Infrastructure Configuration Service - user manual

version 0.2.0 - 11 December 2013

SDSS

Infrastructure Configuration Service

PoSecCo

http://www.posecco.eu

Contents

1 Introduction

This document provides an overview of the *Infrastructure Configuration Service* (ICS), which is the tool used to transform the logical associations (LAs), generated by *LA Generation Service*, into abstract configurations for Data Protection and Filtering in the PoSecCo workflow.

This service consists of a set of different modules with their own user interface. All of this modules and their options are documented in the following sections.

For an introduction on the process see Sec. 2 and D3.6 “Models for generating the desired configurations” [**?**] for a complete description.

The Sec. 3 provides a short description of data formats used, i.e., logical associations, logical association implementations and abstract configurations.

The Sec. 4 is devoted to explaining how the tool works, documenting the refinement process to generate the abstract configurations (from LAs), its internal modules and the graphical user interface.

2 Refinement process

The Infrastructure Configuration Service (ICS) transforms logical associations (LAs) into abstract configurations. ICS is composed by the Data Protection and the Filtering modules that refine LAs into abstract configurations. The Data Protection is executed before the Filtering because the filtering rules depends on data protection abstract configurations. For example, when IPsec is configured, the needed filtering rules must be created to permit related traffic.

Both modules share the following workflow (depicted in Fig. 1):

- **Read the LAs and Landscape**. The first step retrieves the landscape description and the logical associations from the PoSecCo repository. Then, by using the landscape description, it generates an internal (graph-based) model to represent the network, hosts, services and capabilities (e.g., filtering). The information needed to contact PoSecCo repository is gathered from a configuration.
- **Generate all the LA implementations**. Starting from the retrieved logical associations and internal model (that contains the landscape information), this step generates the set of LA implementations. In practice, according to the security mechanisms available in the landscape (i.e., ITResource having a Capability), the module identifies all the possible methods to enforce each logical association. In particular for each filtering LA, the module identifies the different sets of firewalls (named LA filtering implementations) and the needed rules to satisfy the set of logical associations. For data protection policies, the module explores the data protection technologies (e.g., IPsec, SSL/TLS, WS-Security, etc.) available into the landscape to satisfy the LAs. Similarly to filtering, the module generates the set of LA implementations considering the available technologies and the network devices.
- **Prune the LA implementations**. Often, enforcing a security policy of a large network offers a huge set of alternatives, LA implementations in PoSecCo terminology, that increase the complexity of the optimization problem. In order to limit this complexity, LA implementations may be discarded either according to some heuristics or by allowing users to explicitly discard some implementations. Therefore this module can optionally perform pruning of generated LA implementations using a particular criterion. For instance, a user may decide to discard certain implementations using devices with poor performance, or avoid the concurrent use of specific devices for a given policy, or to force the use of a specific device. This step outputs the subset of LA implementations that will be actually used in the optimization problem. This step is under development. Another interesting approach is the Inter Layer Analysis that allows to discover the conflicts that exist in LA implementations. This is useful to identify when two implementations are identical, when an implementations shadows another one, when two implementations can be substituted by a new one that includes the previous ones, etc..
- **Optimization**. This step is composed by two sub-modules that generate the mathematical optimization problem and identify optimal solution (using an external solver). This step transforms the subset of LA implementations into a mathematical optimization problem. The target function represents the objective of the optimization (i.e., the goal function), typically a maximization or a minimization of a function. This step also relies on other weights to express device performance, costs, security risks, and so on. Finally, by using an external solver, the module extracts the optimal solution i.e., the LA implementations to use.
- **Generate the abstract configurations**. Once the tool has identified the optimal solution, this module performs the following steps to generate the abstract configurations:
  1. rule creation: the module adapts the information contained in each LA to derive the rules that need to be inserted in each device according to its capabilities. For instance, for a firewall it identifies the IP addresses, the protocol(s) and the port(s) and the fields to fill the rule conditions;
  2. configuration generation: the module collects all the rules and completes the definition of the configuration adding other data, e.g, priorities, resolution strategies;
  3. configuration commit: the tool write the abstract configurations into the PoSecCo repository.

In the Data Protection module, this step also creates the logical associations (defining the reach privilege and the technology used to ensure data protection) to permit traffic related to selected data protection LA implementations.

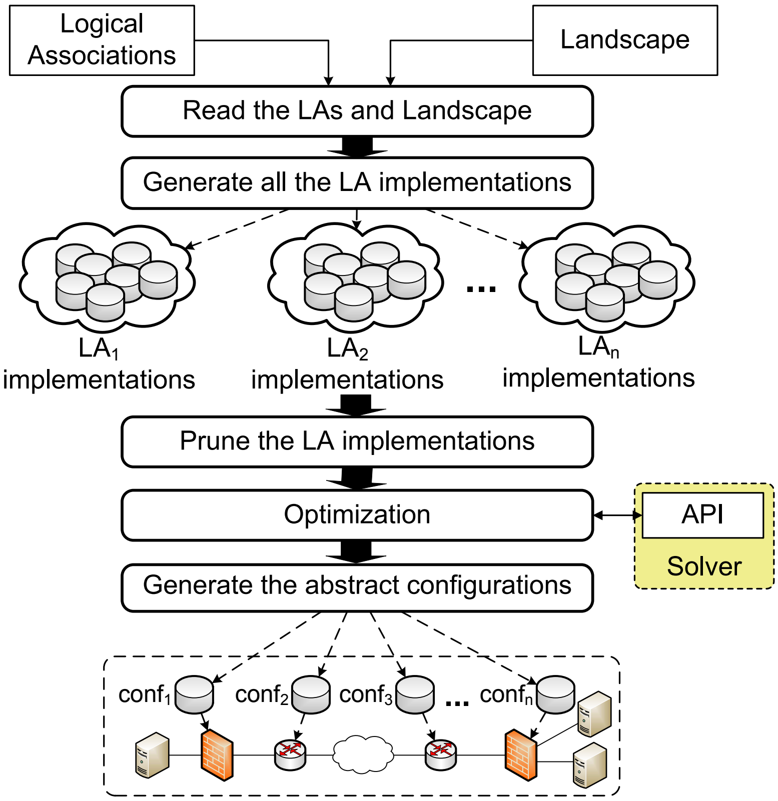


Figure 1: Workflow

3 Data models

3.1 Logical associations

A *logical association*, or *LA* for short, is an intermediate format between the policies and the configurations. It is a lower-level directive than a policy, but it does not contains all the technical information of a configuration.

A logical association is an end-to-end prescription that is used to grant privileges to a subject over an object that also adds the possibility to state additional constraints on subjects and objects and to add privilege properties. The logical associations serve to define authorized communication channels and to state protection requirements to data when they need to be communicated over the network.

In general a logical association contains the following data:

- the communication endpoints, that are a (single or multiple) source and a (single or multiple) destination. Note that the LA endpoints are different from the policies endpoints. The policy endpoints are usually IT services, users and so one, while the LA endpoints are low-level individuals which usually contains IP addresses, ports and URIs;
- a *privilege*, that dictates the privilege between the two endpoints. For our case the privilege is always LAReach that is the two endpoints can communicate;
- a set of security properties, used to select individual protections, e.g., confidentiality, data authenticity, key exchange or peer authentication or aggregation of individual properties by means of templates (e.g., *HighSecurityDataProtection*). Additionally, a set of attributes are used to define other constraints on the ISO/OSI layer where the protection has to be applied or the specific technology (e.g., SSL/TLS, WS-Security, . . .).

The complete description of *Logical Association* meta-model is presented in deliverable D3.6 “Models for generating the desired configurations”.

3.2 Logical association implementations

An *implementation of a logical association* is a way to enforce a LA, formally defined as a set of associations between a security control (taken from the landscape), and a set of configuration rules. In particular the Infrastructure Configuration Service manages two types of implementation: *LA Filtering implementation* and *LA Data Protection implementation*. More precisely a filtering implementation identifies the set of filtering controls, available in the landscape, and a set of rules to enforce an LA. A data protection implementation identifies the two endpoints, the technology (e.g., IPsec, TLS, etc.) and rules to enforce an LA. There exists at least an implementation for a LA, the logical association is enforceable, otherwise it is non enforceable.

Every LA can be usually enforced by using more than one LA implementation. Each implementation is related to the particular security capability of the devices it aims at configuring, in our case, there are filtering and data protection implementations. When more than one implementation is provided for a logical association, the pruning and optimization steps are performed to choose among them using a criteria (named target function). On the contrary, when a logical association is enforced only by one implementation, the pruning and optimization are not required.

Within the Infrastructure Configuration Service, implementations are formally represented using the *Logical Association Implementation* meta-model as described in deliverable D3.6 “Models for generating the desired configurations”.

3.3 Abstract configurations

An *abstract configuration* specifies the set of security controls (technologies and properties, e.g., IKE parameters for IPsec), available in the landscape, to enforce the logical associations.

