following analysis tasks are available:

- *Basic analysis with 'tcpdstat' tool* (for packet-level traces in pcap format). Calculates average traffic rate, average packet inter-arrival time, average packet size, histogram of packet sizes and bandwidth use per-protocol and per-application.
- *Bit rate plots* (for packet-level traces in pcap, erf and tsh formats). Plots the bit rate of captured traffic, calculated over measurement intervals of different length.

4.4.4.5 Modifying and deleting meta-data entry

The registered user can modify previously submitted meta-data entry. Notice, that only the owner of the meta-data entry (and the administrator) has privileges for modifying or deleting the entry.

4.4.5 Administrator

The administrators can perform tasks related with database maintenance. They have complete rights on the MOME database (see Table 4-21).

4.4.5.1 Checking the database statistics

The database statistics (Figure 4-10) include: number of registered users and tools maintainers, total number of tool and meta-data entries, as well as total number and size of entries for each category of measurement data.

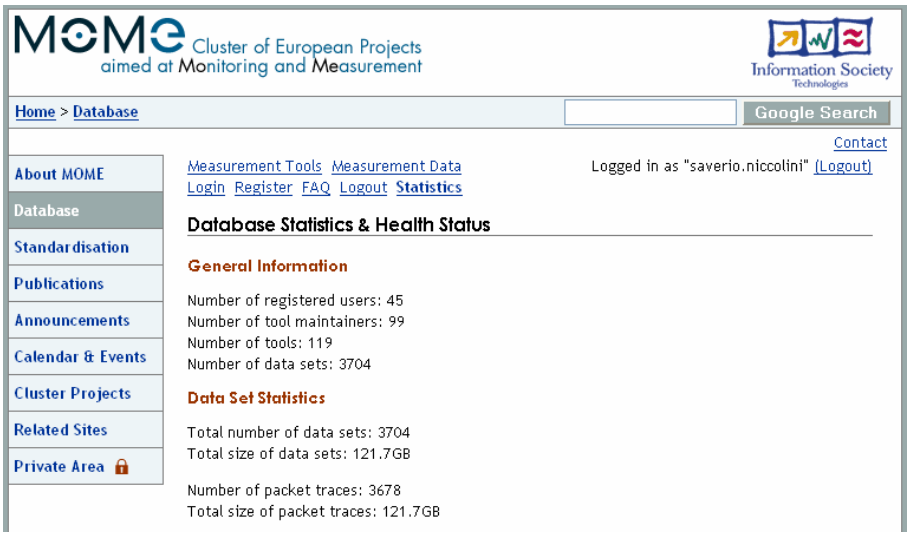


Figure 4-10: Database statistics

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