We distinguish the abstract configurations, that use vendor/product independent syntaxes and formats, from the concrete configurations, configurations that can be directly deployed to a given security control. Configurations are expressed as sets of rules that depend on the control features and directly use the functionalities available at the target control. In fact, even if they are independent of the actual control, also abstract configurations need to be customized to capabilities: filtering controls configuration have peculiarities that are completely different from the ones exposed by channel or message protection controls. Therefore, abstract configurations are categorized by the security capability offered.

The *Filtering Configuration* contains a set of rules, defined using:

- packet filter conditions (e.g., source and destination IP address, source and destination port, protocol type, etc.);
- application layer protocol conditions (e.g., HTTP, FTP, etc.);
- content filter conditions;
- stateful information;
- an action chosen among Allow, Deny, Reject;
- external data, e.g., a priority to express the rule position on the device;
- network interfaces where to enforce the rule.

In addition, a resolution strategy is applied to a Filtering Configuration.

The *Data Protection Configuration* contains a set of rules, defined using:

- packet filter conditions (e.g., source and destination IP address, source and destination port, protocol type, etc.);
- two endpoints that enforce the rules
- an action to perform key exchange, authentication integrity and encryption;
- a set of properties used to configure technology dependent parameters for IPsec, SSL/TLS, IKE etc.;
- network interfaces where to enforce the rule.

Detailed information are described in deliverable D3.6 [**?**].

4 Use of the tool

4.1 Introduction

The Infrastructure Configuration Service is composed by the Data Protection and the Filtering modules that refine logical associations into abstract configurations. The Data Protection is executed before the Filtering one because the filtering rules depends on data protection abstract configurations. For example, when IPsec is configured, the related filtering rules must be created to permit its traffic. The tool automatically manages the logical associations in the corresponding module.

The main GUI of the Infrastructure Configuration Service, depicted in Fig. 2, contains in the left part the workflow steps and the right part is divided into *Data Protection Explorer*, *Filtering Explorer* and *Optimization Models* tabs.

The *Data Protection Explorer* and *Filtering Explorer* contain the following information:

- the *Logical associations* view that contains the set of LAs loaded as input by the tool;
- the *LA implementations* view that contains the set of generated implementations (i.e., the set of security controls and related technologies to enforce each LA) that satisfy the logical associations;
- the *Abstract Configurations* view that contains the set of abstract configurations (that enforce the LAs) generated from the LA implementations according to an optimization goal.

The *Optimization Models* tab contains the Data Protection and Filtering optimization models represented using the LP standard format.

The refinement can be automatic or it can be manually performed step by step whose steps are accessible in *Manual Process View*.

4.1.1 Automatic process

The automatic process that can be executed by the user (by pressing the *Generate All The Configurations* button), and selecting the optimization profiles (prompted to the user by means of a dialog window) for Data Protection and Filtering before starting the process.

4.1.2 Manual process

The following section describes the manual process discussing the steps and related views. Similarly, the automatic process performs the same steps and provides the same information.

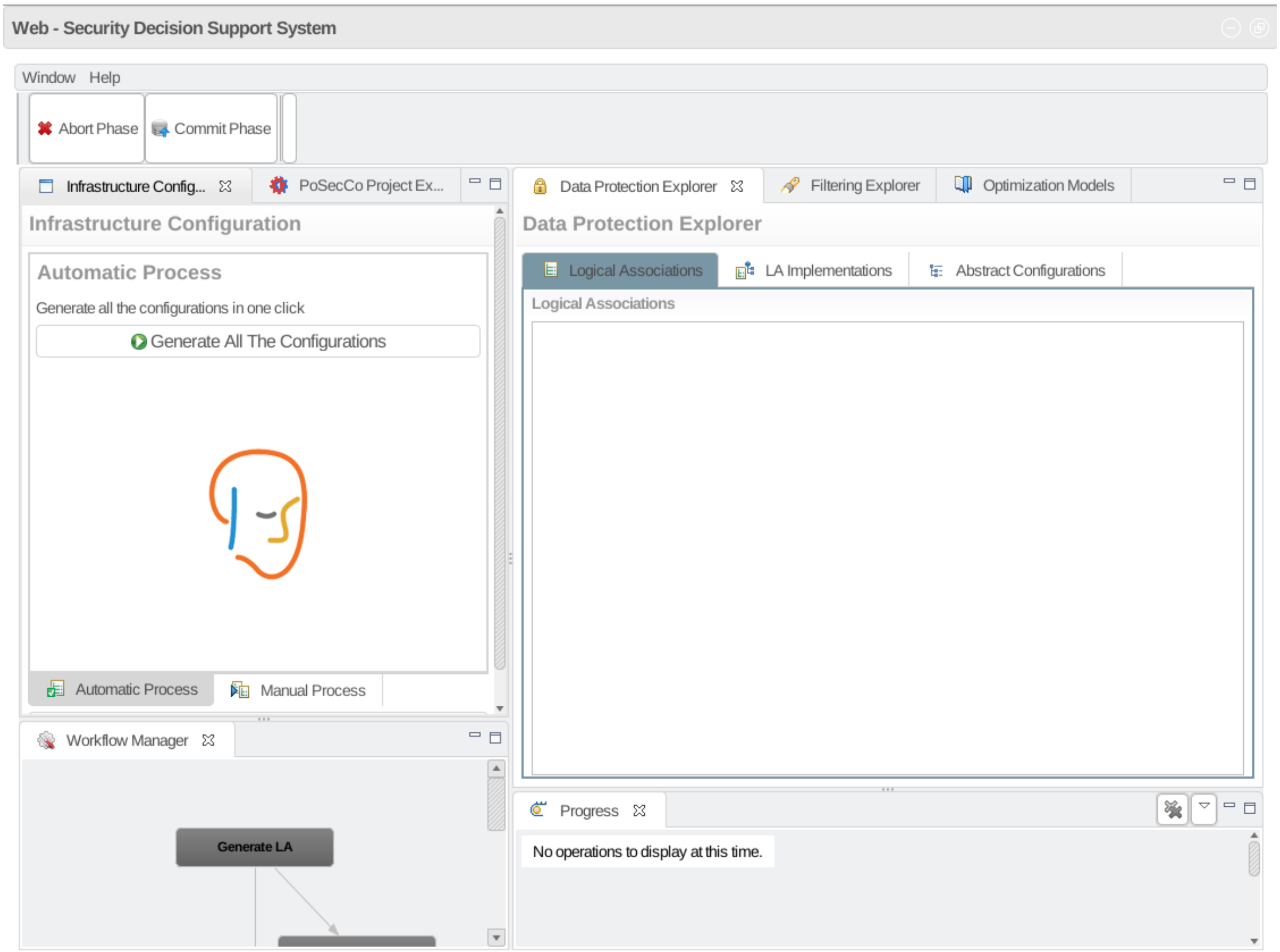


Figure 2: IC Area main window

4.2 Manual process - Data Protection

To present the specific views and the information related to refinement of the logical associations, we start from the Data Protection LAs using the manual process depicted in Fig. 3.

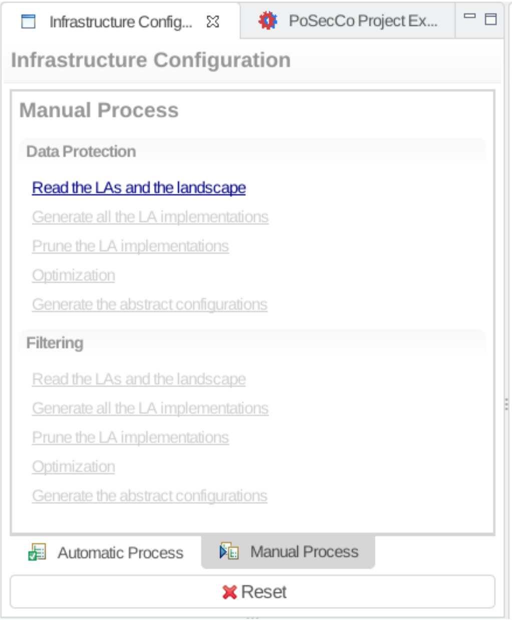
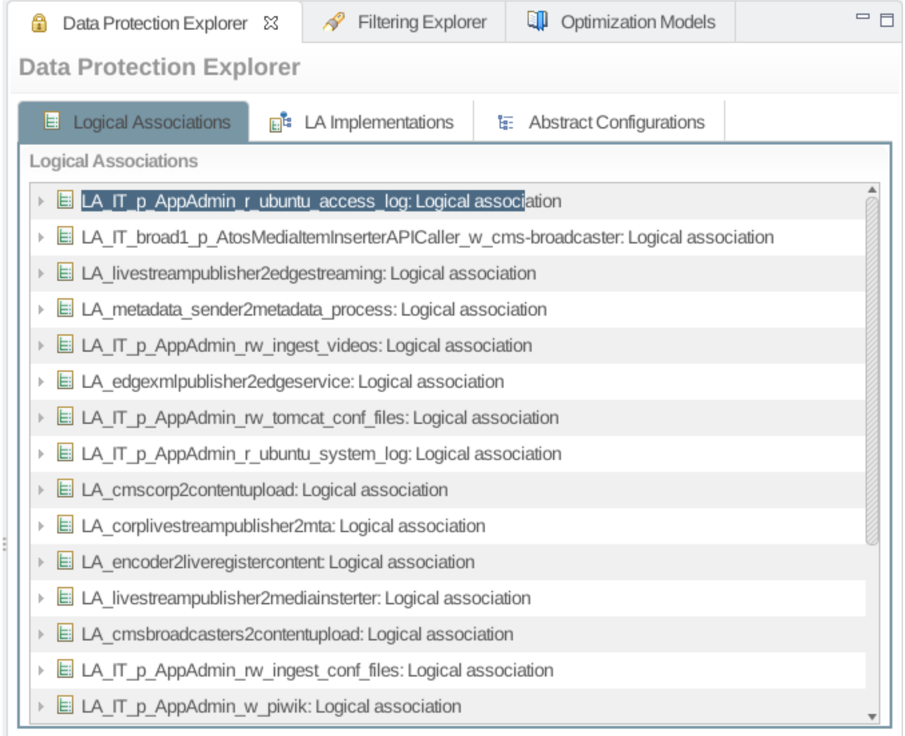

Infrastructure Config...
PoSecCo Project Ex...
Infrastructure Configuration
Manual Process
Data Protection
Read the LAs and the landscape
Generate all the LA implementations
Prune the LA implementations
Optimization
Generate the abstract configurations
Filtering
Read the LAs and the landscape
Generate all the LA implementations
Prune the LA implementations
Optimization
Generate the abstract configurations
Automatic Process
Manual Process
Reset

Figure 3: Data Protection: Manual process menu

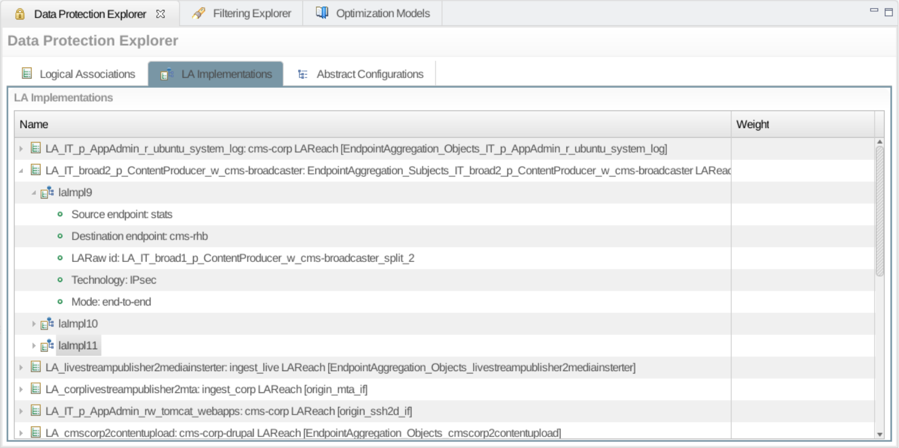
Step 1. By clicking on *Read the LAs and the landscape* the tool loads the Data Protection logical associations and the landscape. The landscape is loaded from MoVE repository and the set of logical associations from an internal data model and generated by *LA Generation Service*. This modules loads only the set of LAs that requires Confidentiality. The input set of LAs is displayed in Fig. 4. Considering the related view, for each LA we have the subject, the object, the LAReach privilege and the template (Confidentiality). In this phase the other menu items are disabled;



LA_IT_p_AppAdmin_r_ubuntu_access_log: Logical association
LA_IT_broad1_p_AtosMediaItemInserterAPICaller_w_cms-broadcaster: Logical association
LA_livestreampublisher2edgestreaming: Logical association
LA_metadata_sender2metadata_process: Logical association
LA_IT_p_AppAdmin_rw_ingest_videos: Logical association
LA_edgexmlpublisher2edgeservice: Logical association
LA_IT_p_AppAdmin_rw_tomcat_conf_files: Logical association
LA_IT_p_AppAdmin_r_ubuntu_system_log: Logical association
LA_cmscorp2contentupload: Logical association
LA_corplivestreampublisher2mta: Logical association
LA_encoder2liveregistercontent: Logical association
LA_livestreampublisher2mediainsterter: Logical association
LA_cmsbroadcasters2contentupload: Logical association
LA_IT_p_AppAdmin_rw_ingest_conf_files: Logical association
LA_IT_p_AppAdmin_w_piwik: Logical association

Figure 4: Data Protection: LAs details

Step 2. By clicking on *Generate all the LA implementations* the tool generate all the possible Data Protection implementations. The resulting set of LA implementations is displayed in Fig. 5. Considering the related view, each LA implementation shows two endpoints to enforce the LA, the selected technology (e.g., IPsec, SSL/TLS, etc.) and the related mode (e.g., end-to-end, site-to-site, remote-access). You can see also cases where the LA is not implementable;



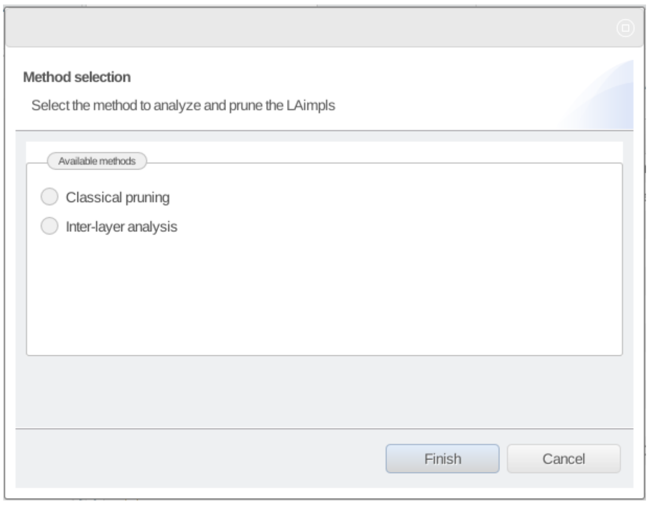
Data Protection Explorer

LA Implementations

Name	Weight
LA_IT_p_AppAdmin_r_ubuntu_system_log: cms-corp LAReach [EndpointAggregation_Objects_IT_p_AppAdmin_r_ubuntu_system_log]	
LA_IT_broad2_p_ContentProducer_w_cms-broadcaster: EndpointAggregation_Subjects_IT_broad2_p_ContentProducer_w_cms-broadcaster LARea	
laImpl9	
○ Source endpoint: stats	
○ Destination endpoint: cms-rhb	
○ LARaw id: LA_IT_broad1_p_ContentProducer_w_cms-broadcaster_split_2	
○ Technology: IPsec	
○ Mode: end-to-end	
laImpl10	
laImpl11	
LA_livestreampublisher2mediainsterter: ingest_live LAReach [EndpointAggregation_Objects_livestreampublisher2mediainsterter]	
LA_corplivestreampublisher2mta: ingest_corp LAReach [origin_mta_if]	
LA_IT_p_AppAdmin_rw_tomcat_webapps: cms-corp LAReach [origin_ssh2d_if]	
LA_cmscorp2contentupload: cms-corp-drupal LAReach [EndpointAggregation_Objects_cmscorp2contentupload]	

Figure 5: Data Protection: LA implementations details

Step 3. By clicking on *Prune the LA implementations* the tool prunes the logical associations, i.e., it discards a subset of them using a heuristic selected by the user. The tool proposes two pruning approaches (Fig. 6): Classical pruning and inter-layer analysis.



Method selection

Select the method to analyze and prune the LAimpls

Available methods

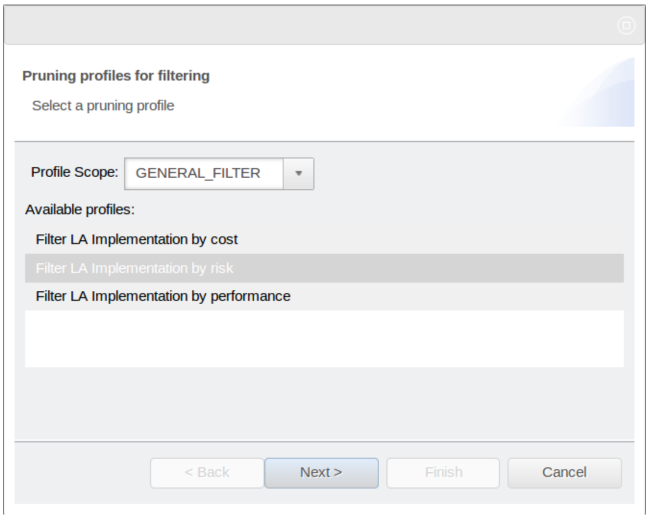
○ Classical pruning

○ Inter-layer analysis

Figure 6: Data Protection: selection of the pruning mode

The Classical pruning Fig. 7 defines a set of filters organised as general and specific. A general filter is applied on the complete set of the logical associations, otherwise a specific filter is applied only on a LA, selected by the user. The available filters, both for specific and general, are:

- select the LAImpls with cost less than a specific value (defined by the user);
- select the LAImpls with security risk less than a specific value (defined by the user);
- select the LAImpls with performance greater than a specific value (defined by the user);
- select the LAImpls with a particular technology and related properties (defined by the user, for example IPsec in site-to-site mode).



Pruning profiles for filtering

Select a pruning profile

Profile Scope: GENERAL_FILTER

Available profiles:

Filter LA Implementation by cost

Filter LA Implementation by risk

Filter LA Implementation by performance

Figure 7: Data Protection: selection of the pruning profile

The Inter Layer Analysis allows to discover the conflicts that exist in LA implementations (LAImpl). These conflicts were defines as Inter Layer Conflicts and they could be considered not critical errors but warnings.

In particular we have classified five types of conflicts that are:

Equivalence, when two LAImpls are identical;

Inclusion, when a LAImpl shadows another one, hence the first LAImpl is included by the second;

Correlation, when two LAImpls can be substituted by a new LAImpl that includes the previous ones;

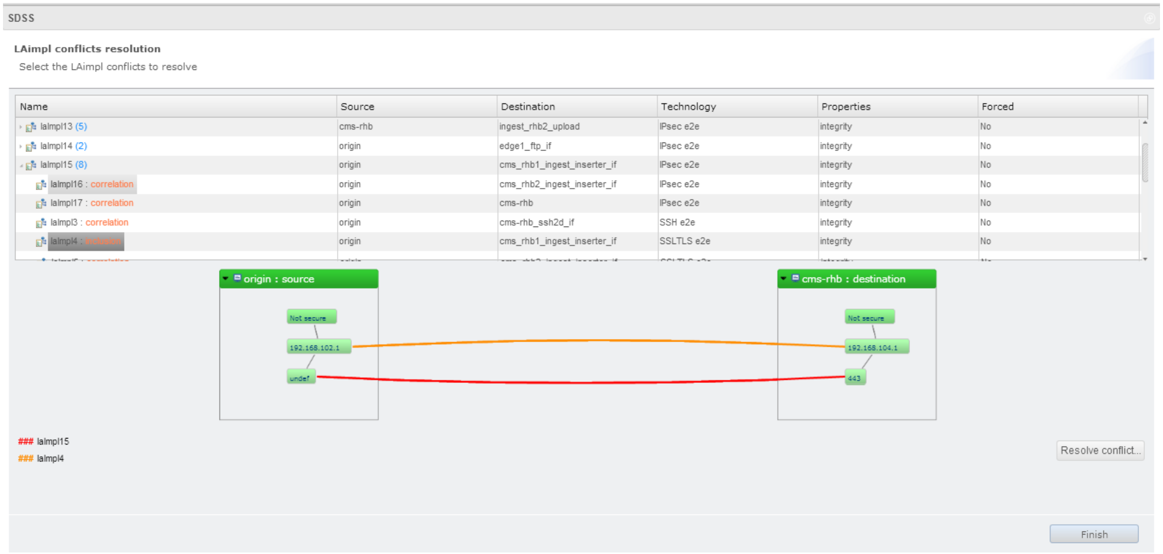
Affinity, when there are two identical LAImpls but for the mode (namely one site-to-site and one end-to-end);

Irrelevant, when a LAImpl can be safely removed without changing the semantic of the network.

The Inter Layer Conflicts are described using a multi-graph, where each sub-graph represents a network node. To be more specific, a sub-graph is composed by a set of vertices layered on four levels, which are:

- The untruthful communications;
- The trustful communications at IP level (like IPSec);
- The trustful communications at transport level (e.g., SSL/TSL);
- The trustful communications at application level (like SSH or WS-Security).

The main wizard of the Inter Layer Analysis, shown in Figure 8, is organized in two main parts. At the top, there is the list of the conflicting LAImpls, while below there is the multi-graph, which represents the conflicts between one or two LAimpls, belonging to the previous list. Note that the first column of the list shows also the conflict type.



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LAimpl conflicts resolution

Select the LAimpl conflicts to resolve

Name	Source	Destination	Technology	Properties	Forced
lalmpl13 (5)	cms-rhb	ingest_rhb2_upload	IPsec e2e	integrity	No
lalmpl14 (2)	origin	edge1_ftp_if	IPsec e2e	integrity	No
lalmpl15 (8)	origin	cms_rhb1_ingest_inserter_if	IPsec e2e	integrity	No
lalmpl16 : correlation	origin	cms_rhb2_ingest_inserter_if	IPsec e2e	integrity	No
lalmpl17 : correlation	origin	cms-rhb	IPsec e2e	integrity	No
lalmpl3 : correlation	origin	cms-rhb_ssh2d_if	SSH e2e	integrity	No
lalmpl4 : inclusion	origin	cms_rhb1_ingest_inserter_if	SSLTLS e2e	integrity	No

🟥 lalmpl15
🟧 lalmpl4

Figure 8: Inter-Layer Analysis: conflict visualization

When the user selects the conflicting LAImpl(s), it is possible to resolve the conflict using the button “Resolve conflict...”. After this, a new resolution window will be opened (as we can see in Figure 9). In this new window, the administrator can choose the specific actions that will be executed on that LAImpl(s). In particular, the possible actions that can be applied per conflict are:

Delete: delete the specified LAImpl;

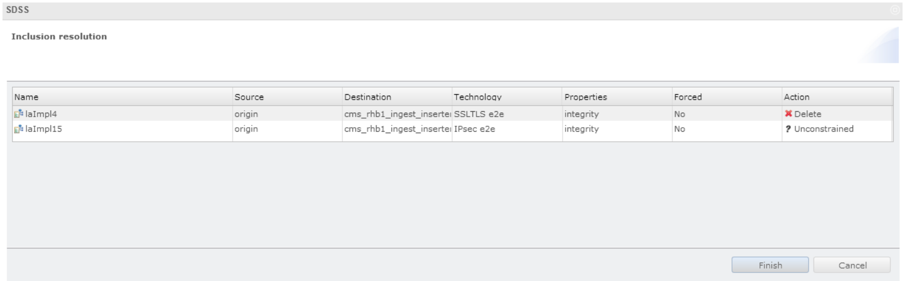
Force: force the use of this LAImpl to implement a logical association;

Unconstrained: leave the optimizer wheather the specified LAImpl must be discarded or used, according to the selected optimization function;

Create unconstrained: create a new LAImpl that shadows the previous LAImpls — the optimizer can choose to discard this newly created LAImpl;

Create forced: create a new LAImpl that shadows the previous LAImpls — this LAImpl will be forced in the optimal solution.

Please note that the GUI will usually not allow the user to choose between all the previously listed actions in order to avoid an unwanted deletion of semantics. For instance during an inclusion resolution it is not possible to delete the including LAImpl, since this action can negatively affect the final configurations.



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Inclusion resolution

Name	Source	Destination	Technology	Properties	Forced	Action
laImpl4	origin	cms_rhb1_ingest_inserte	SSLTLS e2e	integrity	No	✖ Delete
laImpl15	origin	cms_rhb1_ingest_inserte	IPsec e2e	integrity	No	? Unconstrained

Figure 9: Data Protection: resolve conflict

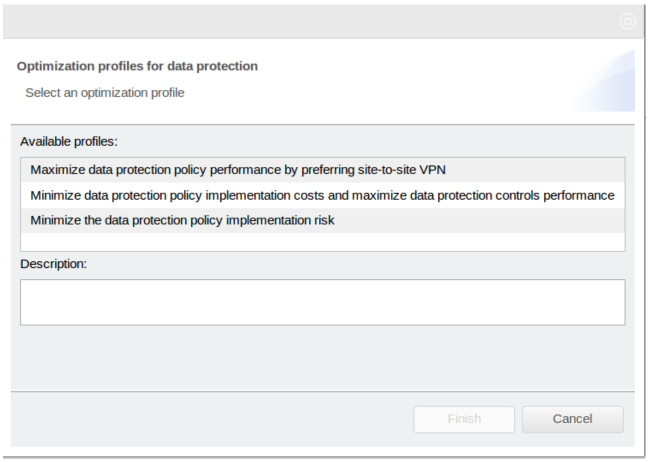
Step 4. By clicking on *Optimization* the user is prompted to select the profile to perform the Data Protection optimization. The available profiles for Data Protection are depicted in Fig. 10. In this release the available optimization profiles are:

1. MIN IMPLEMENTATION COST AND MAX THROUGHPUT PROFILE that minimizes the cost of an implementation and maximizes the throughput according to a set of weights (cost, performance) that are provided independently to the tool and associated to landscape for technologies

and endpoints. The cost of an implementation depends on the selected technology. The throughput depends on the device performance to manage a data protection technology. The objective of this profile is to optimize the trade-off between implementation costs and throughput;

2. MAX THROUGHPUT WITH VPN PROFILE that maximizes the throughput considering performance of technologies and devices. This profile tries to aggregate the traffic of different logical associations using shared IPsec gateways to enforce data protection. When a LA cannot be protected using an IPsec gateway, e.g., the available implementations support only IPsec end-to-end or SSL/TLS, the optimization profile selects the implementation that maximize the throughput (typically IPsec in end-to-end mode);
3. MIN RISK PROFILE that minimizes the security risk according to technologies and endpoints. We assign a security risk to each technology (t_r^j, e.g., t_r^{ipsec}), logical association (l_r^k e.g., l_r^1) and device (d_r^m e.g., d_r^1, d_r^2). Then the tool calculates a composite risk for a LA implementation ($i_r^{n,p}$ e.g., $i_r^{1,1}$ considering the risk of: LA l_r^1, IPsec technology t_r^{ipsec} and devices d_r^1, d_r^2) using the formula:
$$i_r^{1,1} = \lceil max(max(d_r^1, d_r^2), log_2(t_r^{ipsec} \cdot l_r^1)).$$

When the user selects a profile, the tool generates the Data Protection optimization model (Fig. 11) and by using an external solver performs the optimization. This task identifies the set of implementations that optimize the goal, specified by selecting the optimization profile. The result is depicted in Fig. 12. The implementations selected by the solver are identified by a green check mark. To configure external solver see the “Installation Manual”;



Optimization profiles for data protection

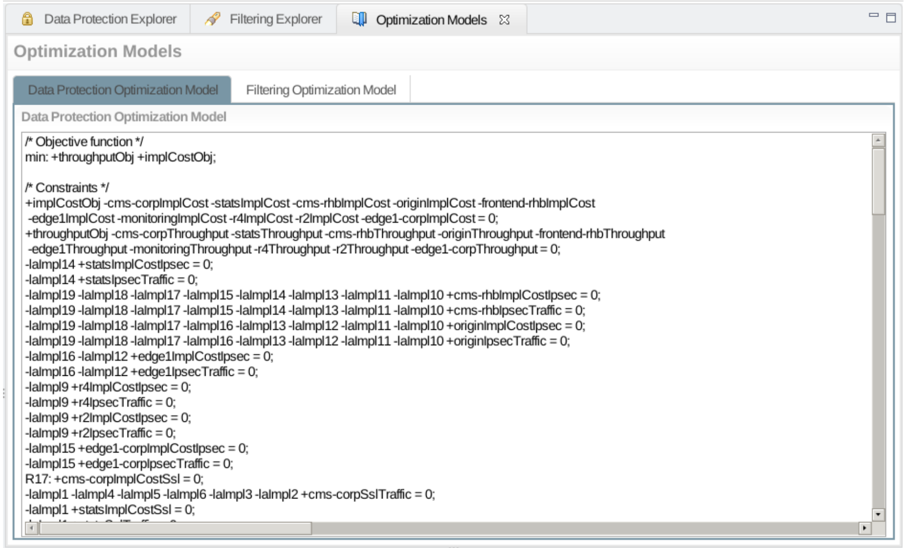
Select an optimization profile

Available profiles:

- Maximize data protection policy performance by preferring site-to-site VPN
- Minimize data protection policy implementation costs and maximize data protection controls performance
- Minimize the data protection policy implementation risk

Description:

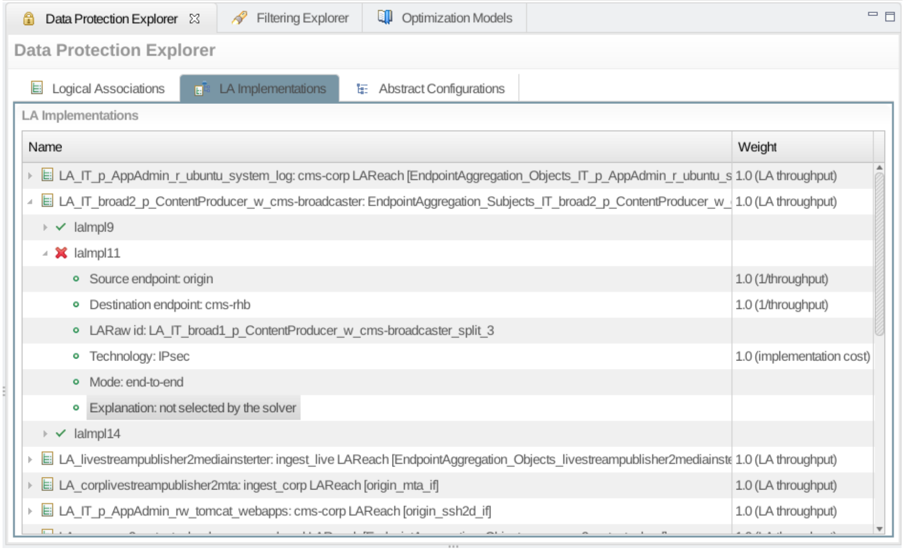
Figure 10: Data Protection: selection of the Optimization profile


Data Protection Explorer
Filtering Explorer
Optimization Models
Optimization Models
Data Protection Optimization Model
Filtering Optimization Model
Data Protection Optimization Model

```
/* Objective function */
min: +throughputObj +implCostObj;

/* Constraints */
+implCostObj -cms-corpImplCost -statsImplCost -cms-rhbImplCost -originImplCost -frontend-rhbImplCost
 -edge1ImplCost -monitoringImplCost -r4ImplCost -r2ImplCost -edge1-corpImplCost = 0;
+throughputObj -cms-corpThroughput -statsThroughput -cms-rhbThroughput -originThroughput -frontend-rhbThroughput
 -edge1Throughput -monitoringThroughput -r4Throughput -r2Throughput -edge1-corpThroughput = 0;
-laImpl14 +statsImplCostIpsec = 0;
-laImpl14 +statsIpsecTraffic = 0;
-laImpl19 -laImpl18 -laImpl17 -laImpl15 -laImpl14 -laImpl13 -laImpl11 -laImpl10 +cms-rhbImplCostIpsec = 0;
-laImpl19 -laImpl18 -laImpl17 -laImpl15 -laImpl14 -laImpl13 -laImpl11 -laImpl10 +cms-rhbIpsecTraffic = 0;
-laImpl19 -laImpl18 -laImpl17 -laImpl16 -laImpl13 -laImpl12 -laImpl11 -laImpl10 +originImplCostIpsec = 0;
-laImpl19 -laImpl18 -laImpl17 -laImpl16 -laImpl13 -laImpl12 -laImpl11 -laImpl10 +originIpsecTraffic = 0;
-laImpl16 -laImpl12 +edge1ImplCostIpsec = 0;
-laImpl16 -laImpl12 +edge1IpsecTraffic = 0;
-laImpl9 +r4ImplCostIpsec = 0;
-laImpl9 +r4IpsecTraffic = 0;
-laImpl9 +r2ImplCostIpsec = 0;
-laImpl9 +r2IpsecTraffic = 0;
-laImpl15 +edge1-corpImplCostIpsec = 0;
-laImpl15 +edge1-corpIpsecTraffic = 0;
R17: +cms-corpImplCostSsl = 0;
-laImpl1 -laImpl4 -laImpl5 -laImpl6 -laImpl3 -laImpl2 +cms-corpSslTraffic = 0;
-laImpl1 +statsImplCostSsl = 0;
```

Figure 11: Data Protection: Optimization model

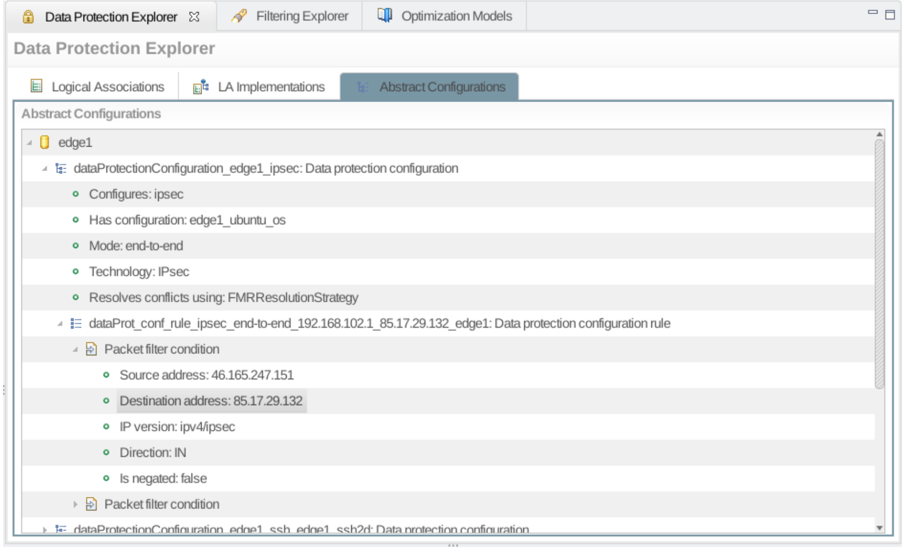


Name	Weight
LA_IT_p_AppAdmin_r_ubuntu_system_log: cms-corp LAReach [EndpointAggregation_Objects_IT_p_AppAdmin_r_ubuntu_s	1.0 (LA throughput)
LA_IT_broad2_p_ContentProducer_w_cms-broadcaster: EndpointAggregation_Subjects_IT_broad2_p_ContentProducer_w_	1.0 (LA throughput)
✓ laImpl9	
✗ laImpl11	
○ Source endpoint: origin	1.0 (1/throughput)
○ Destination endpoint: cms-rhb	1.0 (1/throughput)
○ LARaw id: LA_IT_broad1_p_ContentProducer_w_cms-broadcaster_split_3	
○ Technology: IPsec	1.0 (implementation cost)
○ Mode: end-to-end	
○ Explanation: not selected by the solver	
✓ laImpl14	
LA_livestreampublisher2mediainsterter: ingest_live LAReach [EndpointAggregation_Objects_livestreampublisher2mediainste	1.0 (LA throughput)
LA_corplivestreampublisher2mta: ingest_corp LAReach [origin_mta_if]	1.0 (LA throughput)
LA_IT_p_AppAdmin_rw_tomcat_webapps: cms-corp LAReach [origin_ssh2d_if]	1.0 (LA throughput)

Figure 12: Data Protection: Optimization results

Step 5. By clicking on *Generate the abstract configurations* the tool generates the Data Protection abstract configurations. The results are displayed in Fig. 13. This step also creates the logical associations (defining the reach privilege and the technology used to ensure data protection) to permit traffic related to data protection abstract configurations. These LAs are stored in the internal data model represented as an ontology. The view is implemented using a tree and organized as follow:

- the first level contains the set of configured devices (e.g., s1);
- the second level contains the set of Data Protection Configurations;
- the third level defines the configuration properties and the related rules. For example the Fig. 13 shows that we configure IPsec (end-to-end mode) on `s1.os` using a First Matching Rule strategy.
- the fourth level defines the properties of a configuration rule. For example the Fig. 13 shows the related packet filter conditions (source and destination IP address, direction, etc.).



- edge1
  - dataProtectionConfiguration_edge1_ipsec: Data protection configuration
    - Configures: ipsec
    - Has configuration: edge1_ubuntu_os
    - Mode: end-to-end
    - Technology: IPsec
    - Resolves conflicts using: FMRResolutionStrategy
    - dataProt_conf_rule_ipsec_end-to-end_192.168.102.1_85.17.29.132_edge1: Data protection configuration rule
      - Packet filter condition
        - Source address: 46.165.247.151
        - Destination address: 85.17.29.132
        - IP version: ipv4/ipsec
        - Direction: IN
        - Is negated: false
      - Packet filter condition
  - dataProtectionConfiguration_edge1_ssh_edge1_ssh2d: Data protection configuration

Figure 13: Data Protection: Abstract configurations

4.3 Manual process - Filtering

The refinement of Filtering logical associations follows the same process as the Data Protection. Therefore, similarly to previous case, we present the views of Filtering module using the manual process depicted in Fig. 14.

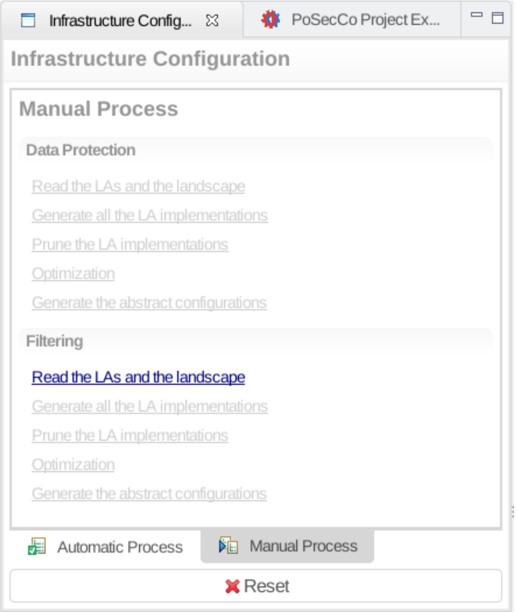
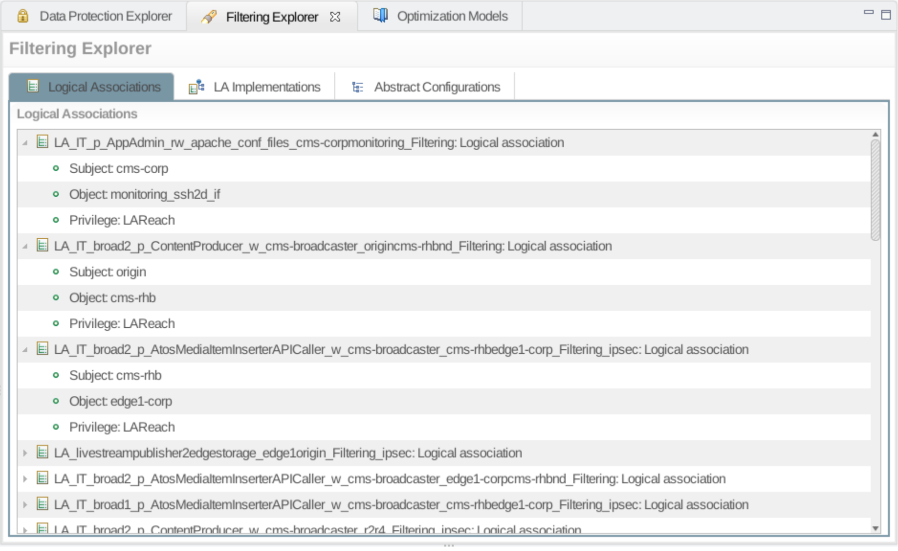

Infrastructure Config...
PoSecCo Project Ex...
Infrastructure Configuration
Manual Process
Data Protection
Read the LAs and the landscape
Generate all the LA implementations
Prune the LA implementations
Optimization
Generate the abstract configurations
Filtering
Read the LAs and the landscape
Generate all the LA implementations
Prune the LA implementations
Optimization
Generate the abstract configurations
Automatic Process
Manual Process
Reset

Figure 14: Filtering: Manual process menu

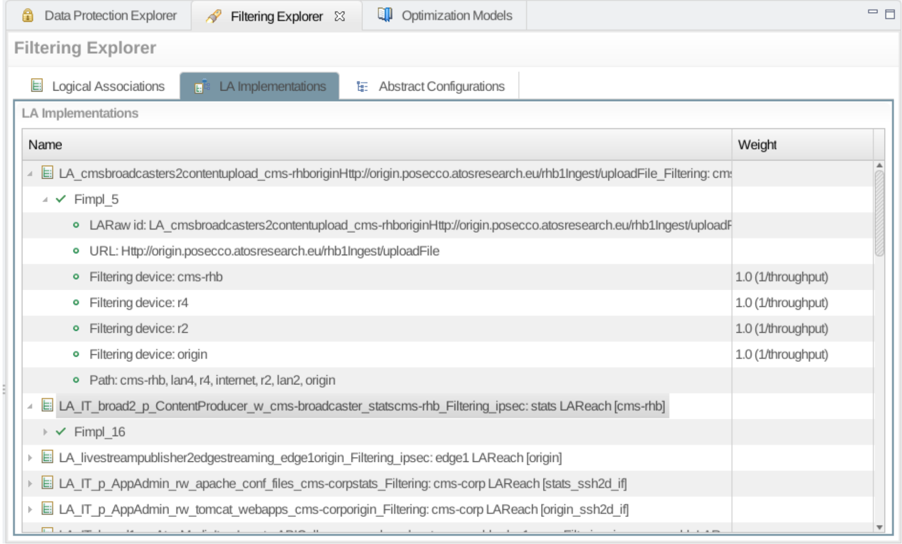
Step 1. By clicking on *Read the LAs and the landscape* the tool loads the Filtering logical associations and the landscape. The landscape and the set of logical associations are loaded from MoVE repository. The input set of LAs is displayed in Fig. 15. In this phase the tool also loads the LAs generated by Data Protection module. According to the related view, for each LA we have the subject, the object, the LAReach privilege and the confidentiality template (Confidentiality). In this phase the other menu items are disabled;



- LA_IT_p_AppAdmin_rw_apache_conf_files_cms-corpmonitoring_Filtering: Logical association
  - Subject: cms-corp
  - Object: monitoring_ssh2d_if
  - Privilege: LAReach
- LA_IT_broad2_p_ContentProducer_w_cms-broadcaster_origincms-rhbnd_Filtering: Logical association
  - Subject: origin
  - Object: cms-rhb
  - Privilege: LAReach
- LA_IT_broad2_p_AtosMediaItemInserterAPICaller_w_cms-broadcaster_cms-rhbedge1-corp_Filtering_ipsec: Logical association
  - Subject: cms-rhb
  - Object: edge1-corp
  - Privilege: LAReach
- LA_livestreampublisher2edgestorage_edge1origin_Filtering_ipsec: Logical association
- LA_IT_broad2_p_AtosMediaItemInserterAPICaller_w_cms-broadcaster_edge1-corpcms-rhbnd_Filtering: Logical association
- LA_IT_broad1_p_AtosMediaItemInserterAPICaller_w_cms-broadcaster_cms-rhbedge1-corp_Filtering_ipsec: Logical association
- LA_IT_broad2_p_ContentProducer_w_cms-broadcaster_r2r4_Filtering_ipsec: Logical association

Figure 15: Filtering: LAs details

Step 2. By clicking on *Generate all the LA implementations* the tool generates all the possible Filtering implementations. The resulting set of LA implementations is displayed in Fig. 16. According to the related view, each LA implementation has at least a path that may contain a set of filtering devices. You can see also cases where the LA is not implementable (e.g., the first LA in Fig. 16 IT_ITP_SPSAdmins_ccD . . .);



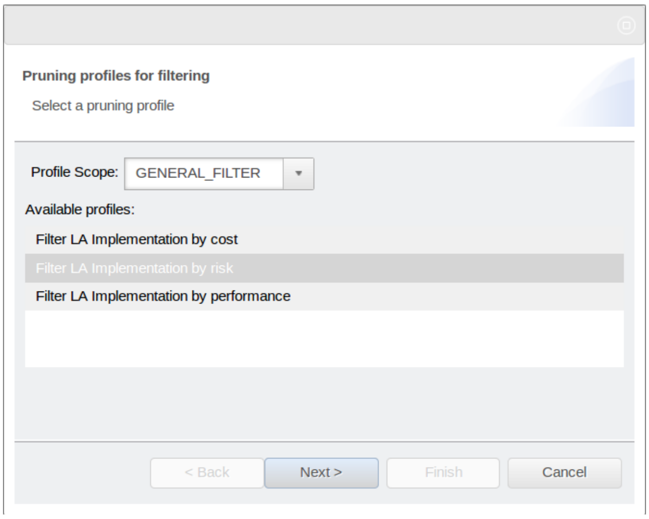
Name	Weight
LA_cmsbroadcasters2contentupload_cms-rhboriginHttp://origin.posecco.atosresearch.eu/rhb1Ingest/uploadFile_Filtering: cm:	
✓ Fimpl_5	
LARaw id: LA_cmsbroadcasters2contentupload_cms-rhboriginHttp://origin.posecco.atosresearch.eu/rhb1Ingest/uploadF	
URL: Http://origin.posecco.atosresearch.eu/rhb1Ingest/uploadFile	
Filtering device: cms-rhb	1.0 (1/throughput)
Filtering device: r4	1.0 (1/throughput)
Filtering device: r2	1.0 (1/throughput)
Filtering device: origin	1.0 (1/throughput)
Path: cms-rhb, lan4, r4, internet, r2, lan2, origin	
LA_IT_broad2_p_ContentProducer_w_cms-broadcaster_statscms-rhb_Filtering_ipsec: stats LAReach [cms-rhb]	
✓ Fimpl_16	
LA_livestreampublisher2edgestreaming_edge1origin_Filtering_ipsec: edge1 LAReach [origin]	
LA_IT_p_AppAdmin_rw_apache_conf_files_cms-corpstats_Filtering: cms-corp LAReach [stats_ssh2d_if]	
LA_IT_p_AppAdmin_rw_tomcat_webapps_cms-corporigin_Filtering: cms-corp LAReach [origin_ssh2d_if]	

Figure 16: Filtering: LA implementations details

Step 3. By clicking on *Prune the LA implementations* the tool prunes the logical associations, i.e., it discards a subset of them using a heuristic selected by the user.

Similarly to Data Protection, the Filtering pruning Fig. 7 defines a set of filters organised as general and specific. A general filter is applied on the complete set of the logical associations, otherwise a specific filter is applied only on a LA, selected by the user. The available filters, both for specific and general, are:

- select the LAImpls with cost less than a specific value (defined by the user);
- select the LAImpls with security risk less than a specific value (defined by the user);
- select the LAImpls with performance greater than a specific value (defined by the user).



Pruning profiles for filtering

Select a pruning profile

Profile Scope: GENERAL_FILTER

Available profiles:

Filter LA Implementation by cost

Filter LA Implementation by risk

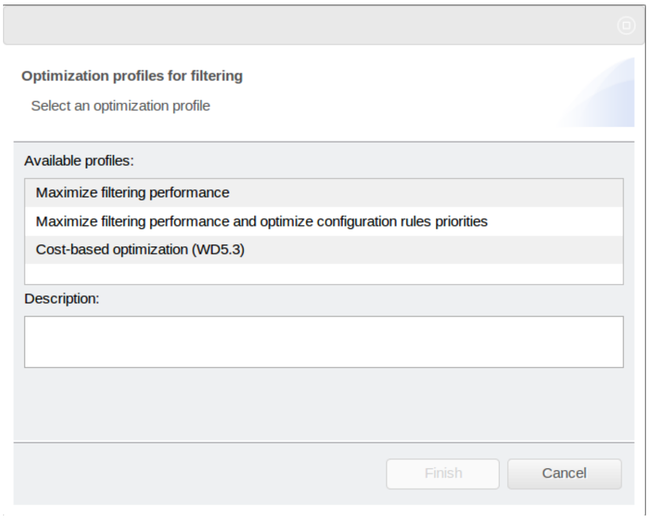
Filter LA Implementation by performance

Figure 17: Filtering: selection of the pruning profile

Step 4. By clicking on *Optimization* the user is prompted to select the profile to perform the Filtering optimization. The available profiles for Filtering are depicted in Fig. 18. In this release the available optimization profile is:

1. MAX FILTERING PERFORMANCE PROFILE that maximizes the performance of devices by minimizing the global number of rules. Each LA implementation installs a set of rules on a specific device and the performance of a device depends on the number of processed rules. Therefore we define two weights: one to define the inserted rule for each LA implementation and another to express the performance (i.e., the number of rules that can be processed in a time unit, e.g., in 1 second). This profile maximizes the global performance minimizing the number of installed rules;
2. FILTERING SORTING RULES CONSIDERING THROUGHPUT that maximizes the throughput considering the rule positions on devices. Software firewalls (e.g., Netfilter) adopt linear search to find the rule that matches a packet. Therefore, considering the resolution strategy (e.g., First Matching Rule - FMR) and the traffic type, the rules that are frequently matched must be positioned accordingly. In case of FMR, the optimization profile assigns high priority to these rules (i.e., the rules are positioned at the top);

When the user selects a profile, the tool generates the Filtering optimization model (Fig. 19) and by using an external solver it performs the optimization. This task identifies the set of implementations that optimize the goal, specified by selecting the optimization profile. The result is depicted in Fig. 20. The implementations selected by the solver are identified by a green check mark. To configure external solver see “Installation Manual”;



Optimization profiles for filtering

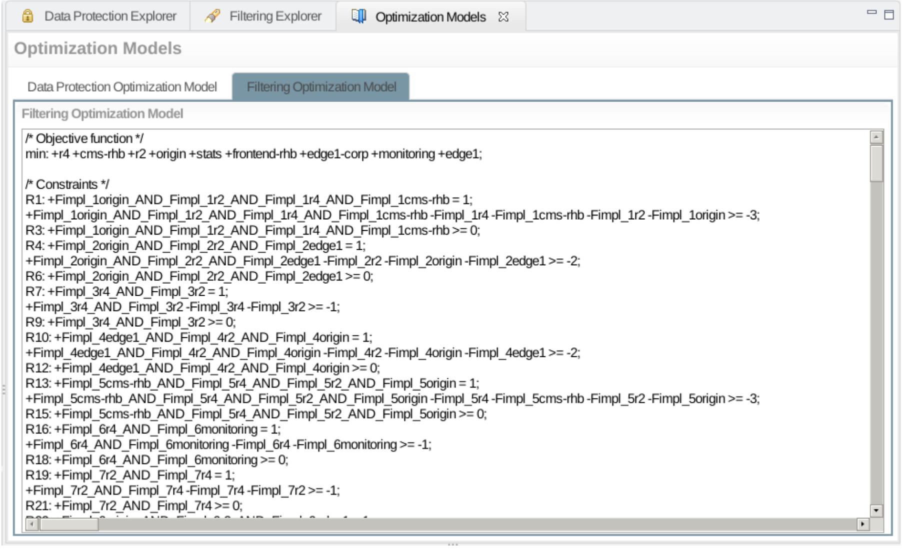
Select an optimization profile

Available profiles:

- Maximize filtering performance
- Maximize filtering performance and optimize configuration rules priorities
- Cost-based optimization (WD5.3)

Description:

Figure 18: Filtering: selection of the Optimization profile

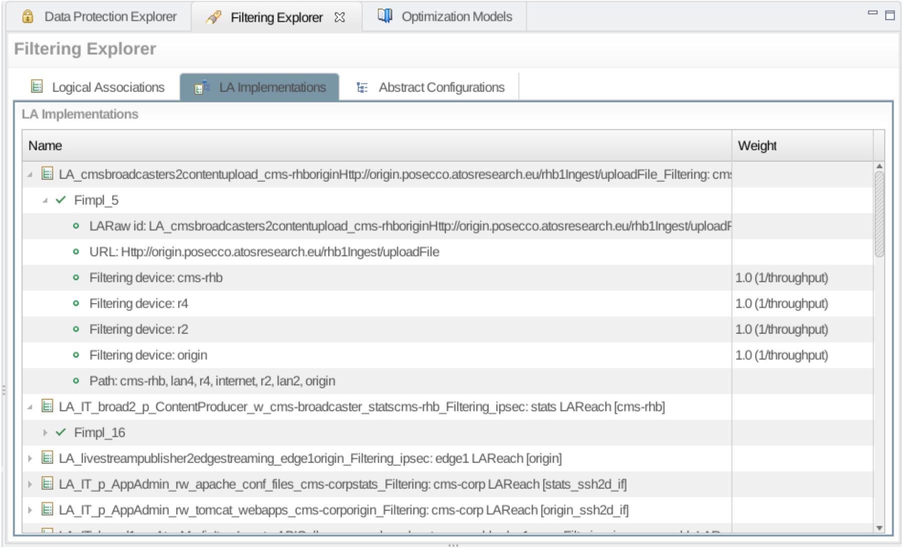


Data Protection Explorer
Filtering Explorer
Optimization Models
Optimization Models
Data Protection Optimization Model
Filtering Optimization Model
Filtering Optimization Model

```
/* Objective function */
min: +r4 +cms-rhb +r2 +origin +stats +frontend-rhb +edge1-corp +monitoring +edge1;

/* Constraints */
R1: +Fimpl_1origin_AND_Fimpl_1r2_AND_Fimpl_1r4_AND_Fimpl_1cms-rhb = 1;
+Fimpl_1origin_AND_Fimpl_1r2_AND_Fimpl_1r4_AND_Fimpl_1cms-rhb -Fimpl_1r4 -Fimpl_1cms-rhb -Fimpl_1r2 -Fimpl_1origin >= -3;
R3: +Fimpl_1origin_AND_Fimpl_1r2_AND_Fimpl_1r4_AND_Fimpl_1cms-rhb >= 0;
R4: +Fimpl_2origin_AND_Fimpl_2r2_AND_Fimpl_2edge1 = 1;
+Fimpl_2origin_AND_Fimpl_2r2_AND_Fimpl_2edge1 -Fimpl_2r2 -Fimpl_2origin -Fimpl_2edge1 >= -2;
R6: +Fimpl_2origin_AND_Fimpl_2r2_AND_Fimpl_2edge1 >= 0;
R7: +Fimpl_3r4_AND_Fimpl_3r2 = 1;
+Fimpl_3r4_AND_Fimpl_3r2 -Fimpl_3r4 -Fimpl_3r2 >= -1;
R9: +Fimpl_3r4_AND_Fimpl_3r2 >= 0;
R10: +Fimpl_4edge1_AND_Fimpl_4r2_AND_Fimpl_4origin = 1;
+Fimpl_4edge1_AND_Fimpl_4r2_AND_Fimpl_4origin -Fimpl_4r2 -Fimpl_4origin -Fimpl_4edge1 >= -2;
R12: +Fimpl_4edge1_AND_Fimpl_4r2_AND_Fimpl_4origin >= 0;
R13: +Fimpl_5cms-rhb_AND_Fimpl_5r4_AND_Fimpl_5r2_AND_Fimpl_5origin = 1;
+Fimpl_5cms-rhb_AND_Fimpl_5r4_AND_Fimpl_5r2_AND_Fimpl_5origin -Fimpl_5r4 -Fimpl_5cms-rhb -Fimpl_5r2 -Fimpl_5origin >= -3;
R15: +Fimpl_5cms-rhb_AND_Fimpl_5r4_AND_Fimpl_5r2_AND_Fimpl_5origin >= 0;
R16: +Fimpl_6r4_AND_Fimpl_6monitoring = 1;
+Fimpl_6r4_AND_Fimpl_6monitoring -Fimpl_6r4 -Fimpl_6monitoring >= -1;
R18: +Fimpl_6r4_AND_Fimpl_6monitoring >= 0;
R19: +Fimpl_7r2_AND_Fimpl_7r4 = 1;
+Fimpl_7r2_AND_Fimpl_7r4 -Fimpl_7r4 -Fimpl_7r2 >= -1;
R21: +Fimpl_7r2_AND_Fimpl_7r4 >= 0;
```

Figure 19: Filtering: Optimization model

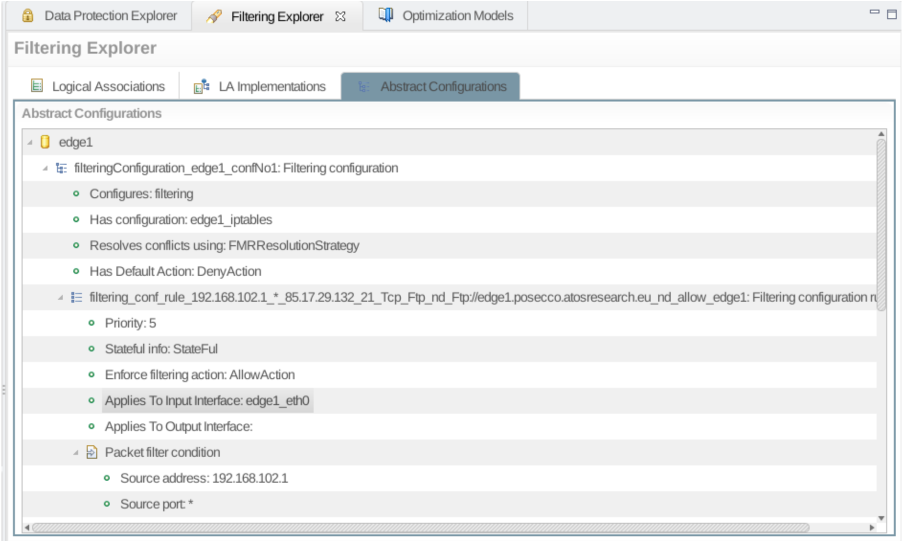


Name	Weight
LA_cmsbroadcasters2contentupload_cms-rhboriginHttp://origin.posecco.atosresearch.eu/rhb1Ingest/uploadFile_Filtering: cms	
✓ Fimpl_5	
○ LARaw id: LA_cmsbroadcasters2contentupload_cms-rhboriginHttp://origin.posecco.atosresearch.eu/rhb1Ingest/uploadF	
○ URL: Http://origin.posecco.atosresearch.eu/rhb1Ingest/uploadFile	
○ Filtering device: cms-rhb	1.0 (1/throughput)
○ Filtering device: r4	1.0 (1/throughput)
○ Filtering device: r2	1.0 (1/throughput)
○ Filtering device: origin	1.0 (1/throughput)
○ Path: cms-rhb, lan4, r4, internet, r2, lan2, origin	
LA_IT_broad2_p_ContentProducer_w_cms-broadcaster_statscms-rhb_Filtering_ipsec: stats LAReach [cms-rhb]	
✓ Fimpl_16	
LA_livestreampublisher2edgestreaming_edge1origin_Filtering_ipsec: edge1 LAReach [origin]	
LA_IT_p_AppAdmin_rw_apache_conf_files_cms-corpstats_Filtering: cms-corp LAReach [stats_ssh2d_if]	
LA_IT_p_AppAdmin_rw_tomcat_webapps_cms-corporigin_Filtering: cms-corp LAReach [origin_ssh2d_if]	

Figure 20: Filtering: Optimization results

Step 5. By clicking on *Generate the abstract configurations* the tool generates the Filtering abstract configurations. The results are displayed in Fig. 21. The view is implemented using a tree and organized as follow:

- the first level contains the set of configured devices (e.g., fw1);
- the second level contains the set of Filtering Configurations (typically one for each firewall);
- the third level defines the configuration properties and the related rules. For example the Fig. 21 shows that we configure filtering capability on `fw1.os` using a First Matching Rule strategy and a Deny All as default action.
- the fourth level defines the properties of a configuration rule. For example the Fig. 21 shows: the priority (the position of a rule into the firewall), the stateful information, the action (allow, deny, reject), the input and output interfaces and the related packet filter conditions (source and destination IP address, direction, etc.).



- edge1
  - filteringConfiguration_edge1_confNo1: Filtering configuration
    - Configures: filtering
    - Has configuration: edge1_iptables
    - Resolves conflicts using: FMRResolutionStrategy
    - Has Default Action: DenyAction
    - filtering_conf_rule_192.168.102.1_*_85.17.29.132_21_Tcp_Ftp_nd_Ftp://edge1.posecco.atosresearch.eu_nd_allow_edge1: Filtering configuration r
      - Priority: 5
      - Stateful info: StateFul
      - Enforce filtering action: AllowAction
      - Applies To Input Interface: edge1_eth0
      - Applies To Output Interface:
      - Packet filter condition
        - Source address: 192.168.102.1
        - Source port: *

Figure 21: Filtering: Abstract configurations